ADB

Environmental Assessment Report

Summary Environmental Impact Assessment
Project Number: 38412
June 2009

India: Assam Integrated Flood and Riverbank Erosion Risk Management Investment Program

Prepared by the Water Resources Department of the State Government of Assam for the Asian Development Bank

CURRENCY EQUIVALENTS

(As of 1 June 2009)

Currency Unit – rupee (Re/Rs)
Re1.00 = $0.02122
$1.00 = Rs47.11

ABBREVIATION

ADB	–	Asian Development Bank
DMO	–	disaster management organization
EA	–	executing agency
EARF	–	environmental assessment and review framework
EIA	–	environmental impact assessment
EIRR	–	economic internal rate of return
EMOP	–	environmental monitoring plan
EMP	–	environmental management plan
FRERM	–	flood and riverbank erosion risk management
IUCN	–	International Union for Conservation of Nature
IWAI	–	Inland Water Transport Authority
KNP	–	Kaziranga National Park
MFF	–	multitranche financing facility
NGO	–	nongovernment organization
PMU	–	project management unit
PPTA	–	project preparatory technical assistance
SEIA	–	summary environmental impact assessment
SIO	–	subproject implementation office
SPCB	–	State Pollution Control Board
WRD	–	Water Resources Department

WEIGHTS AND MEASURES

dBA	–	decibel
Ha	–	hectare
Km	–	kilometer
km^2	–	square kilometer
m	–	meter
mm	–	millimeter
m^3/s	–	cubic meters per second

GLOSSARY

porcupine	–	Tetrahedron-shaped concrete frames commonly made of six concrete members, each 3 meters long connected with bolts, which are placed in an arrayed manner in the riverbed to retard river water flow and induce sedimentation.
revetment	–	A riverbank protection structure constructed on the bottom or banks of a river by placing a layer of material, such as rock, stones, concrete blocks, or mattresses including sand-filled geo-textile containers.

spur	–	A river training structure built from the bank of a river in a direction transverse to the current, by placing a large quantity of rocks, stones, or concrete blocks (or earth armored with these heavy materials).

NOTES

(i) The fiscal year (FY) of the Government of India ends on 31 March. FY before a calendar year denotes the year in which the fiscal year ends, e.g., FY2009 ends on 31 March 2009.

(ii) In this report, "$" refers to US dollars.

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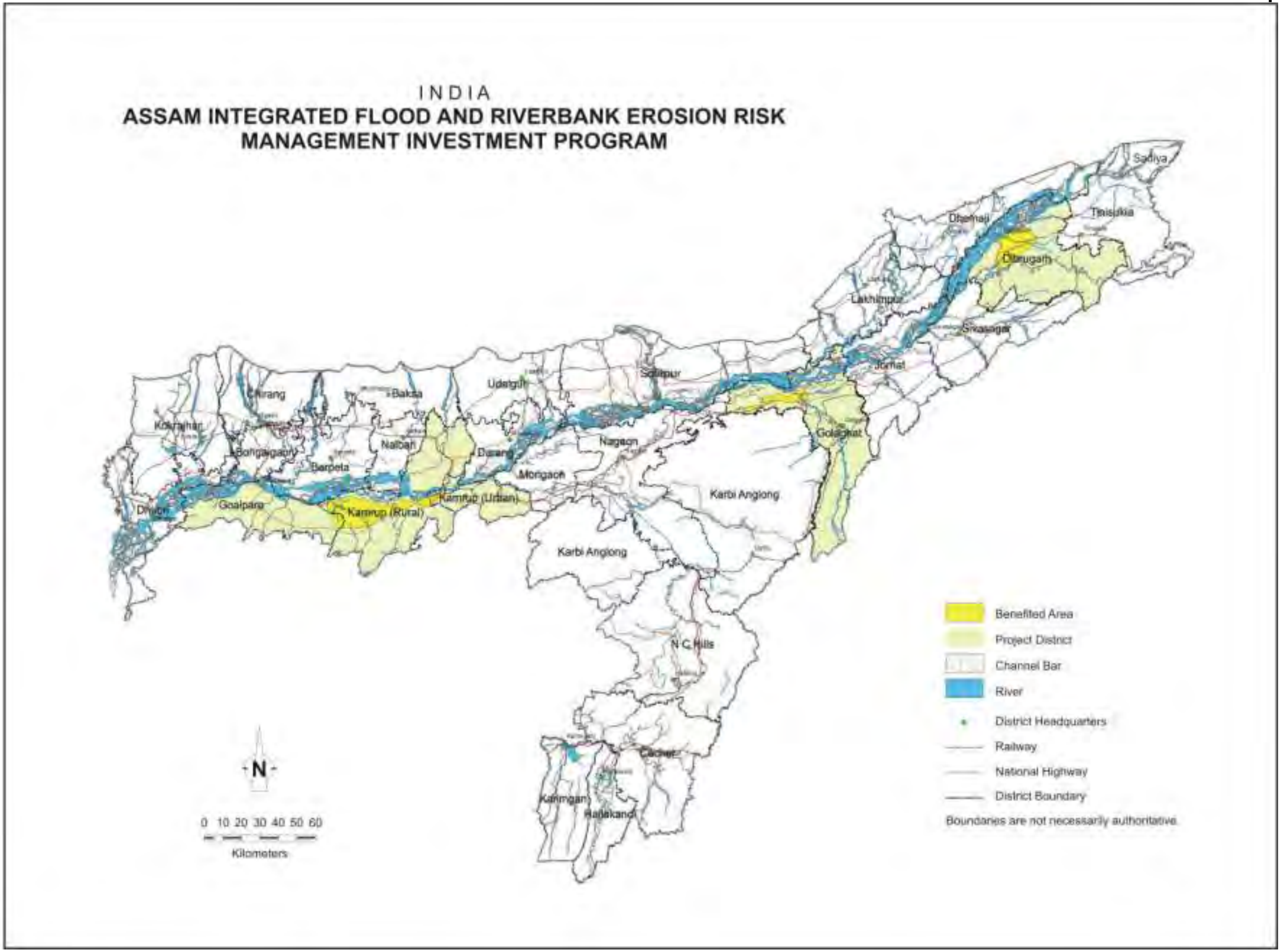

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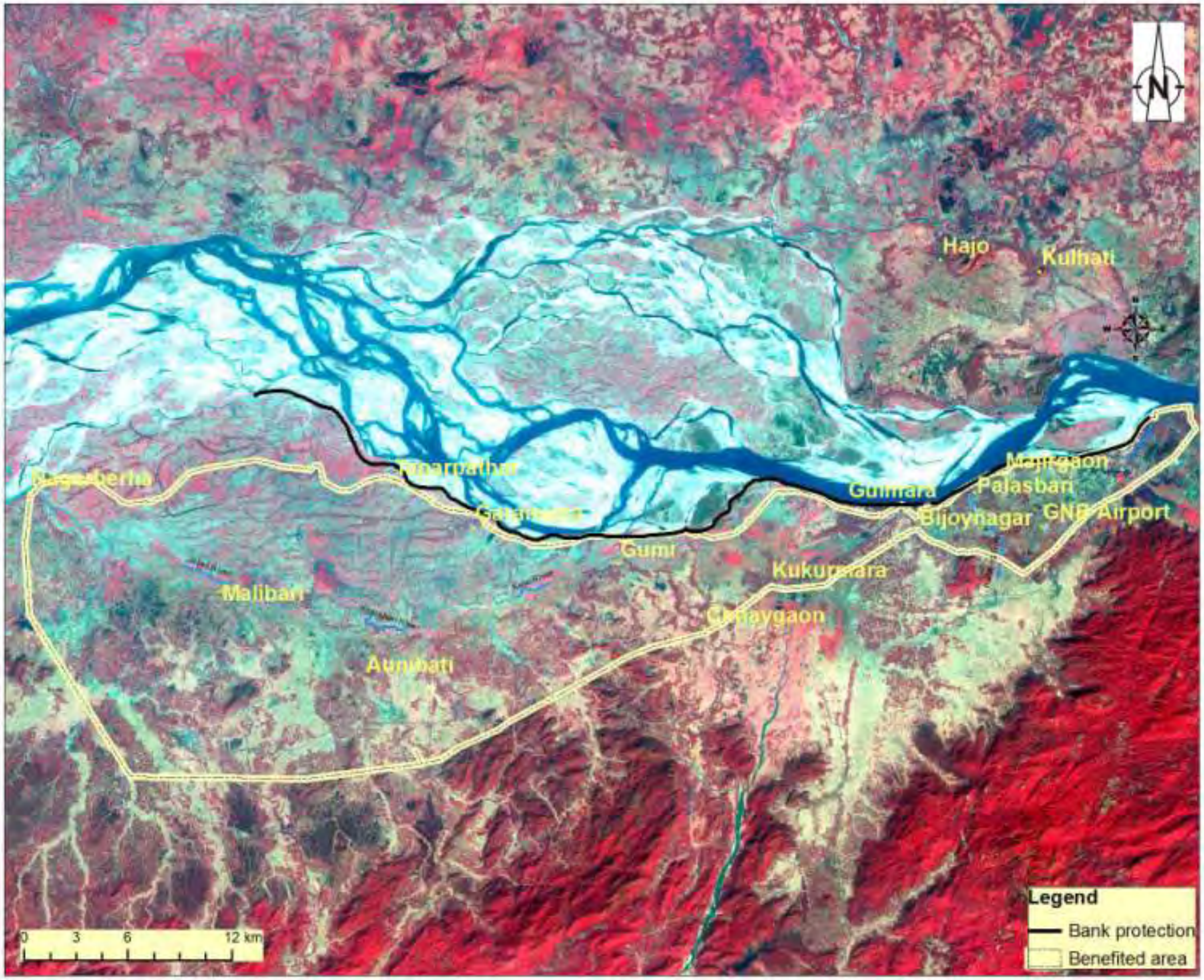
Map 2



Satellite image of the Palasbari subproject

IRS LISS3 image of November 2006

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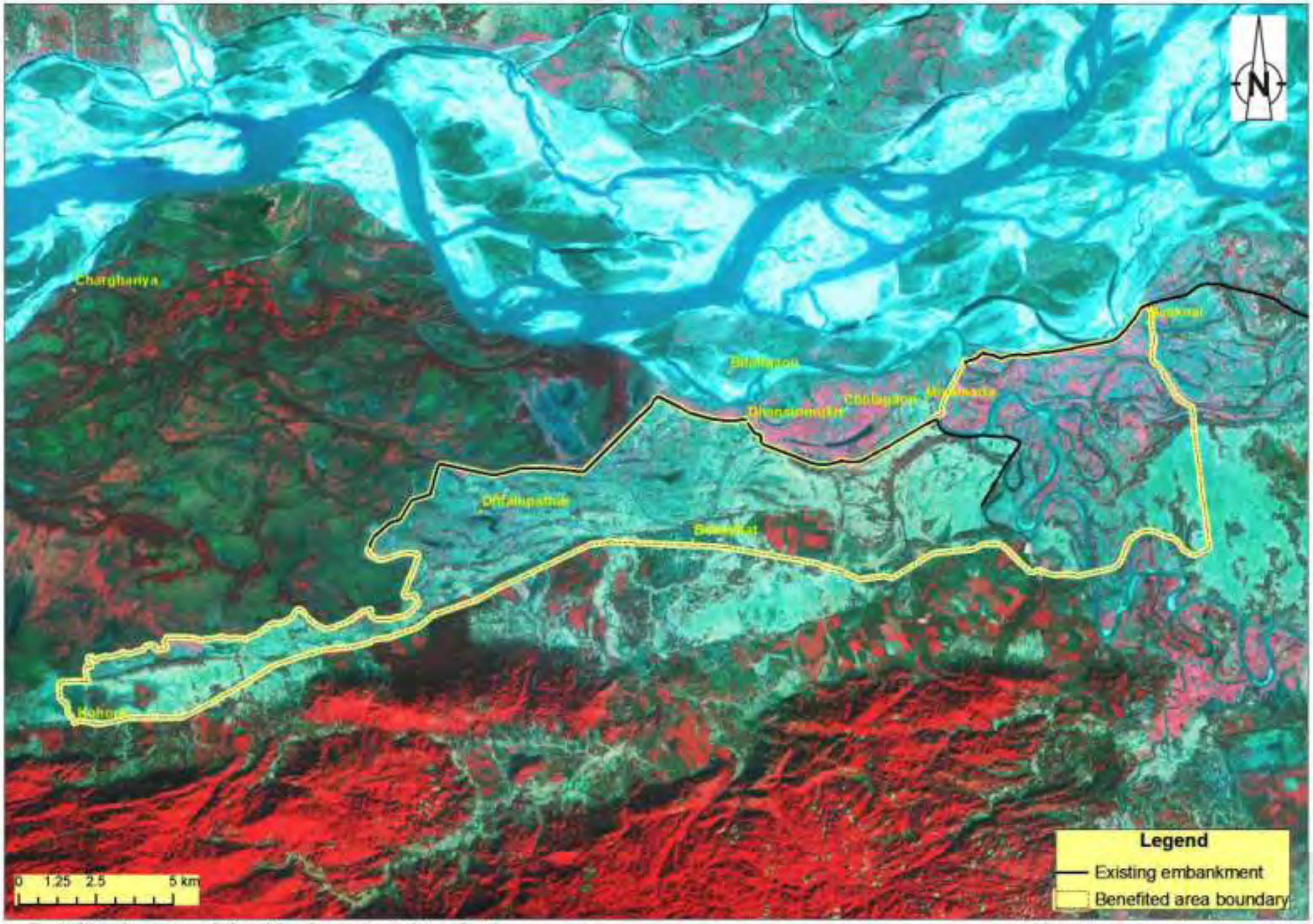
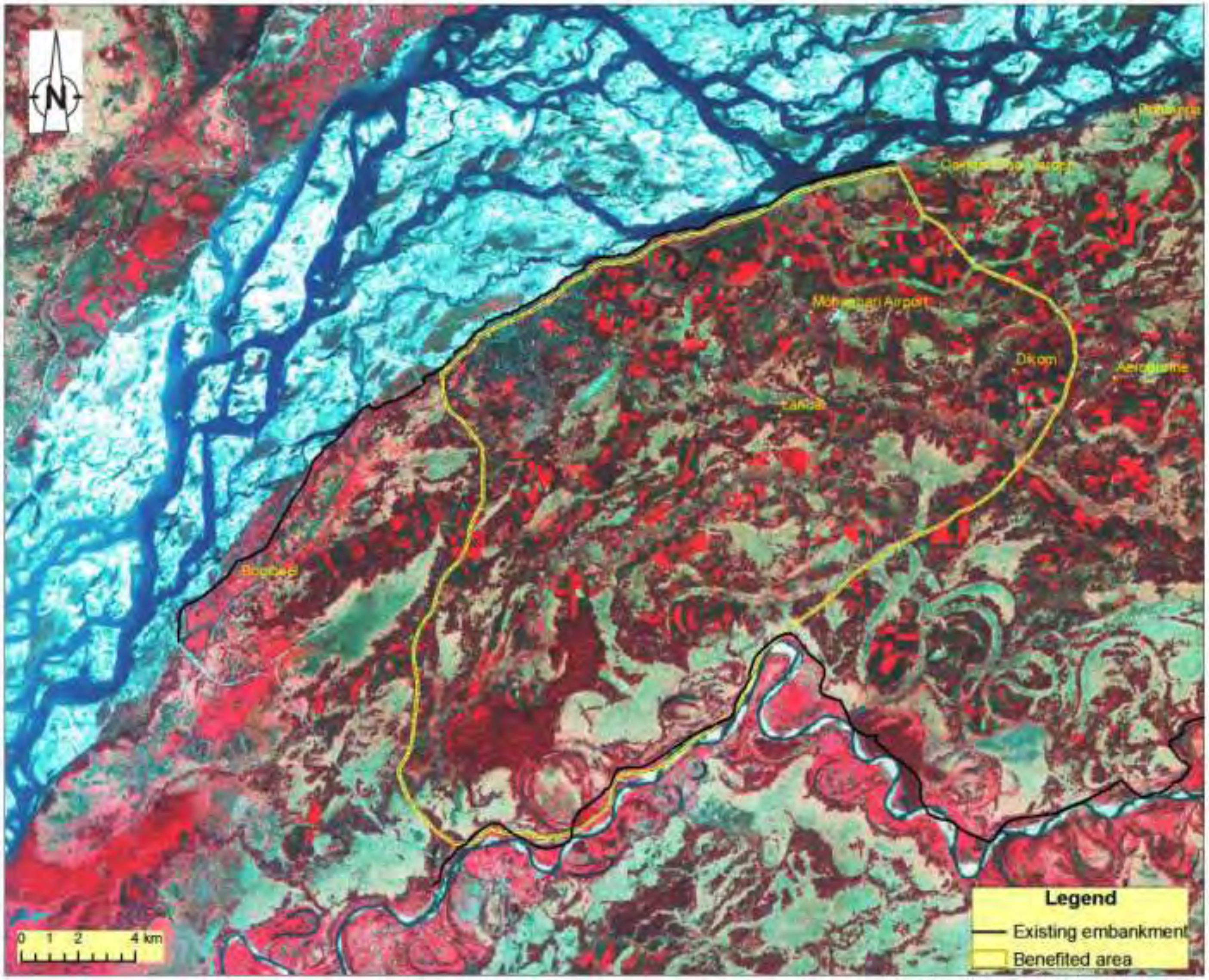
Map 3



Satellite image of the Kaziranga subproject

IRS LISS III image of January 2008

Map 4



Satellite image of the Dibrugarh subproject

IRS LISS III image of November 2007

I. INTRODUCTION

1. The Water Resources Department (WRD) of the state government of Assam, India engaged consultants to undertake an environmental impact assessment (EIA) of a multitranche financing facility (MFF) for the Assam Integrated Flood and Riverbank Erosion Risk Management Investment Program. The Program aims to enhance the effectiveness and reliability of flood and riverbank erosion risk management (FRERM) systems in three existing flood embankment systems (or subprojects) protecting urban, suburban, and other strategic areas of Assam: (i) Palasbari reach (74 kilometers [km]) in Kamrup (south) district; (ii) Kaziranga reach (29 km) in Golaghat district, adjacent to the Kaziranga National Park (KNP); and (iv) Dibrugarh reach (25 km) in Dibrugarh district. The Program also aims to strengthen the policy, planning, and institutional bases to support better FRERM operations. Comprehensive and adaptive structural and nonstructural FRERM measures will be provided in the three subproject areas. These are provided in two tranches during the 7-year implementation period, based on the local priorities.

2. This summary environmental impact assessment (SEIA) report summarizes possible environmental impacts of the three subproject areas, and the mitigating and enhancement measures that will be implemented to address any detrimental impacts and to increase the benefits. The SEIA covers the impacts of both tranches of the MFF in the three subprojects included in the Program. A multidisciplinary team of consultants assisted the WRD in conducting the environmental impact assessment (EIA) during the project preparatory technical assistance (PPTA),[1] which was carried out during April 2007–December 2008. It was based on a range of data, including those obtained from surveys for the PPTA. It was carried out in accordance with the *Environment Assessment Guidelines of the Asian Development Bank*[2] and the guidelines of the Government of India. The WRD prepared the EIA and the SEIA through a consultative process of review by the Asian Development Bank (ADB) and other stakeholders. The state government of Assam has accepted the EIA reports. No formal approval is required from the Government of India in accordance with existing environmental law in India.

II. DESCRIPTION OF THE PROJECT

3. **Rationale.** Assam remains one of the poorest states in India, with per capita income 45% below the national average in 2005. An inability to minimize the impacts of frequent flooding remains one of the serious development constraints.[3] Flooding and river erosion have devastating impacts each year. The floods are caused by the runoff of extremely heavy rainfall during the monsoon and high sediment loads from upper watersheds that are geologically unstable and degraded because of deforestation and changing land use. Their effective management requires a long-term, basin-wide approach with a sound planning framework integrating short- to longer-term programs, including (i) better catchment management, (ii) multipurpose reservoirs where feasible, and (iii) a balanced combination of structural and nonstructural measures to cope with immediate annual flood and erosion risks.

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1 ADB. 2006. Technical Assistance to India for *Preparing the North East Integrated Flood and River Erosion management Project (Assam)*. Manila

2 ADB. 2003. *Environmental Assessment Guidelines of the Asian Development Bank*. Manila.

3 The Brahmaputra Valley in Assam is one of the most acutely hazard-prone regions of the country, with more than 40% of its land (3.2 million hectares) susceptible to flood damage. This is 9.4% of the country's total flood-prone area. The erosion hazard is also extremely severe in several vulnerable reaches. About 7% of land in the state's 17 riverine districts has been lost because of river erosion over the past 50 years.

4. While the state has flood embankment systems protecting 50% of its flood-prone areas, their reliability is constrained by deterioration associated with poor maintenance, failure from river erosion, and local riverbed rising. The improvement of the existing embankments needs to be prioritized, particularly along high-value locations with assured maintenance, supported by riverbank protection where feasible. More cost-effective and flexible options that can adapt to the dynamic river process should be explored. Alternative risk management measures need to be pursued in other areas, such as flood proofing, strategic retirement of embankments, and a range of nonstructural measures including flood and erosion risk prediction and mapping, advance warning, and safety nets for the people threatened and displaced by flooding and river erosion. Comprehensive strengthening of the policy, planning, and institutional basis, data, and knowledge base are also required, along with the effective participatory mechanisms to ensure accountable program management.

5. The Government, in its Eleventh Five Year Plan,[4] has prioritized flood management, in line with the paradigm shift of the country's disaster management strategy to focus more on preparedness than responses. This is also in line with a growing concern about the impacts of climate change. The state government has also initiated steps to establish a sound policy, planning, and institutional framework for water resources management, including drafting a state water policy and a vision for holistically managing flood and riverbank erosion from a basin perspective. The Program is designed to support the state government's initiatives by promoting necessary reforms and strengthening key sector organizations, such as the WRD and local participatory disaster management organizations (DMOs). Structural measures will focus on the three existing embankment systems protecting key urban and productive rural areas, which were selected as the priority sites for putting into operation effective FRERM systems. The establishment of a sound data and knowledge base to effectively manage or respond to the dynamic natural river processes will be emphasized.

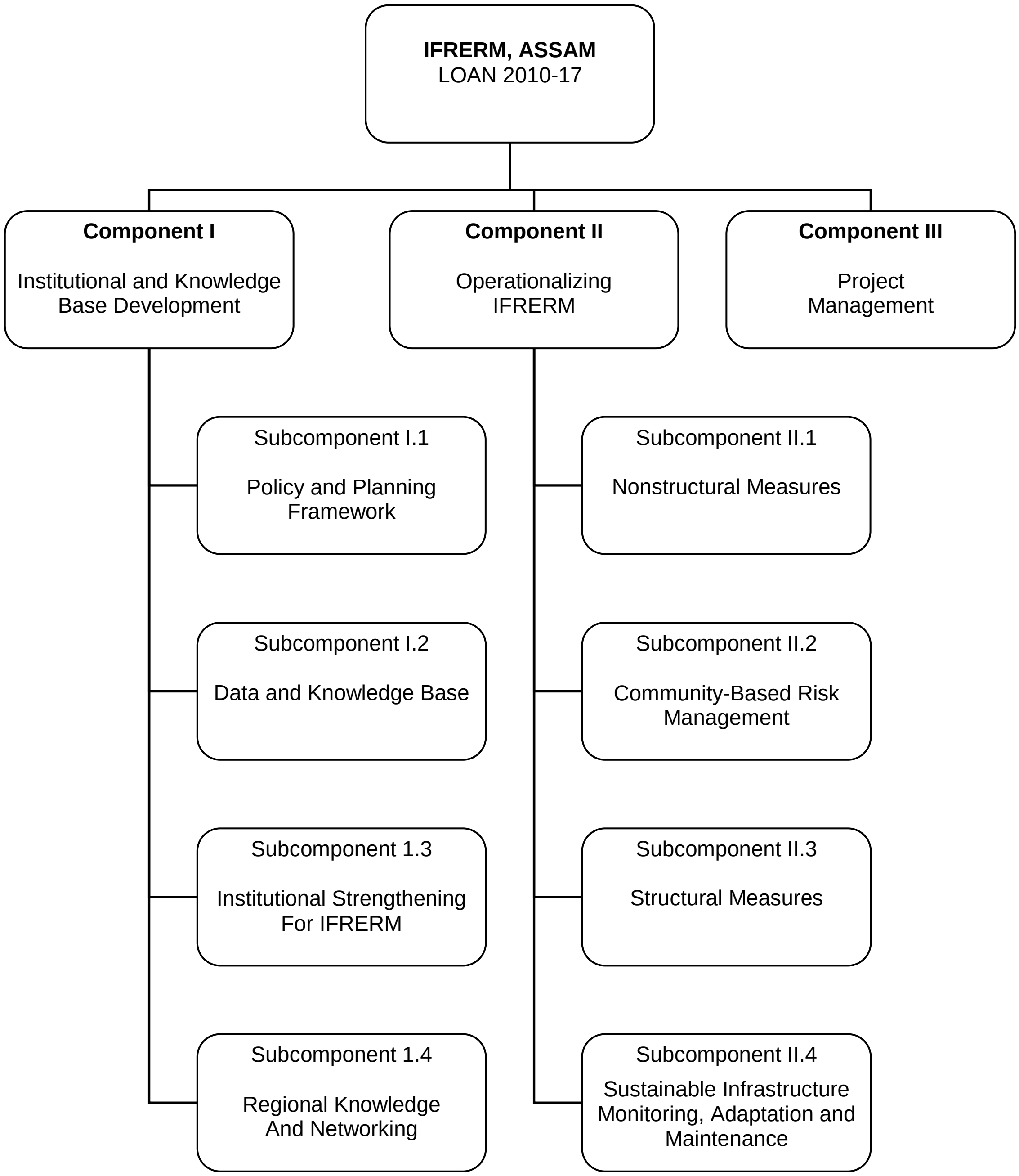
6. **The Program.** The Program intends to (i) improve the state's ability to mitigate flood and erosion damage at three priority subprojects that have embankment systems, (ii) increase economic development, and (iii) reduce poverty. Recognizing the need for a holistic approach to FRERM, the Program has several components that mix structural and nonstructural measures, as shown in Figure 1. Component I will address the enabling environment and institutional framework, particularly the policy and planning framework, institutional strengthening, and capacity building. Component II will address the operationalization of integrated FRERM through structural, nonstructural, and community-based risk management measures. Structural measures include the renovation of existing embankments, including their retirements, to maintain their intended design functions; provision of riverbank protection; and associated drainage structures, such as sluice gates along the embankments, to improve local drainage. Component III will address project management and training of project organizations. It is estimated to cost $149 million including financial charges. The Program is described in more detail in Appendix 1.

7. The Program is to be implemented over 7 years, from 2010 to 2016 (including 1 year for maintenance support). Although designed as a project loan having three appraised subprojects, an MFF is adopted for the implementation of the Program to achieve higher quality implementation, progressively improve program design by incorporating lessons, and progressively develop institutional basis and capacities. Within the MFF framework, the implementation philosophy follows an adaptive approach to allow construction at the right place at the right moment. The flexible response largely applies to the implementation of riverbank

[4] Government of India. 2007. *Eleventh Five Year Plan (2007-2012). New Delhi*

protection measures. As such, the subproject works are divided into two tranches. The first tranche is more definitive for immediate implementation following local priorities, while the second tranche is indicative at this stage and a more definite scope will be defined at the time of its processing. An updated or revised EIA will be prepared at that time as required.

Figure 1: Program Components



8. A participatory and holistic FRERM will be used to implement the Program. For this purpose, a multidisciplinary project management unit (PMU) will be established under the Assam Integrated Flood and Riverbank Erosion Risk Management Agency, which is being established with registeration under the Societies Registration Act. The PMU will provide stable leadership and strong coordination of technical, nonstructural, and participatory agendas. At the

subproject level, multidisciplinary subproject implementation offices will be set up, combining technical, disaster management, and coordination functions. The established system of DMOs, implemented under the United Nations Development Program Disaster Risk Management Project, will be extended to include a wider range of stakeholders and jointly decide on and monitor implementation. The concerned state departments, including the WRD, will be held accountable to DMOs for sound program delivery.

9. **Scope of Environmental Assessment.** As this EIA covers all subprojects implemented under both of the tranches of the MFF, an environmental assessment and review procedure for future tranche works is not necessary. On the other hand, an environmental assessment and review framework (EARF) has been prepared as a supplementary appendix for the community-based flood risk management measures. These will be defined in consultation with the communities and may include minor community infrastructure, such as village platforms and evacuation centers. The individual subproject EIA and associated environmental management plan (EMP) may be revised for the second tranche if the project design is changed based on the implementation and monitoring results of the first tranche.

10. **The Three Subprojects.** The proposed subprojects under component II will develop and implement a range of modern structural measures, along with nonstructural measures that will focus on the prevention of the flood and erosion threat. These have been selected as the priority subprojects for implementation under the Program, and they represent the different types of floodplains in Assam. The Dibrugarh subproject is an example of a densely populated town area. The area of Palasbari is designated for future industrial development, and is expected to change from predominantly agricultural land use to manufacturing and industries. Kaziranga represents an agricultural area with a nearby world heritage site. In total, about 129 km of riverbank, or about 10% of the total length of the Brahmaputra banks, are covered by the core areas with the potential to address erosion, if necessary. The benefited area is estimated to be about 100,000 hectares (ha).

11. A broad outline of the location, existing infrastructure, and proposed structural works of the three subproject areas is in paras. 12–14. A more detailed description of the scope of the subprojects and their layout maps are in Appendix 2.

12. **Palasbari Subproject.** The subproject, on the southern bank of Brahmaputra River, spans a 74 km reach from the confluence of the Kanjan River near Guwahati to the confluence of the Jaljari River. This reach is immediately downstream from the narrowest point of the Brahmaputra (at Pandu), which caused sediment deposition within the subproject reach that formed a large cluster island (or chars) in the central part of the river accompanied by lateral erosion for many decades. As a result, the embankment system, which was constructed in the 1950s, has had a long history of erosion and retirement. The subproject area has a continuous system of dykes, with seven spurs to provide riverbank protection over a 6.3 km long reach of riverbank. However, several sections have a high risk of river erosion and flooding, sand deposition, and Brahmaputra channel migration. The first tranche will retire 4.9 km of existing embankments[5] supported by 7.0 km of revetment alongside the most erosion-prone reach.[6] The second tranche includes 13.6 km of revetment and pro-siltation measures, rehabilitation of three boulder deflectors, and two gated drainage sluices. In addition, the Program will support the provision of sufficient maintenance of existing embankments (70 km).

[5] Embankment design under the Program has followed the existing norms to fix the crest level at an estimated high flood level with 50-year return period plus 1.5-meter free board.

[6] In addition, minor resectioning of embankments will be undertaken to restore its design cross sections.

13. **Kaziranga Subproject.** The subproject is adjacent to KNP, extending from its border upstream (eastward) and covering about a 29 km reach along the Brahmaputra River to Bankoal past the Dhansiri River confluence. Flood embankments have been placed along the Brahmaputra since the early 1960s. They extend inland for 12 km along the KNP border on the western side. There is also 5.5 km of embankment along the west bank of the Dhansiri River. The Brahmaputra embankments have been retired several times because of river erosion. The first tranche will provide (i) 4.7 km of new inner secondary embankment to prevent the sudden intrusion of floodwater into KNP in case the frontline Brahmaputra dyke is breached, (ii) three sluice gates along the KNP boundary dyke, and (iii) 3 km of riverbank protection through pro-siltation measures using porcupines. The second tranche includes (i) renovation of 18.7 km of existing embankments on the western side of the Dhansiri River, and (ii) 6 km of pro-siltation measures upstream and downstream from the Dhansiri confluence. In addition, the project will support the provision of sufficient maintenance of the existing embankments (35 km).

14. **Dibrugarh Subproject.** The subproject covers about a 25 km reach, including Dibrugarh town, and extends upstream towards Oakland. Most of the embankments in this reach were built in the mid-1950s. This includes 9.5 km of town protection, which has also been provided with revetment and a series of spurs that have stabilized the bank line over the past 50 years. On the other hand, this reach is undergoing a process of aggradation of about 1 meter (m) in 30 years, calling for raising the embankments to retain the intended level of protection. The first tranche includes (i) strengthening of 9.5 km town protection embankment, (ii) 1.8 km of bank protection through pro-siltation measures along the town protection dykes, and (iii) 2.4 km of bank protection near Oakland areas through sand-filled geotextile revetment. The second tranche includes (i) strengthening of 4.7 km of the existing tributary dyke, (ii) rehabilitation of seven spurs along the town protection embankment, (iii) two gated sluices, and (iv) a 9.5 km inspection road. In addition, the project will support the provision of sufficient maintenance of the existing embankments (21 km).

III. DESCRIPTION OF THE ENVIRONMENT

15. The environment conditions are similar in the three subproject areas. In this assessment, data were collected on the physical environment, biological environment, and socioeconomic environment of the study areas of the three subproject reaches, with a particular emphasis on an 8–10 km buffer zone around the embankment. These data and information are considered to be of prime importance in relation to the nature and location of the proposed subprojects focused on the three subproject reaches. A brief description of the environment is in paras. 16–43.

A. Physical Environment

1. Climate

16. The climate is subtropical with a hot, humid summer season dominated by the southwest monsoons from early June to mid-September and a cool, dry winter from late October to the end of February. The pre-monsoon season, beginning in the early part of March and continuing until May, is marked by occasional thunderstorms and rising temperatures during the day. The post-monsoon season from last part of September to mid-October generally brings fair weather conditions with declining rainfall as well as temperature.

17. The Brahmaputra River valley in Assam forms an integral part of the subtropical monsoon regime of Eastern Asia, receiving a mean annual rainfall of 2,300 millimeters (mm)

with a variability of 15%–20%. Distribution of rainfall over different river basins in Assam shows marked spatial variations, e.g., from as low as 1,750 mm in the Kopili basin in the central part of the valley to as much as 4,100 mm in Jiadhol basin in upper Assam.

2. Physiography

18. The subproject areas are highly homogenous in terms of their riverine location within the active floodplain tract along the banks of the Brahmaputra River, their composition consisting almost entirely of young alluvial soil, and their acute vulnerability to flood and erosion over the past few decades. However, each subproject shows considerable variations in several other aspects, including biodiversity, urbanization, socioeconomic base, minerals and industries, and infrastructure. The physiography of Assam consists of (i) foothill zone, (ii) middle plain of the north bank, (iii) active flood plain, (iv) middle plain of the south bank, (v) sub-mountain zone, and (vi) hills. All the three reaches are in the active floodplain zone along the bank of the Brahmaputra River. The reaches consist of a variety of landscape elements—rivers, floodplains, wetlands (*beels*), swamps, and occasional hillocks in the study areas of 8–10 km around the embankment.

3. Topography

19. The topography of the subproject areas is characterized by a flat tract that forms part of the active floodplain, including the chars (islands and sandbars) within the bank lines of the Brahmaputra River . The monotony of the floodplain lying at an average elevation ranging from 50 m to 120 m above mean sea level is broken at places by protruding arms of isolated hillocks of Archaen origin. Subproject elevation is 100–115 m for Dibrugarh, 75–85 m for Kaziranga, and 40–55 m for Palasbari subprojects. The floodplain belt in this stretch is marked by a large number of degraded wetlands, abandoned river channels, and waterlogged and drainage-congested areas.

4. Hydrology

20. The Brahmaputra River and the 33 major tributaries joining it in Assam, including the main trans-Himalayan tributaries of Subansiri, Jia Bharali, and Manas, carry about 30% of the country's total surface water. Surface water bodies covering about 8,251 square kilometers (km^2) account for 10.5% of the geographical area of the state. Of these, the river systems, including waterlogged areas, occupy 6,503 km^2. The annual surface water availability is more than 53 million hectare-meters. Brahmaputra valley in Assam has 3,513 wetlands, covering 1,012.3 km^2. Groundwater is also plentiful at shallow depth in the valley; utilizable groundwater is estimated to exceed 2 million hectare-meters.

21. The hydrological characteristics of the Brahmaputra valley are dominated by the intensely powerful monsoon rainfall region of the eastern Himalayas, the freeze–thaw cycle of Himalayan snow, and the immensely dynamic fluvial processes of the river and its tributaries. It is also influenced by the unique characteristics of the physical terrain and tectonic framework of the region. The average annual discharge of the river at Pandu, which is upstream from the Palasbari subproject area, is 19,800 cubic meters per second (m^3/s). The highest recorded daily discharge at Pandu upstream of the Palasbari stretch was 72,700m^3/s (August, 1962). The summer high flows and winter low flows vary in certain years by as much as 20-fold. The average annual flood discharge of the river, which has a return period of 2.2 years, is 48,200 m^3/s, while the maximum recorded flow has a return period of 133 years. The hydrological conditions of the three subproject areas are synthesized in paras. 22–25.

22. **Palasbari Subproject.** In this reach, the Kulsi River, a major south bank tributary of the Brahmaputra originating in the Meghalaya plateau to the south, drains into a large area running westward, parallel and close to the Brahmaputra River, which may avulse into this channel. It eventually joins the Brahmaputra through the Jaljari River near Nagarbera hill, the end point of the subproject. While the Brahmaputra dykes protect the area from flooding by the Brahmaputra, a part of the subproject area is also exposed to tributary flooding and to local flooding from heavy rains. High water levels in the Brahmaputra increase the level and duration of tributary flooding in the Kulsi–Jaljari system, and drainage congestion is widespread around the lower reaches of this system in the western part of the subproject area.

23. **Kaziranga Subproject.** The subproject area is bisected by the Dhansiri River, a major south bank tributary with a catchment area of 12,700 km^2. Flood embankments along the Brahmaputra and Dhansiri west bank protect the western part of the subproject area from Brahmaputra and Dhansiri flooding. However, the eastern part is susceptible to Dhansiri floodwaters, as well as backwater flooding from the Brahmaputra. The subproject area is adjacent to the KNP and Panbari Reserve Forest (Figure A2.2), which are inundated by natural Brahmaputra flooding across the bank lines along the KNP. However, any breach of the Brahmaputra embankment protecting the subproject area west of the Dhansiri confluence will allow the floodwaters to rush into the KNP area along the natural depression that runs parallel to the highway and disconnects the forest area from the KNP. The Brahmaputra may also avulse into this depression.[7]

24. **Dibrugarh Subproject.** While the subproject area has been protected from Brahmaputra flooding for more than 50 years by the Brahmaputra embankments, the area is susceptible to tributary flooding from the Maijan beel (north of Dibrugarh town) and from the Buridihing River (south of the town). High water levels in the Brahmaputra increase the level and duration of tributary flooding. This reach has also suffered from the impact of riverbed aggradation over the years, making the subproject area increasingly vulnerable to Brahmaputra flooding, with seepage and boiling observed along the existing embankments. However, no overflowing of flood water above the town protection dyke has been reported. Local flooding because of heavy rainfall is also an issue as drainage is increasingly difficult.

25. According to the Brahmaputra flood record, the flood of July 2004, which is considered one of the most severe, inundated the following proportions of the subproject areas: 32% of Palasbari, 32% of Kaziranga, and 9% of Dibrugarh. This provides an indicative impact of tributary and local rainfall floods when Brahmaputra embankments are functional. The inundated area is shown in Appendix 3.

5. River Morphology

26. The morphology of the Brahmaputra River is characterized by intense braiding and bar formation—where channels exhibit successive bifurcation and rejoining of flow around sand bars and islands—and highly dynamic river bank line and bed configuration. The morphology and behavior of the river undergoes drastic changes in response to variations in the flow regime and pattern of sediment transport and deposition in the river following the seasonal rhythm of the monsoon. Multiple factors, such as excessive sediment load, large and variable flow, easily erodible bank materials, and aggradation of the channel, have been the possible underlying factors. Another striking feature of the river's morphology is the continuous shift of the thalweg (deep channel) from one location to another within the unstable bank lines of the river. Bank

[7] These would affect the KNP wildlife by disrupting their seasonal migration between the KNP and the reserve forest when KNP is inundated.

materials of the Brahmaputra consist mainly of fine sand and silt with only an occasional presence of clay. They have a relatively fine-grained top stratum and a coarser substratum. Table 1 shows the recent history of erosion and accretion in the vicinity of the three subprojects.

Table 1: Comparison of Erosion Figures at the Three Subproject Sites

Item	Dibrugarh	Kaziranga	Palasbari
Reach length investigated (Length of subproject reach)	78 km (25 km)	115 km (29 km)	91 km (74 km)
Erosion (period) total per km	1967–2008 150 km² 1,920 m	1967–2008 70 km² 660 m	1911–2008 153 km² 1,550 m
Accretion (period) total per km	1967–2008 6 km² 80 m	1967–2008 35 km² 330 m	1911–2008 23 km² 230 m
Ratio erosion/accretion	24	2	7
Erosion Maximum (m/year) Minimum (m/year) Average (m/year)	114 7 49	61 18 16	45 10 17

km = kilometer, km² = square kilometer, m = meter, m/year = meter/year.
Source: Water Resources Department, State Government of Assam.

27. Different patterns of erosion and accretion occur at different locations within a few kilometers of the riverbank at the same time, and erosion and accretion follow each other in different magnitude at the same location. All three sites are characterized by substantial riverbank erosion and represent priority sites for Assam, although the erosion patterns are different and vary widely. The geomorphic features and past bank erosion alongside the subproject areas are shown in Appendix 4. All subproject areas have the risk of avulsion—a new channel development of the Brahmaputra within the flood plains, which may be initiated by a breach of the embankment and subsequent floodwater flow along low-lying areas and drainage channels that may develop into a new Brahmaputra channel.

6. Geology and Seismology

28. The Brahmaputra valley is considered a tectono-sedimentary basin, 720 km long and 80–90 km wide, underlain by recent alluvium about 200–300 m thick consisting of clay, sand, and pebble. Because the basin is underlain mostly by very young and unweathered sedimentary formations, the river carries mainly fine sand and silt with very little clay. Due to their strategic location close to the border of the colliding Eurasia (Chinese), Indian, and Burmese tectonic plate boundaries, the Brahmaputra valley and its adjoining hill ranges are seismically very unstable, falling in zone V (very severe seismic intensity zone) under seismic zoning. Active seismicity of the North Eastern region has caused extensive landslides and rock falls on the hill slopes, subsidence and fissuring of ground in the valley, and changes in the course and configuration of several tributary rivers as well as the Brahmaputra mainstream. These have had a significant impact on the hydrologic regime and morphology of the Brahmaputra basin. Their occurrence led to the intensification of flood and river erosion hazards, especially in the aftermath of the two great earthquakes of 1897 and 1950.

7. Air Quality and Noise Levels

29. The Dibrugarh reach has urban character, whereas Palasbari reach has township and suburban areas that may further develop as industrial areas. The Kaziranga subproject area is rural and poor in economic development and infrastructure. The ambient air environment is relatively undisturbed with no major sources of air pollution. Ambient air quality monitored at 2–3

locations for particulate matters and gaseous pollutants stays well within the National Ambient Air Quality Standards at each monitoring location. The noise levels monitored in each reach during the day and at night are also well within the national standards with respect to permissible noise in residential areas.

8. Water Quality

30. Surface water and groundwater quality as observed meet all the desirable and permissible water quality standards with respect to Indian Standards (IS)10500:1991 in all three subproject areas. Groundwater is also easily available in 5–10 m below ground level even during the lean period. In some samples, fluoride and coliforms were observed to be marginally above the desirable limits.

B. Biological Environment

1. Terrestrial Ecology

31. Assam is one of the most important biodiversity "hot spots" in the North Eastern region of India. The area harbors wide varieties of wildlife species in its diverse mosaic of natural habitats. The wilderness habitat of Assam supports 689 species of birds, 194 species of mammals, 185 species of fish, 115 species of reptiles, 54 species of amphibians, more than 900 species of butterflies, and immense varieties of moths. In terms of floral diversity, Assam has documented 6,027 species of plants, of which 3,010 are flowering plants. The area sustained 33 endangered mammalian fauna, more than 20 endangered avian fauna under the Wildlife Protection Act, 1972, and 45 globally threatened avian fauna and 17 endemic birds. In addition, the state supports more than 15 endangered reptilian and amphibian fauna each, and 43 endangered insets fauna.[8] The terrestrial ecology resources have been studied around the core zone of impact in all the three subproject reaches and are summarized in paras. 32–34 .

32. **Palasbari Subproject.** The study revealed the presence of 223 avian fauna, 19 mammalian fauna, 32 reptilian fauna, and 11 amphibian fauna. A total of 9 endangered species of reptilian fauna, 4 mammalian fauna, 16 avian fauna, 17 globally threatened avian species, and 1 amphibian fauna were observed in the area. No migratory route of terrestrial fauna was observed in Palasbari reach. The survey also recorded about 271,000 trees inside the embankments and 239,100 trees outside the embankments that were counted in a belt of 200 m width from the middle of the embankment. The bambusa species, khokon trees, sissoo trees, and segun trees are valuable.

33. **Kaziranga Subproject.** This is the most important reach in terrestrial ecology because of its proximity to KNP. KNP supports 40 globally threatened avian species, of which 2 are categorized as endemic, 2 critically endangered, 4 endangered, and 18 vulnerable. According to the International Union for Conservation of Nature (IUCN), KNP has 8 endangered, 11 vulnerable, 2 data deficient, and 10 less concerned species of mammalian faunas. Within 100 meters of the work sites of the Kaziranga reach, 2 endemic, 2 endangered, and 11 vulnerable

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[8] Saikia, P. K. and M. Kakati 2000. Diversity of Bird Fauna in North East India. *Jour. Assam Sci. Soc.* Vol: 41(4)**;** Chaudhury, A. U. 1997. *Checklist of the Mammals of Assam*. Gibbon books with Assam Science Technology and Environment Council; Das, S. K. 2000. Fish Genetic Resources of North East India and their status of Conservation. *Jour. Ass. Soc.* Vol: 41(4); Hattar, S. J. S. 2000. Overview of Faunal Diversity of Northeast India. *Jour. Assam Sci. Soc.* Vol: 41(4); Evans, W. H. 1932. *Identification of Indian Butterflies*. Croom Helm Ltd., Kent. (BI); Mao, A. A. and T. M. Hynniewta. 2000. Floristic Diversity of North East India. *Jour. Assam Sci. Soc.* Vol: 41(4); Saikia, P. K. and M. Kakati 2000b. Endangered fauna of Northeast India with special reference to Conservation. *Jour. My Green Earth.* Vol: 1(3).

avian fauna were spotted, as well as 2 endemic, 6 endangered, and 7 vulenerable mammalian fauna. However, none of these species has its habitat around the concerned work site area. Altogether 2,000 trees were counted in the embankment vicinity. Of the 15 economically important tree species identified, 6 have timber value, 4 have fuelwood value, 3 are economically valuable fruit tree species, and 2 are economically important seed producing trees.

34. **Dibrugarh Subproject.** The subproject area has 156 avian fauna, 16 mammalian fauna, 24 reptilian fauna, and 8 amphibian fauna. No endemic wildlife species were found in this reach, but a few endangered species were recorded. The study recorded 2 endangered mammalian fauna, 5 reptilian species, and 10 endangered avian faunas. This reach harbors 33 species of plants in the dyke area, including a tea plantation. About 34,000 trees were counted along the embankment vicinity, of which 15,600 were noted as economically important.

2. Aquatic Ecology

35. The three subproject reaches have a rich diversity in aquatic fauna—macro-invertebrates, such as crabs, molluscs, snails, lizards, and amphibians, as well as other aquatic mammals (river dolphin and otter). In addition, phytoplankton and zooplankton were also found in abundance. In the Palasbari and Kaziranga subprojects, 65 species of fish belonging to 23 families were identified, while 55 species belonging to 23 families were found in Dibrugarh.

36. Migratory fish species migrate through the main channel of the river i.e. through the deeper zones of the river. Hilsa showed anadromous migratory behavior, while the Anguilla showed catadromous migratory behavior. Other fish species, such as *Crossocheilius, Tor*, showed only local migration from upper to lower reaches of the river.

37. Four endangered fish species were found: *Anguilla bengalensis, Tor tor, Garra gotyla stenorhynchus, and Laguvia shawi.* In addition to fish, turtles, a few amphibians, and Ganges dolphins are also under Schedule-I endangered species.

C. Socioeconomic Environment

38. Key socioeconomic indicators of the subproject areas are shown in the Table 2.

Table 2: Socioeconomic Indicators of Subproject Reaches of Program

Indicator	Palasbari	Kaziranga	Dibrugarh
District	Kamrup	Golaghat	Dibrugarh
Project Area Investigated (ha) Benefit area (ha)	 88,850 62,150	 40,112 13,810	 27,970 25,140
Population	575,000	48,600	266,000
Population Density (persons/km²)	647	352	865
Average HH size	6.1	5.5	7.1
% of poor HHs	58%	32%	41%
Villages	333	119	134
SC Population (%)	8	12.5	5
ST Population (%)	10	23.5	6
Education Facility	Primary – 596 Middle – 172 Secondary – 68 Sr. Sec. – 7 College - 6	Primary – 215 Middle – 68 Secondary – 30 Sr. Secondary – 3 College – 2	Primary – 137 Middle – 46 Secondary – 16 Sr. Secondary – 0 College – 1

Indicator	Palasbari	Kaziranga	Dibrugarh
Industries	Small-scale household industries	Cane goods and furniture, tea, and bricks	Tea and Muga Cloth
Connectivity	Poor (mostly through unpaved roads)	Modest (73 villages have paved road connectivity)	Poor (29 villages have paved road connectivity)
Power Facility	243 villages (73%)	100 villages (84%)	125 villages (93%)
Drinking Water	Mainly through groundwater resources	Mainly through groundwater resources	Mainly through groundwater resources
Medical Facility	Limited – only primary health care facility is available	Primary health care facility along with allopathic hospitals in some villages	Primary health care facility along with allopathic hospitals in some villages

ha = hectare, HH = household, SC = scheduled caste , ST = scheduled tribe.
Source: Socio Economic Survey 2008, Water Resources Department, State Government of Assam.

39. **Land Use and Settlement.** The land use patterns for the three subproject areas are predominantly agricultural. Agriculture land accounts for 60% of the land for Palasbari, 64% for Kaziranga, and 60% for Dibrugarh. In Dibrugarh, a large-scale urban settlement exists, covering 6,300 ha (or 25% of the subproject area) and has an estimated population of 228,000. No archaeological sites will be affected in the subproject areas. For Palasbari, 58% of the population deals with agriculture, 6% industries, and 36% services. For Kaziranga, 49% deals with agriculture, 6% industries, and 45% services. For Dibrugarh, 17% deal with agriculture, 10% industries, and 73% services. As shown in Table 2, the percentage of the population that is poor is high in the subproject areas, ranging from 32% for Kaziranga to 58% for Palasbari.

40. **Land Productivity.** While all subproject areas have flood embankments protecting them from the Brahmaputra flooding, the reliability and effectiveness of the embankments are generally insufficient because of structural deterioration and ongoing riverbank erosion. However, the level of reliability varies by subproject, with Dibrugarh possibly considered more reliable than the other subprojects, which have had more frequent breaches of their embankments. As such, agriculture productivity is low with relatively frequent flood damage because of breaches of the embankments, tributary flooding, and local rainfall, or combinations of those factors. Cropping intensities in the subproject areas are low at 142% in Palasbari, 135% in Kaziranga, and 130% in Dibrugarh. Productivity is also low, with the yields of monsoon paddy, the predominant monsoon crop in all subproject areas, remaining 2.5 tons per ha in Palasbari, 3.1 tons per ha in Kaziranga and Dibrugarh. Fishery activities within the subproject areas are generally less developed, with community ponds and beels accounting for 3.6% of the protected area in Palasbari, 1.9% in Kaziranga, and 1.0% in Dibrugarh.

41. **FRERM Systems.** People in the area appreciate the measures implemented in response to their post-flood and riverbank erosion situation, which helped to sustain their livelihood. However the risk and uncertainty from flooding and erosion remains, severely affecting long-term development. Considerable areas are affected by flooding when embankments are breached. Poor post-flood drainage in the Dibrugarh subproject area also adversely affects people. The local communities believe that the major cause of their unrelenting flood and drainage problems is the unreliability of the deteriorated infrastructure. Other concerns raised include (i) the inadequate quality of embankment construction; (ii) delayed or nonpayment of land acquisition and resettlement for completed works; and (iii) the need for community participation in planning, implementation, and management. More support was also requested to tap the agriculture- and land-based development potential of the subproject areas.

42. Dibrugarh and Palasbari have a number of industrial and service sector estates and enterprises, whereas the Kaziranga subproject area is predominantly rural. In Dibrugarh, key

enterprises include tea (accounting for more than 50% of Indian production), oil, and timber. The city also serves as the education and health care hub of upper Assam. While Palasbari remains predominantly rural, its eastern part has important facilities such as an international airport, educational establishments, and information technology parks. Township areas with commercial centers and business estates are rapidly expanding, along with an increasingly large number of small and medium-sized enterprises.

43. **Water Transport and Navigation.** Water transport is an important means of travel for the people living in all of the subproject areas. Motorized and manually operated boats carry agricultural goods, including livestock, to other markets and bring commodities for the local population. The Inland Water Transport Authority (IWAI) of India is responsible for providing navigational infrastructure, developing and maintaining navigational channels, and regulating them. The Dhubri to Sadiya channel (890 km) on the Brahmaputra has been declared National Waterways No 2. IWAI is responsible for ensuring a "least available depth" of 2 m between Dhubri to Dibrugarh and 1 m between Dibrugarh to Sadiya. The channel has one fixed terminal at Guwahati, and eight floating terminals are being developed. In general, the water transport traffic is limited in all the subproject areas, except for the traffic of small-scale country boats carrying local passengers and goods.

IV. ALTERNATIVE ANALYSIS

44. **Alternatives.** Since the Program aims to sustain the functions of the existing flood embankment systems protecting a large number of people and landmass from frequent devastating flooding and riverbank erosion of the Brahmaputra River, the scope for assessing alternatives to the project is limited. The subprojects are also site specific. Therefore, the "without project" option was considered and compared against the "with project" option. In addition, an intermediate option of continuous or repeated embankment retirement in response to the progress of riverbank erosion was considered as another alternative, as opposed to providing riverbank protection works under the "with project" scenario.

45. **Without Project.** In the "without project" scenario, loss of land at rates between 34 ha per year at the Kaziranga subproject (1,020 ha in 30 years) and 103 ha per year at the Dibrugarh subproject (3,090 ha in 30 years) will continue because of riverbank erosion. For all the subprojects, but particularly Palasbari and Kaziranga, there is a risk that Brahmaputra channels may avulse into inland depression areas, creating a major new channel and affecting large areas of settlements and agricultural and other productive lands. The consequence is that the adjacent floodplains and wetlands would be flooded annually to a much larger extent than currently, reverting to their former function supporting aquatic life during the flood season. A larger number of people will become vulnerable to flood and riverbank erosion effects. Many people displaced from the eroded land may be forced to resettle on the flood embankments as landless squatters, or encroach into forest and public lands. Moreover, because of the increased annual flooding, the agriculture productivity of the currently protected areas will be reduced, although this may be slightly offset by higher capture fishery production during the monsoon. Floods also cause many linked socioeconomic and health problems. During the public consultations, most of the people considered riverbank erosion and flooding the major

threat to their livelihoods, causing severe social and economic hardships.[9] They sought to enhance the reliability of the existing FRERM infrastructure.[10]

46. **Repeated Embankment Retirement.** This option involves the continual retirement of embankments in response to riverbank erosion without riverbank protection. It includes land acquisition and resettlement. In this scenario, the loss of land is of the same scale as in the "without project" option, and the same number of people associated with the eroding land will be displaced. To the extent that the flood embankments can sustainably function without breaching, the risk of Brahmaputra avulsion can be contained, with the maintenance of present environmental and socioeconomic conditions within the present protected area. Nevertheless, there is always a risk of failure of flood embankments through sudden and unexpected riverbank erosion because of delays in embankment retirement, because of the lengthy time and procedures required to acquire the land and retire the embankments. During the public consultations, local stakeholders strongly favored the "with project" option of stabilizing the bank line with the riverbank protection works over this option. Their reasons included severe displacement impacts on affected people in riverine areas. In addition, the subproject areas do not have much land to resettle people displaced by the riverbank erosion.

47. **With Project.** In the "with project" scenario, riverbank protection measures will prevent the loss of eroding land in the subproject areas as specified in the "without project" option, while protecting the subproject area from the Brahmaputra flooding and channel shift with higher reliability. With the implementation of mitigation measures, the overall impact on the project is likely to be positive on the biological environment. Fish productivity and wetland conditions will remain the same or will improve, because of the placement of sluice gates to facilitate effective water exchange between the embankment and riverine areas. With more reliable and effective functioning of the existing FRERM infrastructure, agricultural production is likely to rise where farmers can increase the number of crops per year. More investment under a lower flood risk environment will facilitate higher yields. The Program will also provide better commuting opportunities to the people of the area through the paved road atop some embankments and protected land inside, which means shorter commuting time to reach the markets and education, health, and other facilities. Thus, the post-project scenario will enhance the economy of the area.

48. Under the "with project" option, assessments have been made between (i) active river training through spurs and guide bunds to control river channels, and (ii) passive riverbank stabilization along the naturally developed bank lines. The second option has been selected (except where existing spurs require rehabilitation) because of possible significant upstream and downstream morphological impacts associated with actively controlling the river channels as well as the possible high costs of maintenance. Within the stabilization option, various materials, such as quarried rock, concrete blocks, and sand-filled geotextile containers, have been analyzed for their cost-effectiveness and environmental suitability for use in riverbank protection work. The inert geotextile containers are generally preferred for riverbank protection works except where quarried rock is readily available with limited environmental implications for the collection sites. Geotextile is a very stable material used worldwide with semipermanent life far exceeding the project's economic life (30 years). Its use is considered favorable from the perspective of providing a living environment for aquatic fauna.

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[9] This is especially the case for the small and marginal farmers, whose continuously shrinking land is insufficient to feed their families throughout the year.

[10] In addition, the recent ADB publication (ADB. 2007. *Learning from the Poor: Findings from Participatory Poverty Assessment in India.* Manila) concludes that poor people prefer long-term solutions to short-term rehabilitation.

49. **Conclusion.** Based on the assessment of the available alternatives, the "with project" option is preferred for the local population. It is considered optimal, because its feasibility and sustainability during the project life and beyond can be ascertained. It will generate positive social, environmental, and economic impacts; negative impacts can be mitigated through appropriate safeguard measures as defined in the related subproject EIAs and the social safeguards assessments. The local stakeholders showed strong ownership through their willingness to participate in the planning, implementation, and post-implementation stages of the suggested interventions. Nevertheless, the embankment retirement option would need to be considered if other available options are not found to be feasible and sustainable from technical, morphological, economic, social, and environmental perspectives.

V. ANTICIPATED ENVIRONMENTAL IMPACT AND MITIGATION MEASURES

A. Physical Environment

1. Climate

50. **Design and Construction Phase.** Temperature may rise in the short-term in the immediate vicinity of the embankment because a large number of trees will be cut down. About 15,000 trees in Palasbari, 2,000 trees in Kaziranga, and 10,000 trees in Dibrugarh reaches are likely to be cut down. Maximum efforts have to be made to minimize the cutting of the trees while designing the embankments. Compensatory tree plantation will be undertaken, preferably on the basis of three trees planted for each tree cut.

51. **Operational Phase.** The proposed Program is not anticipated to have any impact on the climate. However, climate change (global warming) in the catchments area may play a significant role because of its implications on water resources and related environments. While the indications are diverse, one projection model[11] indicates an increase in precipitation for the North Eastern region as a result of a relatively moderate increase in temperature of about 2°C by 2041–2060. This could increase the incidence of flooding in the Brahmaputra basin over the long term. Monitoring of the extreme hydrological events requires special attention. Free board of 1.5 m is provided in the proposed design of the embankments to withstand floods of a return period of up to 100 years within the 30-year economic life of the Program. Specific attention must also be given to maintaining the feeder line inflow–outflow of water to wetland areas, with provision of sluice gates to be made in the embankment.

2. Hydrology and Morphology

52. No impact is envisaged during the design phase. The impacts associated with the construction of program components related to hydrology and morphology are addressed in the water quality (para.66), biological environment (paras. 68–71), land use and settlement (paras. 74–75), and soil compaction and contamination (para. 77)sections. The impacts in the operational phase on hydrology and morphology are summarized in paras. 53–65.

a. Flooding within Subproject Areas

53. The proposed structural flood protection works consist of renovating and retiring existing Brahmaputra dykes, and providing sluice gates in natural drainage courses. No new embankments are proposed along the Brahmaputra bank line. Hence, the proposed works will

[11] Global climate model Hadley General Circulation Model version 2.

have little effect on the current flooding behavior of the Brahmaputra River (apart from confirming the intended flooding behavior by eliminating breaches). The improved embankment systems will prevent inundation of the protected areas, and will reduce the risk of sudden devastating floods. This will have positive benefits in terms of protecting households, land, and people. Adequate provision for sluice gates will be made to leave natural drainage systems undisturbed. Adequate provision will also be made in designing embankments and sluice gates to withstand extreme meteorological and other geophysical events. Numerical hydraulic models will be developed for subproject areas to identify low-lying locations with a risk of deep inundation during major floods particularly through tributaries and internal rainfalls. The option of providing raised flood refuge platforms at appropriate locations in these areas will be explored. These platforms may be designed for multiple purposes, such as flood shelter, public meeting grounds, and schools.

b. Drainage within Subproject Areas

54. The existing embankment system along the Brahmaputra impedes natural drainage channels that previously drained into the Brahmaputra in several locations. The proposed embankment works will have no additional adverse impacts on current drainage conditions within the protected areas. Under the Program, additional sluice gates will be provided, and computer models will be used to investigate and define the optimal location, size, and methods of operation. These sluice gates will improve drainage within the protected areas. As a part of the computer investigation, preservation and/or improvement of the environmental flooding regime of the wetlands and beels within the protected area will be studied.

c. Wetlands and Beels

55. No additional embankments will be constructed as part of the Program. Thus, it will have no impact on wetlands and beels outside the embankments. For the wetlands and beels within the protected areas, the placement of sluice gates is expected to provide beneficial impacts by making possible the controlled exchange of water between the wetlands and/or beels and the river. In terms of potential adverse effects, with the more reliable FRERM systems in place, farmers might use more fertilizers and pesticides and grow more crops in the fields, which may affect wetland water quality and increase the tendency to eutrofy during the dry season. An integrated management strategy for wetlands and beels will be adopted for sustainable development of these resources, and to provide optimum benefits to the natural ecosystems and the population.

d. River Water Levels

56. Given the presence of the existing embankment systems and the enormous natural conveyance capacity of the Brahmaputra River, no discernible effect on river water levels is anticipated in any of the subproject areas. Changes in channel conveyance brought about by the existing natural processes of riverbank erosion, accretion, and channel avulsion will play a much greater role in any future changes in water levels. The reduced risk of sudden devastating floods through an improved embankment network will provide more predictable and stable water levels in the flood plains. Under the Program, changes in the cross section will be monitored regularly to detect any changes in the river profile.

e. Flow Velocity and Discharge Intensities

57. The proposed interventions are limited to bank line areas. As such, they will not have any effect on average cross-sectional flow velocities in the alluvial Brahmaputra River. Because the river is so wide, any near-bank velocity changes will be dissipated. The discharge and associated velocities in the Brahmaputra River undergo drastic changes seasonally because of the unique hydro-meteorological and geophysical characteristics of its basin. Any change in flow velocity and discharge intensity arising from these natural perturbations will far outweigh any minor perturbation that may be introduced as a result of the proposed activities on or near the riverbank. The flow will be monitored regularly using both field-based and remote sensing techniques.

f. River Morphology

58. The impact of the proposed flood protection measures (renovation of existing embankments along the Brahmaputra River and provision of sluice gates) is expected to be negligible, since they will not alter the existing channel flow patterns. On the other hand, the riverbank protection works will confirm and stabilize the present bank line. They will have significant positive impacts by protecting the productive agriculture and homestead land from progressive river erosion. However, the construction of riverbank protection measures leads to a river response, commonly deepening of the channel alongside the protection works in the case of revetments. This is a consequence of flow concentration and a reduction of sediment entrainment from eroding bank. The reduced sediment entrainment along the protected reach tends to encourage more stable channels along the concerned reach, as opposed to causing destabilizing impacts on the opposite banks area. Pro-siltation measures, such as the placement of porcupines, will lead to sedimentation of the immediate bank line. However, the impacts are generally limited to the intervention area and are not expected to alter the unstable pattern of constantly changing in-stream channel bars within the river area. Overall, the Program's approach of stabilizing the existing or naturally developing bank line through revetments and pro-siltation measures avoids causing artificial impacts on the downstream river reaches or the opposite char area.

59. The Program will not build new river training works or spurs. While existing spurs will be rehabilitated in the Palasbari and Dibrugarh subprojects, interventions will be limited to repairing local damage, which will not change their length or orientation. As the existing spurs are long established, limited rehabilitation will result in limited change in their impact on the dynamic river and char systems. In the subproject reaches of the Brahmaputra River, a number of channel bars or char lands are also used for seasonal cropping and other uses. Char lands in the immediate vicinity of the subproject sites do not have permanent settlements. The subproject interventions are not expected to alter the current pattern of constant changes of in-stream channel bar formation and deformation, although some localized and possibly insignificant impacts from the riverbank protection structures cannot be ruled out.

60. The Program envisages systematic annual planform analysis and prediction, including the analysis of the structural response to riverbank protection work. The analytical tools consist of (i) satellite-image-based, large-scale morphological analysis of Brahmaputra reaches; (ii) large-scale bathymetric surveys covering the near bank channel pattern, starting from several km upstream of the interventions and ending about 10 km downstream; and (iii) near-bank surveys, which provide a detailed picture of the structural performance and river response. In case unexpected morphological changes are detected that affect areas away from the subproject sites, these will be analyzed as part of the permanent monitoring program. This

monitoring will be carried out during implementation of the first tranche, and any findings and recommendations will be considered in the design of the second tranche. If any negative changes are found to originate from the structures implemented by the Program, an appropriate compensation program will be implemented.

g. Silt Deposition and Bed Level Change

61. The Brahmaputra River carries the second-highest sediment load of all major rivers in the world. While the riverbed is largely formed by the coarser sediments, especially sand and more upstream gravel largely mobilized during the high flood season, the floodplains are built from finer silts and clay. The latter constitute the wash load in the river, which is normally transported within the channels to the sea without settlement. Only after inundation of the floodplains and in areas without noticeable flow do the finer sediments settle. Part of this settlement has been cut off through the construction of embankments in many places since 1950s and 1960s when the embankments were constructed. The inhibited deposition of the fertile finer clay and silt requires the use of alternative fertilizing methods to maintain overall soil fertility.

62. Breaches in the embankments are problematic. These result in high velocities in the breach area, allowing the flowing water to transport coarser, infertile sand through the breached section. This sand gets deposited downstream where the area widens and the flow velocities drop. The resulting sand carpets are disastrous for the small and marginal farmers as they render the fertile floodplain land unusable and can only be removed at great cost. The bank stabilization and retirement of the embankment system will reduce the risk of embankment breaches and the associated deposition of infertile land in the area of the breach. This will help in supporting agriculture and livelihood of the dominant small and marginal farmers. In general, about 35.5% of the land within an 8 km buffer behind the embankments is used for agriculture. The dynamic pattern of silt deposition in the river and areas adjacent to the bank, especially in the vicinity of riverbank protection works, will be monitored regularly to contribute to the knowledge base and understanding of the Brahmaputra morphology. Corrective measures will be initiated, under existing project provisions, if required.

h. Impacts of Development Works in Upstream Catchments

63. A large number of hydroelectric projects (57 as of February 2008 with a total generation capacity of 15,000 MW) are being investigated, and some are being constructed, in the upstream catchments of the Brahmaputra basin. These projects are expected to affect tributary flood behavior in the subproject areas.[12] The upstream dams, albeit mostly run-of-the-river schemes, would reduce flood peaks, while acting as sediment traps that will reduce the outflow of sediments to the Brahmaputra (at least until the reservoirs fill with sediment).[13] Likewise, better watershed management practices in upstream catchment areas will help reduce flood peaks and sediment transport over the long term, but the reduction in the peak discharge of major floods is expected to be insignificant. The effect of a reduction in sediment inflows on the Brahmaputra main stream channel cross sections and flood behavior is difficult to predict. However, it is likely to lead to a reduction in flood levels and aggradation, because a lower sediment load assists the development of a more stable channel pattern, with deeper channels characterized by higher conveyance. Systematic monitoring and analysis of hydrological and geomorphological parameters will help identify measures that may have to be considered to

[12] A dam across the main stem of the Brahmaputra is considered unlikely, at least in the near term.
[13] An effective information network needs to be set up to inform the local population about the sudden changes in discharge volumes in advance, to cope with abrupt water level rise in the tributaries.

adapt to unexpected changes over the longer term. The Program will also promote holistic catchment management through state-wide planning and coordinated implementation.

i. Impacts of Dynamic Natural Morphological Changes

64. Given the dynamic morphological process of the Brahmaputra River, reaches upstream and downstream of the proposed subproject works may continue to erode, and this may start to affect the protection structures. In particular, upstream erosion may outflank the bank protection works. This risk appears relatively low for the Palasbari subproject, where the protected bank line extends from the natural nodal point (narrowing of the river due to erosion-resistant bank materials). While the other two subproject areas do not have nodal points immediately upstream,[14] severe active erosion is going on at Dibrugarh in the upstream reaches associated with the avulsion of the Brahmaputra to the south of the Dibru Saikhowa Reserve Forest. This may start to affect the subproject areas over the medium term. To mitigate this risk, the Program will systematically monitor the morphological process and develop short-term prediction models based on which critical risks will be identified and mitigation measures provided. The Program will also adopt an adaptive approach, i.e., provide riverbank protection works at the right place at the right moment with substantial contingencies to cope with the unpredictable morphological and hydrological events. The capacities of the WRD will also be strengthened to detect any future changes with the use of erosion-prediction models, and the necessary resources will be mobilized to cope with the outflanking risk of protection works.

j. Cumulative Impacts of Subprojects

65. The additive impacts of the three subprojects on the hydrology and morphology of the Brahmaputra River is considered minimal for the following reasons:

(i) The subprojects will renovate the existing flood embankments that have been functional since their construction in the 1950s and 1960s (thereby reducing the risk of flooding, but not necessarily changing the flood regime).
(ii) The benefit area of the subprojects–focused on strategically important area–account for less than 3% of Assam's total flood-prone areas.
(iii) The total volume of flood flow would remain the same.
(iv) Water quality may be affected, but this would be limited to the vicinity of the construction sites during the construction period.
(v) The Program's approach to riverbank protection is also to stabilize the bank line along the naturally developing alignment, and as such any external impacts are anticipated to be localized.

3. Water Quality

66. While the quality of surface water and groundwater is not expected to be affected by the subprojects, construction camps may affect the quality. Septic tanks must be provided in each camp to treat the domestic sewage. The provision of mobile toilets should also be considered so that the sewage can be channeled to a septic tank in a closed-loop system. Adequate facilities should also be provided to the flood shelter platforms when they are constructed under the community-based FRERM.

4. Air and Noise Environment

[14] Bogibeel Bridge, built downstream of the Dibrugarh subproject, could be considered a nodal point. However, it is necessary to monitor how the river would react to this major interference.

67. During construction, air pollution will be mainly from fugitive dust emissions, movement of vehicles and machinery, and hot mix plants. The hot mix plants should be located away from populated areas and fitted with air pollution control devices. Dust emissions from the crusher and vibrating screen of the stone quarries should not exceed the national standards for permissible noise level in residential areas. Emission from these crushers will be reduced through water suppression, establishment of wind-breaking walls around the crusher, vibratory screens, and stockpiling areas; and by adopting clean practices. Vehicles delivering loose and fine materials, such as sand and fine aggregates, will be covered to reduce spills on the road. Water will be sprayed regularly on earthworks. The general noise levels during construction, such as that generated by heavy earth moving equipment and machinery installation, may reach 100 decibel (dBA) or more at the work sites. While manual labor and limited use of machinery are preferred, care will be provided during the selection of construction machine installation and workers camps, and the scheduling and timing of construction works near larger settlements, places of worship, and education facilities. Construction equipment will be fitted with silencers and stationary equipment will be placed in uninhabited areas. Construction workers will be provided with earplugs or earmuffs. The average equivalent noise level at the construction site is expected to be 80–85 dBA, which will dissipate to about 55 dBA at a distance of 100 m. These sites will be set up at least 1 km away from inhabited or sensitive areas, resulting in no impact in these areas.

B. Biological Environment

1. Disturbance to Vegetation

68. A substantial number of trees will need to be cut along the subproject reaches in association with embankment renovation, retirement, and extension. Three trees will be planted for every tree cut. The plantation program should be initiated in parallel with construction activity. The native and existing vegetation profile must be maintained during the plantation program to allow local inhabitants to utilize their resources. During the operational phase, while no impact is anticipated, a tree survivability audit will be conducted.

2. Migratory Route, Habitat Destruction, and Endangered Species

69. The Palasbari and Dibrugarh reach areas do not have any migratory routes of wildlife species, indicating no impact on animal distribution. In Kaziranga, the subproject site is adjacent to the KNP. The Kaziranga reach is upstream from the KNP, and the areas close to the KNP boundary are ecologically sensitive. KNP is the most significant natural habitat of the one-horned rhinoceros and a host of other precious wildlife. However, the proposed works are not expected to harm its biological resources, since they will be implemented outside the KNP area. Any civil works planned along the KNP border will be mostly of minor earth and related works implemented with the involvement of local labor. These can be implemented without affecting the natural habitat of the wildlife, subject to application of due mitigation measures such as avoidance of construction camps along the border area, particularly near the wallowing site of the rhinoceros, wild buffalo, and other protected species of KNP. The KNP's hydrological environment, including wetlands and water courses, will remain the same—receiving annual flooding from the unprotected bank line within KNP. A positive impact is expected from the prevention of abrupt intrusion of floodwater through a natural depression that originates from an embankment breach in the subproject area. The impacts of riverbank protection works in the Kaziranga subproject on morphology of KNP area are also considered negligible (para. 58).

70. As to endangered species, river dolphins are found or recorded in all subproject areas, particularly near the confluence of tributaries and deep water channels. Two breeding sites were found in the Palasbari subproject area (Appendix 5). Both are near the sites for riverbank protection envisaged during the second tranche of the Program, but not within the sections of the revetment works. These are considered part of the dolphins' wide habitat, stretching to deep water channels across the Brahmaputra River. Nevertheless, to avoid any negative impacts on the river dolphins, construction works will be avoided during the breeding period (May–August), particularly near the identified breeding sites. In addition, care will be taken to ensure that construction waste and other pollutants do not end up in the water in this area.[15] After construction, few impacts are anticipated for their natural habitat. Within the three subproject areas, while several endangered species (mammalian fauna, reptilian fauna, and avian faunas) have also been recorded, no endemic wildlife species were found—except in Kaziranaga subproject where two endemic avian fauna and two endemic mammalian fauna have been spotted. Nevertheless, their habitats are not likely to be affected by subproject works.[16]

3. Effect on Fisheries, and Fish Spawning and Breeding Grounds

71. During construction of the revetment works and placement of pro-siltation flow retarding screens, fish species may be temporarily flushed towards the deeper part of the river. Construction may also increase the turbidity on the bank temporarily, although fish species are accustomed to this and little impact is expected. Likewise, the rehabilitation of spurs will not affect fish activity in the river. In general, the subproject reaches have few breeding and spawning grounds for fish. However, two locations have been identified in Palasbari site (coinciding with the dolphin breeding sites) and one in the Dibrugarh subproject site (Appendix 5). Given that the breeding season for almost 80% of fish species starts in April and ends in August (i.e., during the pre-monsoon and monsoon seasons), construction will be restricted during this period at the concerned breeding and spawning sites. Provision will be made to increase the fish productivity of wetlands, beels, and fish ponds substantially. After the construction phase, few impacts are anticipated for the natural habitat of fish species.

C. Human and Socioeconomic Environment

1. Land Acquisition and Resettlement

72. The Program will involve (i) 32.9 km of renovation (for all subproject areas) and 4.9 km of retirement (for the Palasbari subproject area) of existing embankments, (ii) 4.7 km of new inner embankment extension (for the Kaziranga subproject area), (iii) 7 sluice gates under embankments across natural drainage channels, (iv) 33.8 km of revetment and pro-siltation measures, and (v) rehabilitation of 7 spurs (in Dibrugarh) and 3 boulder deflectors (in Palasbari). Some of these structures, particularly embankment retirement and extension, will require strip land acquisition and resettlement of the landowners, formal and informal tenants, and squatters. Under the Program, the resettlement activities will be implemented in accordance with

[15] The river dolphins usually breed in deep water channels. They sometimes come near the bank, particularly to the breeding sites during the monsoon period. Its offspring also go back to deep water channels as water recedes. Construction camps will be located away from these breeding sites.

[16] While few endangered, endemic and vulnerable avian and mammalian fauna have been spotted in the Kaziranga reach and recorded in other subproject reaches, none of these have habitats around the project work site. Since these animals roam in a much wider area, little impact is anticipated on these species during construction as they usually stay away from the construction sites. No impact is anticipated during the operational stage of any of the subprojects.

applicable laws and regulations of the Government of India and the state government of Assam, as well as ADB's Involuntary Resettlement Policy (1995). A resettlement framework and indigenous peoples development framework were prepared to cover the subproject area. The scope of these frameworks will be finalized following the detailed design and before the tendering of the concerned infrastructure works. A resettlement plan, including for the 4.7 km extension embankment for the Kaziranga subproject, has also been prepared. This includes the livelihood enhancement of the concerned indigenous people affected.[17] Experienced consultants and nongovernment organizations (NGOs) will be recruited to assist with the preparation and implementation of the resettlement plan and indigenous peoples development plan, as required.

73. The existing embankment systems have provided substantial benefits to the local communities by protecting them from loss of crops, assets, and displacement. However, some people affected by land acquisition when those embankments were constructed have not received compensation as required by the Assam Land (Requisition and Acquisition) Act, 1964. Compensation remained an outstanding issue for these households. In the Dibrugarh subproject, 81 cases are pending from 1972 to 2003; in the Palasbari subproject 8 major land acquisition cases are pending from 1984 to 2000. The WRD is addressing these land acquisition cases in the context of preparing the subproject proposal under the Program.[18]

2. Land Use and Settlements

74. **Design and Construction Phase.** For retirement and renovation of the embankment, substantial earth will be needed. The earth will be provided by excavating borrow pits in the vicinity of the river embankment in the Palasbari and Kaziranga reaches. For the Dibrugarh reach, it needs to be taken from lands away from the embankment. Access to the construction sites is mostly through the single-lane, rural roads (paved and unpaved) except at Dibrugarh, where the road could require strengthening to sustain heavy trucks. In addition, construction camps are likely to be located about 10–15 km apart and close to the embankment, which will temporarily change the land use of the area and possibly put stress on the local population. Since the impact zone covers productive land, the diversion of land will be minimized by avoiding the use of cultivable lands for embankment, camp, and access and haulage for road construction. The construction camp sites will be made reusable and/or cultivable after closure. Use of local labor will be prioritized to avoid stress on local residents. No construction debris will be deposited on agricultural land. Loss of land or crops for construction camps will be compensated.

75. The Program will also require a significant amount of construction materials. Illegal quarrying may lead to changes in land use, and air and noise pollution. The aggregate demand for construction of river embankment with paved roads on the top in the subproject reaches will be met by the operating quarries located outside the subproject areas in each reach and approved by State Pollution Control Board (SPCB). Sand to be used to fill in geotextile containers is mined from the riverbed. Setting up of stone crushers, if required, will be done only after obtaining the consent of SPCB and taking adequate measures to control air and noise pollution.

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[17] In general, the scope of land requirement for other structures needs to be defined upon stabilization of the bank line through riverbank protection works.

[18] Under the resettlement framework of the Program, due diligence would be undertaken at the time of preparing the resettlement plan for the concerned infrastructure to assess if any embankment section has outstanding grievances from any past acquisition. Any identified grievances will be included in the resettlement plan and addressed before launching the subproject works.

76. **Operational Phase.** Encroachment on embankment for habitation and cultivation purposes may affect embankment stability. Villagers living nearby also sometimes cut embankment to create approach paths to the riverine front for toileting, cattle grazing, and farming. Borrow pits where soil is taken for construction and resectioning of embankments may cause income loss of concerned landowners, accidental hazards such as falling of vulnerable people, and landscape deterioration, unless properly rehabilitated. To mitigate these impacts, the embankment design will provide for access to the riverbank close to the settlement areas. Where possible, platforms will be attached to the embankments to provide space for possible squatters, with regular monitoring and guidance so that encroachers will not affect the integrity of the embankment. The contractors must ensure rehabilitation of borrow pit areas before handing over the subprojects.

3. Soil Compaction and Contamination

77. Soil around the construction site, haulage road, construction camp, and workshop will get compacted because of the transportation of machines and materials. Agricultural yields may decline substantially because of soil compaction. Soil may also get contaminated around construction sites, machine maintenance areas, fueling stations, construction camps, hot mix plant sites, and haulage roads. The movement of construction vehicles, machinery, and equipment will be restricted to the embankment sites and pre-defined haulage road. Adequate provision for approach roads will be made to avoid damaging existing village roads, crop lands, and settlement areas. Construction waste shall be disposed of in the properly delineated places approved by the State Pollution Control Board. .

4. Water Supply and Sanitation

78. Local people depend on groundwater to meet their drinking water needs. Sanitation facilities are poor, and people go to the riverbank to meet their daily needs, often damaging the embankments. Polluted water is also discharged from nearby villages to the surface water bodies. Access steps will be provided on the embankments near the habitat areas for the upkeep of the embankments. To preserve the water environment, awareness programs will be provided to villagers through the participatory organizations set up under the Program on sanitation, wastewater, and solid waste management, and use of fertilizers and pesticides.

5. Boat Transport and Navigation

79. People navigate the river to move from one place to another location on the riverbank, and to move to char lands for fishing and/or farming. Larger vessel transport is limited. They use small motor boats and fish landing sites or boat ghats for these movements. Each of the subproject areas has various fish landing sites. These landing sites and/or boat ghats could be disturbed by subproject activities. However, the navigability of the river will not be affected because subproject activities will be limited to the riverbank and beyond. Provision is made in the project design to provide alternate landing sites and/or boat ghats with requisite sanitation and berthing facilities, as well as easy access to these sites. The completed riverbank protection work will incorporate steps for easier access to the water and from boats to the shore.

6. Accidents and Safety

80. While the risks associated with the Program are small, efforts will be made to avoid the creation of any hazardous traffic conditions on the narrow roads by construction vehicle movement. Adequate signage in the local language will be provided at the construction sites to

prevent local people from entering the construction area and getting hurt. The workers will be provided with necessary personal protective equipment and a first aid unit, including an adequate supply of dressing materials, transport means, and nursing staff. The executing agency (EA) will also carry out HIV/AIDS awareness programs for workers and disseminate information at worksites as part of health and safety measures for those employed during construction.

VI. ECONOMIC ASSESSMENT

81. The project preparatory study for the Program undertook an economic assessment of the three subproject areas as a part of the feasibility assessments. Returns on project investments were evaluated over the economic life of 30 years, including the implementation period of 7 years. The estimated economic internal rates of return (EIRRs) are 15% for Kaziranga, 18% for Palasbari, and 20% for Dibrugarh. Key quantified economic benefits include (i) reduced loss of land caused by riverbank erosion; (ii) reduced annual flood damage (to agriculture, industries, urban and settlement buildings, public infrastructure, and fisheries) caused by the Brahmaputra River floods; and (iii) modestly higher agriculture productivity, which is expected to be induced by reducing the risk of flood and riverbank erosion. Unquantified benefits include indirect benefits such as follow-on impacts on nonfarm sectors associated with reduced flood damage and higher agriculture production, and more urban and industrial activities associated with reduced flood and erosion risks. Positive impacts are also anticipated on the quality of life, such as better access to education and health facilities with increased affordability. The sensitivity assessment of the EIRRs indicated the need for timely project completion. More than 2 years of implementation delay would reduce the EIRRs by 0.5%–0.7%. Sustainability and appropriate functioning of the FRERM infrastructure is also important to ensure the envisaged benefits.

82. In the individual EIAs, the financial value of negative environmental impacts and their mitigation costs for each subproject have been compared with the direct benefits delivered by the subproject interventions. Negative impacts evaluated include the cutting of trees, whereas mitigation costs include those associated with tree plantation; fisheries (development cost); and water, air pollution, and noise management. These were compared with the benefits of maintaining agriculture production in the eroded land, plantation, and fisheries, which has indicated significant positive value for all subproject areas.

Table 3: Summary of Cost–Benefits Analysis (in Rs million)

Issue	Impact Cost (I)	Mitigation Cost (M)	Benefits (B)	Net Benefit N=B-(I+M)
Erosion	—	—	208.2	208.2
Plantation	75.6	4.4	178.9	98.9
Fisheries	—	4.2	11.5	7.3
Air, Water, and Noise Pollution	—	4.5	—	(-) 4.5
Total	**75.6**	**13.1**	**398.6**	**(+) 309.9**

Source: Water Resources Department, State Government of Assam.

VII. ENVIRONMENTAL MANAGEMENT PLAN

A. Environmental Management Plan and Monitoring Plan

83. The environmental management plan (EMP) aims to ensure that adverse impacts of the Program are prevented or properly mitigated. The EMP consists of a set of mitigation, monitoring, and institutional measures to be taken in a time-bound manner during the design, construction, and operation of the Program. The EMP identifies the parties responsible for implementing each action. The EMP developed for the subprojects is in Appendix 6. The implementation schedule for the EMP is in Appendix 7.

84. As a part of the EMP, an environmental monitoring plan (EMOP) has also been prepared to cover the various components of the environment that may be affected by the Program, including hydrology and morphology, drainage, wildlife, fisheries, cropping pattern, soil erosion, tree plantation and survivability, air quality, water quality, and noise and vibration (Appendix 8). The EMOP is subject to change depending on the analysis results obtained.

85. Small works to enhance flood risk mitigation will be defined in consultation with the local stakeholders during the preparation of the community FRERM, and thus were not covered under the EIAs. To assess the environmental impacts and arrange for the required mitigation measures, an environmental assessment and review framework (EARF) is developed as a supplementary appendix. The EARF covers the following aspects:

(i) environmental policy and regulatory framework for subproject selection,
(ii) environmental criteria for small works selection,
(iii) environmental assessment requirements,
(iv) responsibilities of the EA and ADB,
(v) compliance with ADB's Environmental Policy (2002) due diligence,
(vi) public disclosure, and
(vii) institutional arrangement for implementing the EARF.

B. Contingency Response Plan

86. Field study, public consultations, and consultants' experience suggest that the Program may experience several types of emergencies during implementation. First, an embankment may breach in a subproject area because of riverbank erosion, overtopping, or structural failure. Local communities are well practiced in dealing with such emergencies. The Program will build on the communities’ practical experience in developing community-based FRERM plans that include a contingency response. Part of this planning process will include improvements to local warning systems to maximize the available response time, and preparation of evacuation plans. In addition, efforts will be made to focus and strengthen the effectiveness of the emergency response by authorities to these circumstances. Riverbank erosion will be monitored over the course of the Program, and the possibility of an associated embankment breach will be identified. Where required, preventive and corrective action will be initiated, including warning people likely to be affected of the need to evacuate. Second, a spill of toxic or polluting material during construction operations is a possibility. The local people will be informed about likely accidental spills and the appropriate response. The program authorities will ensure accidental spill management either by developing in-house capabilities or by associating with a competent third party.

C. Implementation Responsibilities for the EMP

87. The responsibilities for the implementation of the EMP and EMOP will be tiered based on the activity. All the policy decisions, including incorporation of the EMP requirements, will be the responsibility of the Assam Integrated Flood and Riverbank Erosion Risk Management Agency. This is proposed to be established as an EA registered under the Societies Registration Act, with representation of the WRD, the Department of Revenue and Disaster Management, and other line departments and stakeholders. Its program management unit (PMU) will have a social and environmental unit, including a senior environment officer who will ensure that the environmental mitigation actions are implemented according to the contract documents and the EMP. Consultants for institutional strengthening and project management, including international and national environment specialists, will provide assistance. In each subproject, a subproject implementation office (SIO) will be set up comprising a technical team and disaster risk management and coordination team. The latter will have an environment officer who will oversee EMP implementation and be responsible for timely monitoring of various parameters and compliance with the proposed mitigation measures. The environment officer will ensure that the SIO is able to effectively oversee the implementation of the EMPs and monitor their progress. A resultant database will be included in the program management information systems for effective flow of information between various levels and functions. The EA will prepare and submit a semiannual environmental monitoring report to the state government of Assam, the Government of India, and ADB in an agreed format that covers the compliance and status of the EMP.

D. Mechanisms for Feedback and Adjustment

88. The SIO environment officer, with the help of contractors, will submit quarterly progress reports to the PMO senior environment officer on the implementation status of the EMPs as well as environmental quality monitoring results, including problems that have been identified and mitigation measures taken. Any deviation from the contract requirements with respect to the proposed EMP will be corrected within 2 weeks and records will be maintained for the same period. The SIO environment officer will also gather and maintain information on any damage or public concern that may be raised by the local people, local authorities, and NGOs. While immediate solutions are to be worked out with the help of the contractors and under the guidance of the PMU senior environment officer, a detailed report will be submitted to the PMU senior environment officer for consideration in the PMU. Resulting decisions will be communicated back to the SIO and contractors for correction and future implementation.

E. Institutional Capacity

89. The WRD does not have an environment office, and needs to be strengthened with respect to environmental management. Under the Program, a senior environment officer will be engaged in the PMU from the market or designated from the Department of Environment and Forest, along with the assignment of a WRD engineer as environment officer with training. An environment officer will be assigned in each SIO to coordinate site-level environmental activities. The senior environment officer will report to the PMU program director, while field environment officers will report to the PMU senior environment officer. They will be assisted by subject matter experts (EIA, hydrology, morphology, wildlife, fisheries, horticulture, and agriculture) who will be hired as needed. The field officer will also have laboratory support. SIO environment officers will support the preparation of initial environmental examinations for the community-based flood risk management activities following the EARF included in the supplementary appendix. The overall process and requisite capacity development are also

supported by a team of institutional strengthening and project management consultants, including international and national environment specialists. To enhance the capacity of the WRD officials for effective implementation of the mitigation measures and monitoring the resultant effect, environmental training programs will be provided as part of the Program (Appendix 9).

F. Mitigation, Monitoring and Institution Strengthening Cost

90. The mitigation cost, including monitoring cost and training during the life cycle of the Program (construction and operations phases) is estimated at Rs77.9 million ($1.65 million) for all three subprojects (Appendix 10). The mitigation cost including monitoring is estimated at Rs57.9 million during the construction phase and Rs5.5 million in operational phase. Institutional support for fisheries is also included. The cost of establishment and training are estimated at Rs7.5 million and contingencies at Rs7.0 million. These costs are included as part of the total cost and will be secured during the implementation stage.

VIII. PUBLIC CONSULTATION AND DISCLOSURE

91. The WRD and the consultants organized public consultations between December 2007 and April 2008 with stakeholders including government officials, local people, and civil society organizations to understand their concerns, apprehensions, and opinions.[19] Informal meetings and interviews were organized covering all subproject reaches. The stakeholders were provided with a brief and simplified project outline in their native language and accompanied by an administration of project perception questionnaire. Discussions during the consultations focused on (i) environmental problems as a result of flood and erosion of the Brahmaputra River; (ii) program benefits, particularly safety from flood and erosion; (iii) negative impacts of the Program during the different stages; and (iv) possible impacts on livelihood, wetlands, drinking water, and the local economy. Impacts on flora and fauna were raised and discussed with the forestry officers. Substantial discussions were also devoted to the acceptability of the proposed mitigation measures, and the issues of tree cutting, the impact on the physical environment, disturbances of fishing activities and fish productivity, and productivity of beels in the study area.

92. The consultations were accompanied by socioeconomic and poverty surveys, organized in 37 villages in Palasbari (of 339), 16 in Kaziranga (of 119), and 19 in Dibrugarh (of 134). The surveys were conducted in two urban wards in Dibrugarh as well. A number of focus group meetings were organized with the most vulnerable groups, including landless poor, women, indigenous peoples, fishers, and scheduled castes. The WRD also organized state-level workshops in December 2007, June 2008, and February 2009 to present the findings of the project preparatory studies, including findings of the environmental assessment, which were followed by press briefings.[20] The outcomes of the public consultations were used for the impact assessment and design of mitigation measures.

93. Participants' views on the effect of flood and erosion were gathered with special regard to environmental degradation, loss of productive land, fish productivity, soil productivity, and flora and fauna (particularly on dolphins and the KNP). Their views were also gathered with

[19] Organizations included the Forest and Environment Department, Assam Science Technology and Environmental Council, Department of Soil Conservation, Department of Charland Development, municipal authorities, Water Resources Department, Pollution Control Board, and NGOs and research institutions working in this area.

[20] The presentation materials by the consultants and WRD, along with the executive summaries of the consultant findings, were posted on the following ADB website: http://www.adb.org/projects/project.asp?id=38412.

regard to possible impacts of the Program on agriculture, wetlands and/or beel productivity, protected areas, animal movement, drainage, drinking water facilities, protection from flood and riverbank erosion, and the local economy. Almost all of the local stakeholders consulted were supportive of the Program and expressed their belief that it will help provide the much-needed protection against the recurrent ravages of erosion and floods, and bring prosperity to the region. Villagers were supportive based on the substantial economic benefit they anticipate, particularly because of the likely increase in agriculture produce and fish productivity. The local people did not perceive any adverse impact from the proposed Program. The potential affected people repeatedly stated their resettlement and compensation worries, noting that the compensation for the past land acquisition has still not been provided, which will be addressed under the Program (as shown in para. 73.) A temporary increase in air and noise pollution from induced traffic and construction activities was of the least concern to them.

94. Local NGOs consulted also generally welcomed the Program, and said that it would help protect agricultural land, domestic animals, and fishing communities. Nevertheless, NGOs and experts in local research organizations also emphasized the need to ensure the effectiveness of the various institutions and their program delivery mechanisms to implement structural and nonstructural measures. Based on past performance, some experts noted the high risk and expressed doubts about attaining these intended functions. The capacities and willingness of the subproject organizations to adopt a people-centered approach, as suggested by the Program, also remain constraints. Other useful advice included (i) the need for preventing any change to natural drainage; (ii) the livelihood implications for the poor, including those who reside outside the embankments; (iii) the provision of platforms at different locations of flood-prone areas for use by people and animals; (iv) the protection of the fish spawning grounds during construction; (v) an assessment of the wider implications, such as the impact of global climate change and upstream hydropower development; (vi) the need for sound database and knowledge base development, building on the existing bases owned by different central and state organizations; (vii) effective quality control and sustainability assurance measures; (viii) better understanding of the performance and lessons of FRERM, including its hydrological, morphological, environmental, and social implications; and (ix) sufficient disclosure of program planning and implementation documents. The program implementation arrangements have incorporated measures to address these recommendations, including the establishiment of a multidisciplinary Agency with stable leadership and high-level scrutinization by the state government of its organizational performance. Local DMOs will be involved in program implementation and decision-making processes, and the program delivery organizations will be held accountable to them.

95. Future public consultations are also envisaged during program preparation and processing, as well as in the implementation stage. The EMP provides for monitoring the effectiveness of the mitigation measures proposed, gathering feedback from the public and NGOs, and taking corrective actions. Provision has also been made for regular information dissemination and an awareness program during the construction and operations phases. The specific environmental impacts observed, mitigation measures adopted, and the prospects for impacts on further structural works will also be consulted and reported at the time of the processing of the second tranche of the Program.

IX. CONCLUSIONS

96. The Program will generate various impacts on the environmental setting of the area. No significant negative impacts are anticipated. Impacts are not anticipated on endangered

species such as the river dolphin along the three subproject areas. While the dolphins can be seen in the Brahmaputra River, particularly at the tributary confluence and deep channels, impacts can be avoided by ensuring that construction does not occur during the breeding season (between April and August) near the identified breeding areas. Efforts should also be made to ensure that construction waste does not end up in the water and channels are not obstructed. Likewise, the impacts of program activities on the one-horned rhinoceros and other protected animals in the KNP can also be avoided. No activities are envisaged within the KNP area, and all works along the border areas are minor and involve mostly earth works by local workers. No construction camps will be located near the KNP border, particularly in the vicinity of the wallowing site of the wildlife in the KNP. Furthermore, care will be taken that construction will not obstruct the breeding period (April–August) in the fish breeding sites and that construction waste will not enter the river water there.

97. External negative impacts on river hydrology, morphology, and sediment transport are anticipated to be insignificant because of the nature of the Program to support the strengthening of the existing embankment systems to maintain their intended design functions. They will formalize the flooding behavior that has persisted since these embankments were constructed in mid-1950s to early 1960s. Riverbank protection measures—with their focus on revetments and pro-siltation measures along the naturally developing bank lines in an adaptive manner—will not alter the existing dynamic channel formation pattern of the Brahmaputra morphology. Nevertheless, river hydrology, morphology, and sediment transport will be systematically monitored under the Program. Mitigation measures will be provided if any unexpected effects caused by a subproject are observed. To this end, the Program takes an adaptive approach with substantial contingencies to respond to river changes.

98. The subproject areas may be affected by the impacts of climate change and other external events, including major earthquakes and upstream development works such as hydropower development. While the impacts of these events may extend the economic life of the subproject investments (30 years), one study indicates that increased precipitation is one possible climate change impact in the North Eastern region by 2040–2060, although opinions vary. A large earthquake (and landslides) may exacerbate the sediment loads of the Brahmaputra, whereas the hydropower dams upstream may reduce the sediment inflow and flood peaks. Systematic monitoring of the river dynamics, which will be strengthened under the Program, will facilitate the identification and implementation of necessary measures to adapt to any emerging changes in the construction and post-construction phases of the subprojects.[21]

99. During the construction phase, a number of trees along the embankment are likely to be cut. If the compensatory afforestation plans are implemented effectively and survival rates are monitored and sustained, the result will be positive. Program activities are likely to generate other adverse environmental impacts during construction, but these will be temporary. Implementation of the prescribed mitigation measures including the environmental management and monitoring plans will minimize the adverse and minor impacts.

100. In view of the strong and almost unanimous support by the local population in the subproject areas, and subject to the further confirmation of the economic feasibility and sustainability, the subproject interventions are recommended for implementation, along with the implementation of the EMP and EMOP. This should follow the participatory and integrated implementation arrangements and should include strengthening of the relevant institutions and

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[21] The nonstructural component of the Program will also pursue establishment of warning systems in case of sudden changes in discharge volumes.

capacities. However, in proceeding with the implementation of the Program, the following measures will also be considered:

(i) The EIA was carried out following the basic designs of the structure works during the feasibility study stage. Any major changes during the detailed design stage, or any major additional work other than the proposed program activities, will require updating the EIA. The additional assessment will be submitted to government authorities and ADB for clearance before civil works start. The EA will also submit the detailed engineering designs to ADB, which will review and examine whether major changes or major additional works have been included.

(ii) The WRD has limited capacity to address the environmental measures in house. As such, the institutional capacity of the WRD needs to be enhanced with regard to environmental training, monitoring infrastructure, and environmental guidelines. Adequate training will be imparted as proposed under the EMP to increase its capability. Environmental guidelines focused on effective implementation of mitigation measures will also be developed under the Program. Performance indicators will be developed as part of these guidelines to monitor and assess the effectiveness of the mitigation measures.

(iii) An awareness program for a wider public need will be launched for flood embankment renovation and riverbank protection works, as well as conservation of the natural environment and sanitation during the construction and operations phases of the Program. The awareness program will be provided through the participatory local disaster management committees to be established under the Program.

PROGRAM COMPONENTS

1. The specific components included in the Assam Integrated Flood and Riverbank Erosion Risk Management Investment Program are as follows:

Component 1: Institutional and Knowledge-Base Development

(i) Policy and strategic planning framework: (a) consultations towards finalizing a state water policy and steps for initiating implementation; and (b) long-term state flood and riverbank erosion risk management (FRERM) plan (building on existing plans, with integration to wider watershed issues).

(ii) Database and knowledge-base (linking with central and state institutions): (a) database on hydrology, morphology, sediment transport, and topography; (b) tools including flood-risk mapping and short-term erosion prediction system; (c) strengthened of flood warning system; and (d) monitoring and evaluation, and research and development system.

(iii) Institutional strengthening for integrated FRERM: (a) institutional development actions for the Water Resources Department and line departments; (b) improved guidelines and manuals including nonstructural measures, (c) FRERM infrastructure asset management information system, and (d) comprehensive capacity development.

(iv) Regional knowledge and networking: (a) international networks for FRERM and disaster risk management, (b) knowledge exchange.

Component 2: Operationalizing Integrated FRERM in Selected Subproject Sites

(i) FRERM structural measures: (a) upgraded embankments with assured maintenance (with extended platforms as appropriate); (b) systematic riverbank protection exploring cost-effective, adaptive, and sustainable alternatives; and (c) associated infrastructure (e.g., drainage sluices, canals).

(ii) FRERM nonstructural measures: (a) flood and erosion risk mapping; (b) improved warning systems; (c) participatory flood emergency response system; and (d) other flood adaptation measures (e.g., adaptive cropping, fish culture).

(iii) Community-based risk management: (a) participatory systems integrated with local disaster management committees; (b) community FRERM plans; and (c) plan implementation such as community awareness, flood shelters, and associated flood coping and development programs, e.g., adaptive cropping, fisheries, and livelihoods

(iv) Sustainable FRERM infrastructure maintenance.

Component 3: Project Management

(i) Project management support with community participation (through disaster management systems) with staffs including those seconded from the existing organizations or hired from the market, implementation consultants, and nongovernment organizations (NGOs).

(ii) Training for program-related operations.

SUBPROJECT SCOPES

I. Structural Works

A. Palasbari Subproject

1. Tranche 1 (years 1–3):

(i) **Retirement of 4.0 kilometers (km) of Brahmaputra dyke from Palasbari to Dakhala Hill (Rs65 million).** Bank revetment will be constructed between Palasbari and Dakhala Hill. Bank erosion has adversely affected the residents of the area by destroying their homes and land, by eroding the embankment. Local residents recall severe erosion for at least 50 years. Many have lost their land and have been forced to move repeatedly. Embankments in Palashbari have been retired several times because of erosion; any further efforts to upgrade and/or retire embankments in this area must be accompanied by effective erosion protection. The revetment works will be implemented in years 1–3.

(ii) **Revetment of 5.0 km length between Palasbari and Dakhala Hill (Rs440 million).** The embankment between Palashbari and Dakhala Hill will be retired where necessary, and strengthened. Large sections of this embankment have been completely eroded, while some sections require raising and strengthening. Flood protection works constructed in this area will protect valuable land, including Guwahati airport and the areas that are to form parts of an extension of the city. This work will be implemented in years 2–3.

(iii) **Gumi revetment (Rs12 million)**. Emergency bank protection will be constructed at Gumi (3 km), during Tranche1. The emergency protection will consist of (1) a launching heap of geo-bags, which will protect the bank toe from erosion, and (2) temporary wave protection in the form of geo-bags placed along the bank slope. Future work (Tranche 2) will include comprehensive bank protection. This work will be implemented in year 1 to year 2.

The total estimated cost of tranche 1 works is Rs625 million.

2. Tranche 2 (years 4–6, subject to future verification):

(i) **Construction of two gated drainage sluices (Rs40 million).** These sluices will be placed in areas that experience local drainage congestion.

(ii) **Revetment of about 7 km between Majirgaon and Palashbari (Rs717 million).** This revetment is required to safeguard the embankment in this reach. The Brahmaputra River has flowed along the bank line for a number of years and is likely to continue so.

(iii) **Revetment and pro-siltation measures of 2.5 km at Taparpathar (Rs114 million).** This revetment is required to stabilize the embankment in places where the Brahmaputra River approaches the embankment

(iv) **Revetment and pro-siltation measures of 4 km at the Gumi area (Rs336 million).** This revetment is required to stabilize the embankment in places where the Brahmaputra River approaches the embankment

(v) **Rehabilitation and strengthening of three boulder deflectors near Gumi (Rs35 million).** The boulder deflector will continue protecting the existing bank from erosion after upgrading and strengthening.

The total cost of tranche 2 works is Rs1,242 million.

The total estimated cost for the subproject is Rs1,867 million. The work distribution over 6 years is estimated in Table A2.1.

Table A2.1: Summary of Work at Palasbari by Tranche (%)

Item	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
Palasbari embankment 4.9 km		50	50			
Palasbari revetment 4.0 km	50	30	20			
Gumi revetment 3.0 km	50	30	20			
2 gated drainage sluices					50	50
Majirigaon revetment, 7.1 km				50	50	
Taparpathar revetment, 2.5 km					50	50
Gumi revetment, 4 km					50	50
Gumi, 3 boulder deflectors				70	30	

Source: Water Resources Department, State Government of Assam.

B. Kaziranga Subproject

3. **Tranche 1 (years 1–3):**

(i) **Construction of 4.7 km of inner dyke from Diffalupathar to National Highways (NH) 37 (Rs120 million).** The proposed Diffalupathar-NH 37 embankment will enclose the area between Dhansiri River, Kaziranga, and NH 37, providing protection from Brahmaputra flooding (the area is already protected from Dhansiri flooding by an existing embankment). A gated sluice will be provided at the existing opening in the village road near NH 37, allowing drainage of ponded floodwaters following local (rain) floods or an upstream breach. Another gated sluice will be provided at the Diffalu Channel crossing.

(ii) **Construction of three drainage sluices in the Diffalupathar–Moriaholla embankments (Rs120 million).** Three sluices (with three gates) will be constructed on the breaches in Moriaholla–Diffalupathar embankment. It is essential to the functioning of the new embankment that all three sluices be constructed in the same dry season. Together with the subsequent strengthening of the embankment, the work is expected to support reliable flood protection and drainage.

(iii) **Pro-siltation measures of 3 km in front of Krishibund (Rs15 million).** Pro-siltation measures with systematic placing of porcupine screens will be constructed from 29.7 km post on the Brahmaputra embankment to 2.2 km post on the Krishibund for about 3 km. The bank is on the outside of a sharp bend, and has been eroding for past few years. The screens increase the friction of the channel flow, reduce the slope of energy grade line, and encourage siltation. The placement of the porcupine screens is adaptive over 3 years, with the possibility of placing additional layers of screens over previous ones once they have been silted in.

The total cost of tranche 1 works is Rs255 million.

4. **Tranche 2 (years 4–6, subject to future verification):**

(i) **Rehabilitation and strengthening of 18.7 km dyke from Moriaholla to Diffalupathar (Rs130 million).** This dyke protects the area between Dhansiri

River and Kaziranga National Park. Part of the embankment is being upgraded, and the remaining length will be upgraded.

(ii) **Porcupine revetment near Moriaholla area 4 km (Rs35 million).** This riverbank protection provides additional safety against erosion of the flood embankment.

(iii) **Additional revetment and pro-siltation measures of 2 km length in front of Krishi bundh (Rs17.5 million).** The work will supplement the work from the first tranche. This dyke protects the area between Dhansiri River and Kaziranga National Park. The Water Resources Department started providing pro-siltation measures in this reach in recent years. Under this initiative, the remaining length will be upgraded.

The total estimated cost of tranche 2 is Rs182.5 million.

The total estimated cost for the subproject is Rs437.5 million. The work distribution over 6 years is estimated in Table A2.2.

Table A2.2: Summary of Work at Kaziranga by Tranche (%)

Item	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
Inner dyke, 4.7 km		50	50			
3 drainage sluices	40	60				
Krishibundh pro-siltation, 3 km	50	30	20			
Moriaholla–Diffalupathar dyke, 18.7 km				50	50	
Porcupine Moriaholla, 4km				50	30	20
Krishibundh pro-siltation, 2 km				50	30	20

Source: Water Resources Department, State Government of Assam.

C. Dibrugarh Subproject

5. **Tranche 1 (years 1–3):**

(i) **Rehabilitation and strengthening of 9.5 km of Dibrugarh town protection (DTP) embankment (Rs420 million).** The existing embankment section needs to be raised in response to the rising riverbed levels over the years. To reduce the impact on the existing settlement along urbanized areas, the design takes additional measures to minimize the width of the embankment and to stay as much as possible within the acquired width of 100 feet.

(ii) **DTP dyke bank protection (Rs15 million).** Along the DTP dyke, especially between 6.5 km and 8.3 km posts, channel erosion will be controlled through systematic placing of porcupine screens. The screens increase the friction of the channel, reduce the slope of the energy grade line, and encourage siltation. The placement of the porcupine screens is adaptive over 3 years, in general starting from the downstream end of the town and moving upstream.

(iii) **Mothola–Oaklands bank protection (Rs255 million).** Between 7.8 km and 5.4 km points (Spur No. 1 and Nagaguli Spur) along the Mothola–Oaklands dykes, bank protection will be implemented using sand-filled geotextile bags (below the low-water leve) and concrete blocks (above the low-water level, for wave protection).

The total estimated cost for tranche 1 works is Rs690 million ($17.2 million).

6. **Tranche 2 (years 4–6, subject to future verification):**

(i) **Minor rehabilitation of seven existing spurs in front of the DTP dyke (Rs28 million).** The work comprises an extended under water carpet around the spur head consisting of geotextile bags and limited slope protection above water. The spurs will then be functional.

(ii) **Rehabilitation and strengthening of 4.7 km Hiloidhari Bundh–Titadimaru dyke (Rs68 million).** This dyke protects the upstream flank of Dibrugarh against flooding from the Maijan beel.

(iii) **Construction of 9.5 km inspection road over the DTP dyke (Rs39 million).** The crest of the existing embankment provides the only quick access during emergencies along the densely populated area of the town. To maintain this access, the subproject proposes black top carpeting.

(iv) **Construction of two gated drainage sluices at selected locations of the DTP dyke (Rs40 million).** Certain areas of the town need to be provided with additional rainwater drains to reduce pumping costs during the early monsoon season and to drain low-lying areas at the end of the flood season.

The total estimated cost of tranche 2 works is Rs175 million.

The total estimated cost for this subproject is Rs865 million. The work distribution over 6 years is estimated in Table A2.3.

Table A2.3: Summary of Tranche Work at Dibrugarh by Tranche (%)

Item	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
DTP dyke, 9.5 km		50	50			
DTP dyke bank protection, 1.8 km	50	30	20			
Mothola Oakland bank protection, 2.4 km	50	50				
Rehabilitation of 7 spurs				40	60	
Hiloidhari–Titadimary dyke , 4.7 km				50	50	
Inspection road 9.5 km				25	75	
2 gated drainage sluices					75	25

DTP = Dibrugarh town protection

Source: Water Resources Department, State Government of Assam.

II. Nonstructural Works and Community-Based Risk Management

7. **Land Use Guidelines**. Land use guidelines are aimed at ensuring that land use across the floodplain is consistent with the likelihood, risk, and hazard of flooding. For this purpose, current and likely future land use in flood-prone areas will be reviewed, especially the expected population growth and its impact on future flood risk and damage in higher-risk areas. In addition, the use of land use zoning to preserve wetlands and protect existing flood storage areas from further development will be assessed.

8. **Building and Development Guidelines.** While building and development controls are also not expected to provide a panacea for reducing flood risk and flood impacts in Assam, the flood proofing of public infrastructure is one area where improvements might be possible (to

ensure it is ready and effective to return to service after a flood). The Program will assess flood damage to buildings and public infrastructure to identify possible improvements. The United Nations Development Program Sisaster Management Project has had work undertaken on the design and construction of flood-resilient buildings, which will be reviewed.

9. **Flood Forecasting and Warning*.*** Flood forecasting is a means to an end—to provide timelier and more accurate flood warnings. It is the warning that is essential, rather than the forecast. While a variety of public agencies participate in the flood forecasting and warning (FFW) process in Assam, most villagers receive no formal flood warnings—they generate their own warning by watching the river during the flood season, taking into account local rainfall. The Program will review the elements of FFW process, paying special attention to warning needs of villages and possible improvements in communities and flood emergency management. An important element of an improved FFW system is anticipated to be the provision of local forecasts by the Water Resources Department, i.e., the translation of regional forecasts by Central Water Commission (CWC) into clear and easily understandable warnings to villages. Local communities will be centrally involved in this process.

10. **Flood Emergency Planning and Management**. Flood emergency planning includes prevention, preparation, response, and recovery activities. Flood emergency planning and management (FEPM) is and will remain a central plank of flood risk management in Assam—flooding is a regular recurring natural event that cannot be prevented or entirely eliminated by structural measures. Flood emergency planning will to be reviewed and probably strengthened at the village, district, and state levels (e.g., through the use of the army for evacuation).

11. **Community-Based Flood Risk Management (CBFRM)*.*** CBFRM is one area where considerable opportunity exists to reduce the impacts of floods on village communities. Under the Program, comprehensive community surveys will be undertaken to address community concerns on flood risk management. Based on the responses, a CBFRM plan will be prepared, including raised platforms and associated facilities (e.g., permanent latrines, a raised tube-well for water supply, and permanent public buildings that are needed during flood emergencies, such as the local school and dispensary, and emergency shelter), along with community nonstructure programs, such as flood warning and flood education.

12. **Flood Education*.*** Villagers appear to be very aware of floods and highly flood resilient. The need for further flood education in villages will be assessed in the community surveys. Flood management in Assam is fragmented across many different agencies. The Program will promote cooperation and the exchange of ideas and information between the different agencies through workshops, seminars, etc. (a form of flood education).

13. **Financial Measures*.*** When in emergency accommodation during floods, flood-prone villagers cannot afford kerosene for cooking purposes. Relief payments—whether in cash or kind—are a financial measure (and a form of insurance) aimed at reducing the impacts of flooding. Under the Program, the system of flood relief payments, food, and stock fodder issue and other relief measures will be reviewed and possible improvements will be pursued.

Figure A2.1: Palasbari Subproject Structural Works

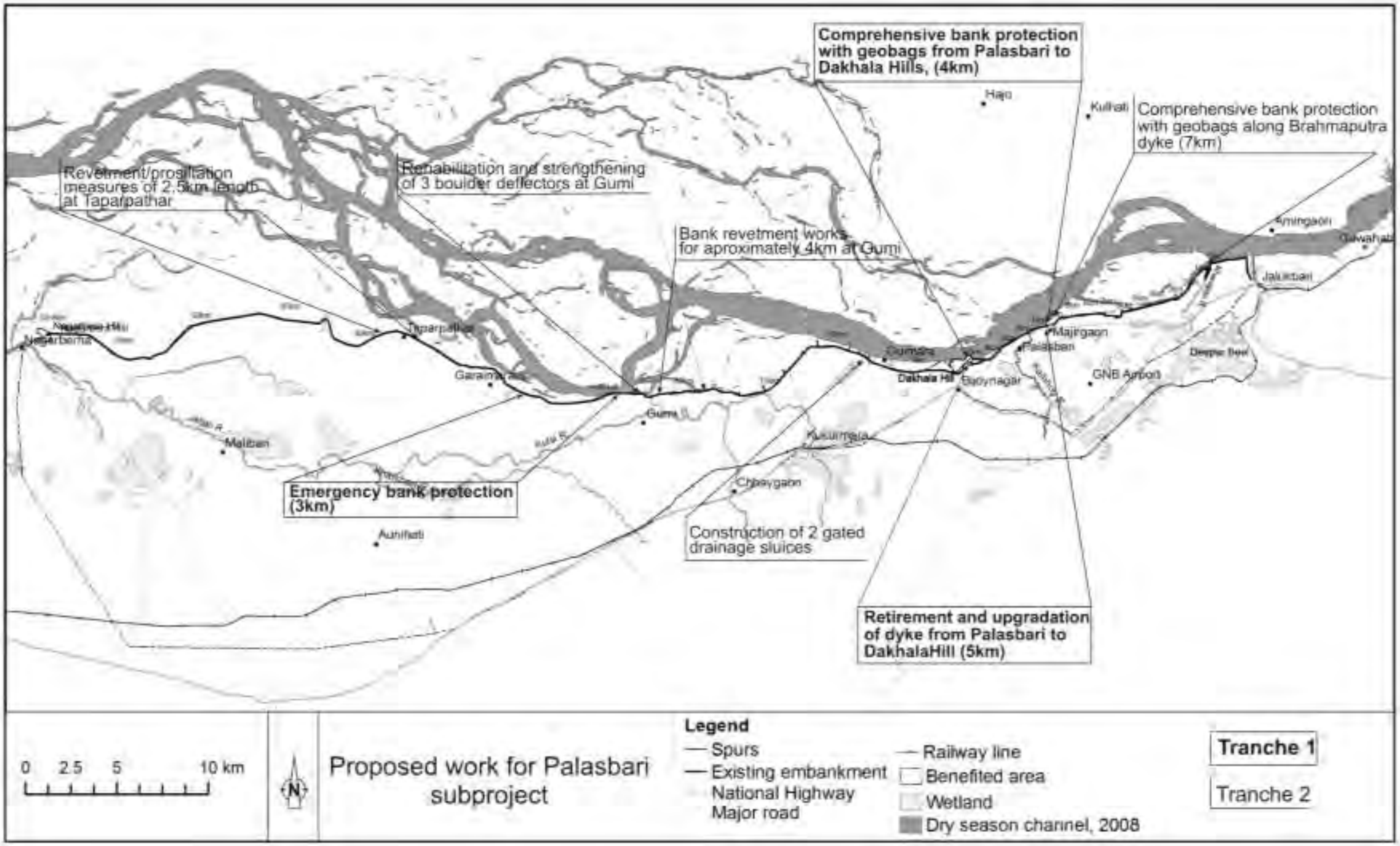


Figure A2.2: Kaziranga Subproject Structural Works

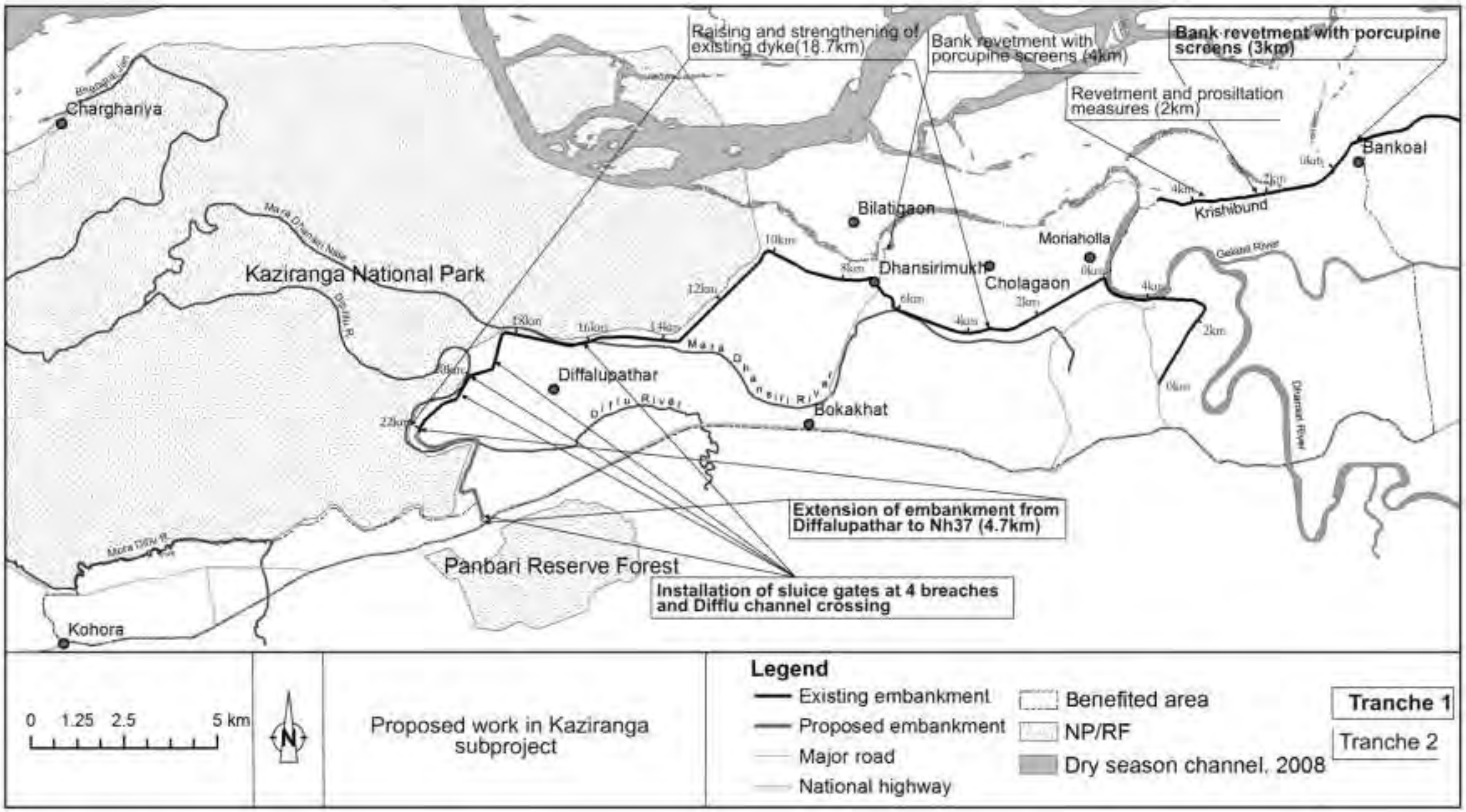
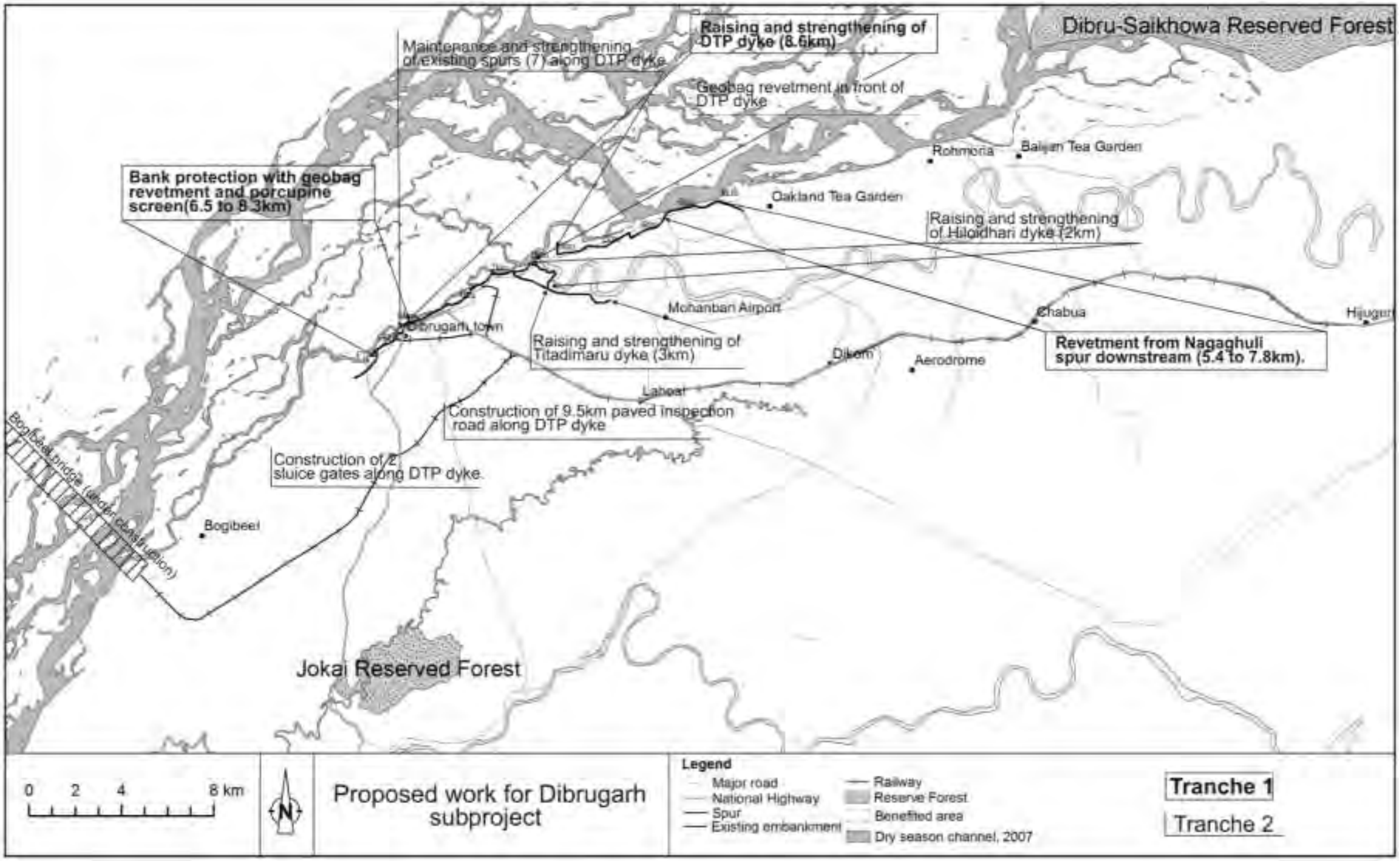


Figure A2.3: Dibrugarh Subproject Structure Works



FLOOD INUNDATION IN SUBPROJECT AREAS (JULY 2004)

Figure A3.1: Palasbari Subproject Area

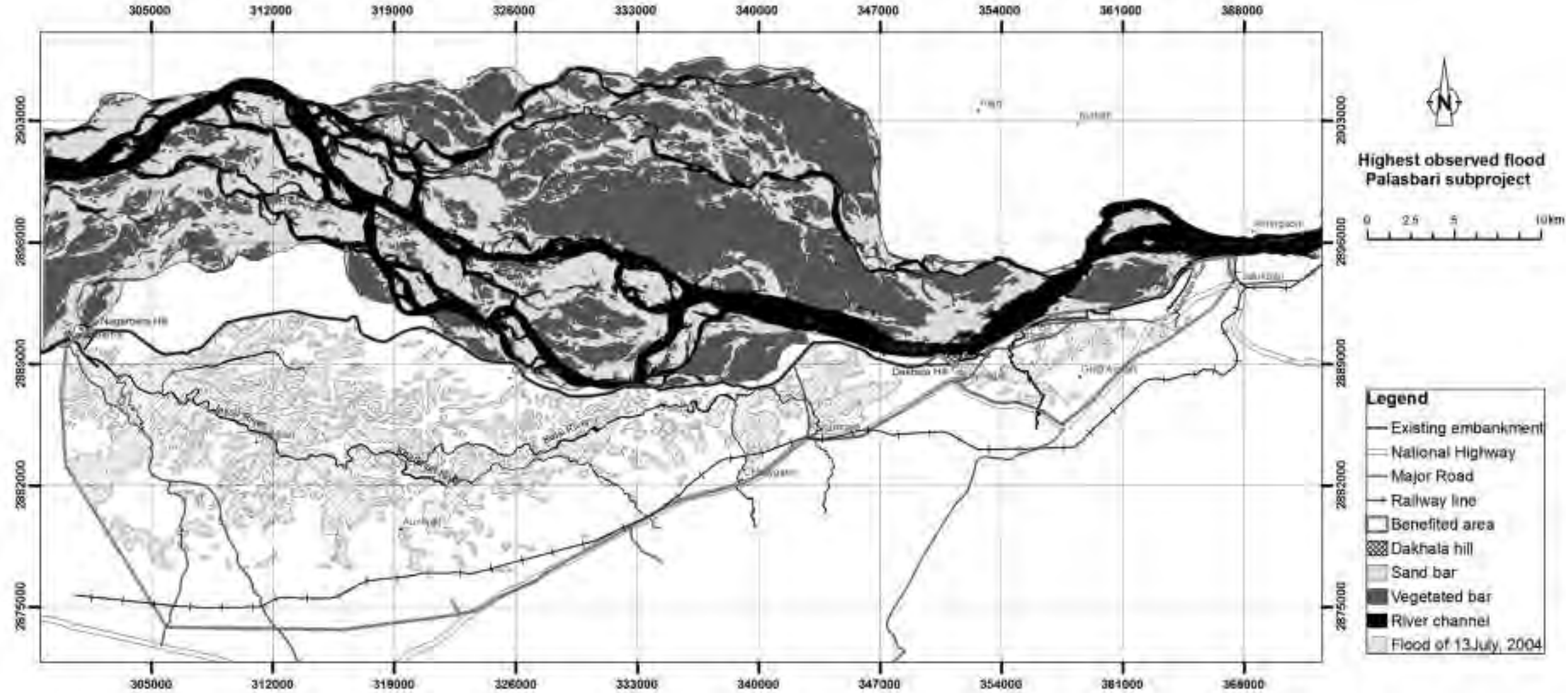


Figure A3.2: Kaziranga Subproject Area

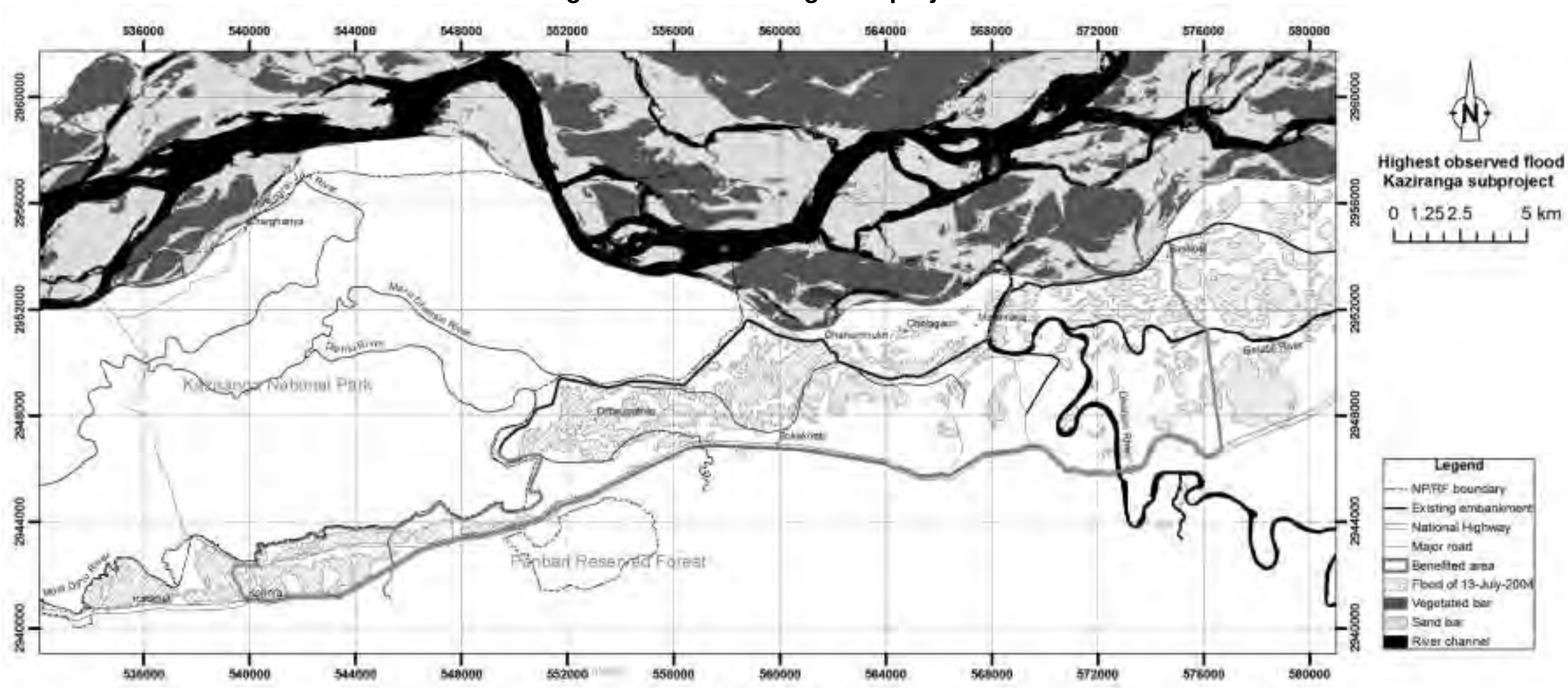
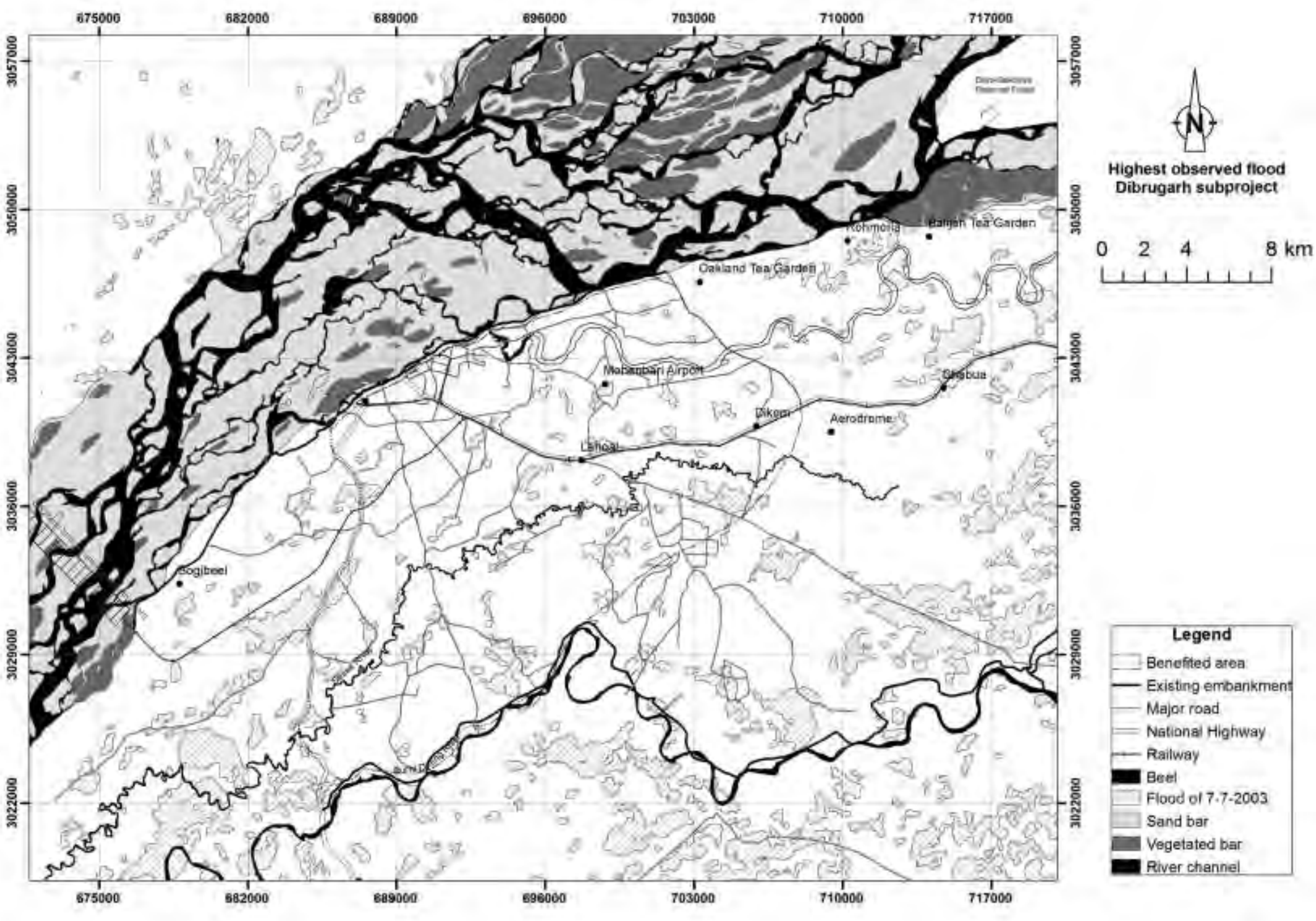


Figure A3.3: Dibrugarh Subproject Area



SUBPROJECT AREA MORPHOLOGY

Figure A4.1: Geomorphic Features and Past Bank Erosion along Palasbari Subproject

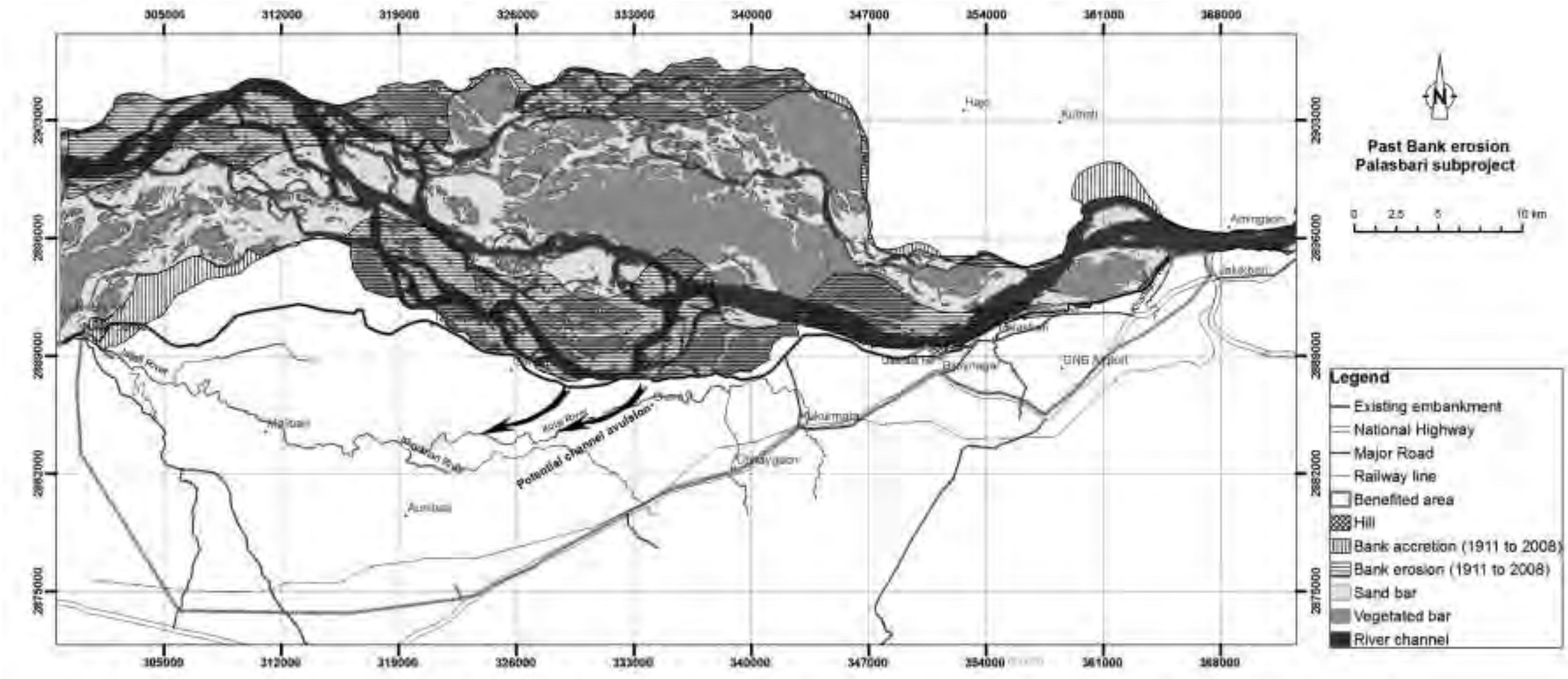


Figure A4.2: Geomorphic Features and Past Bank Erosion along Kaziranga Subproject

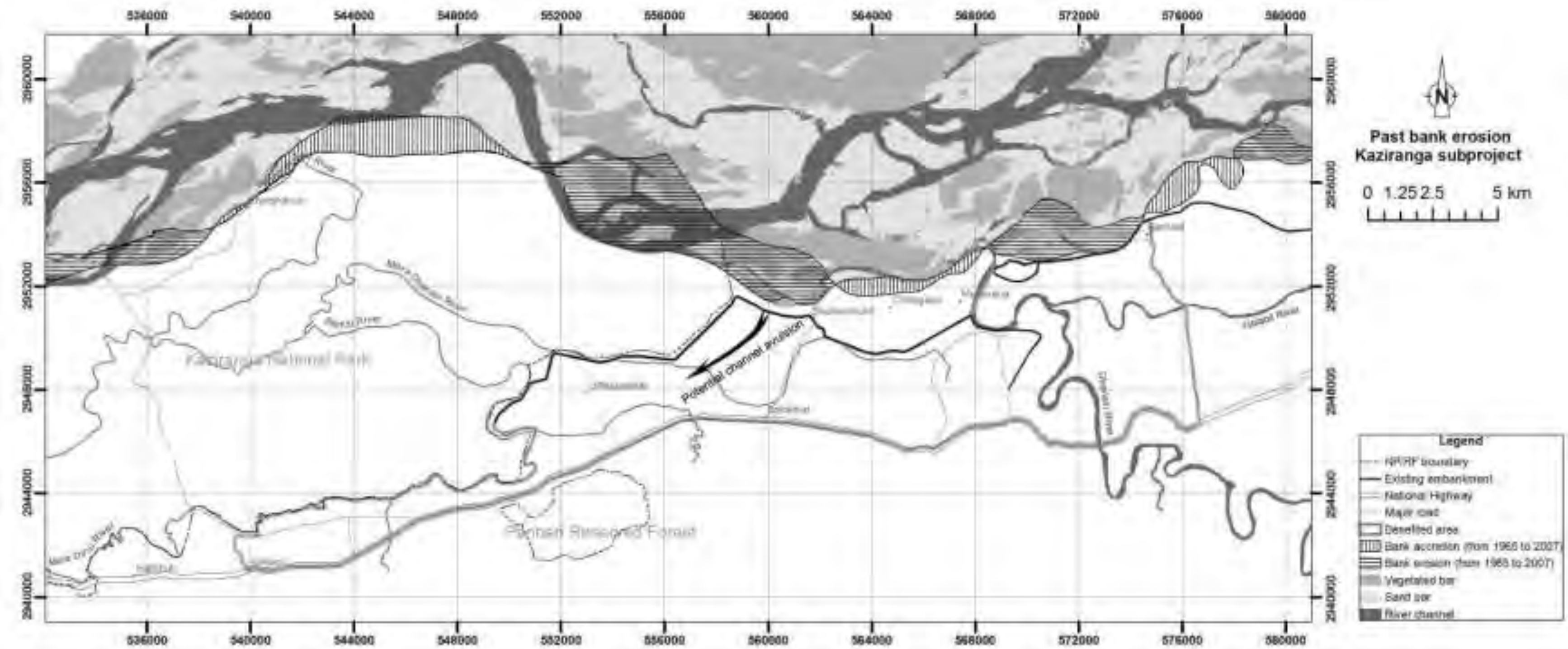
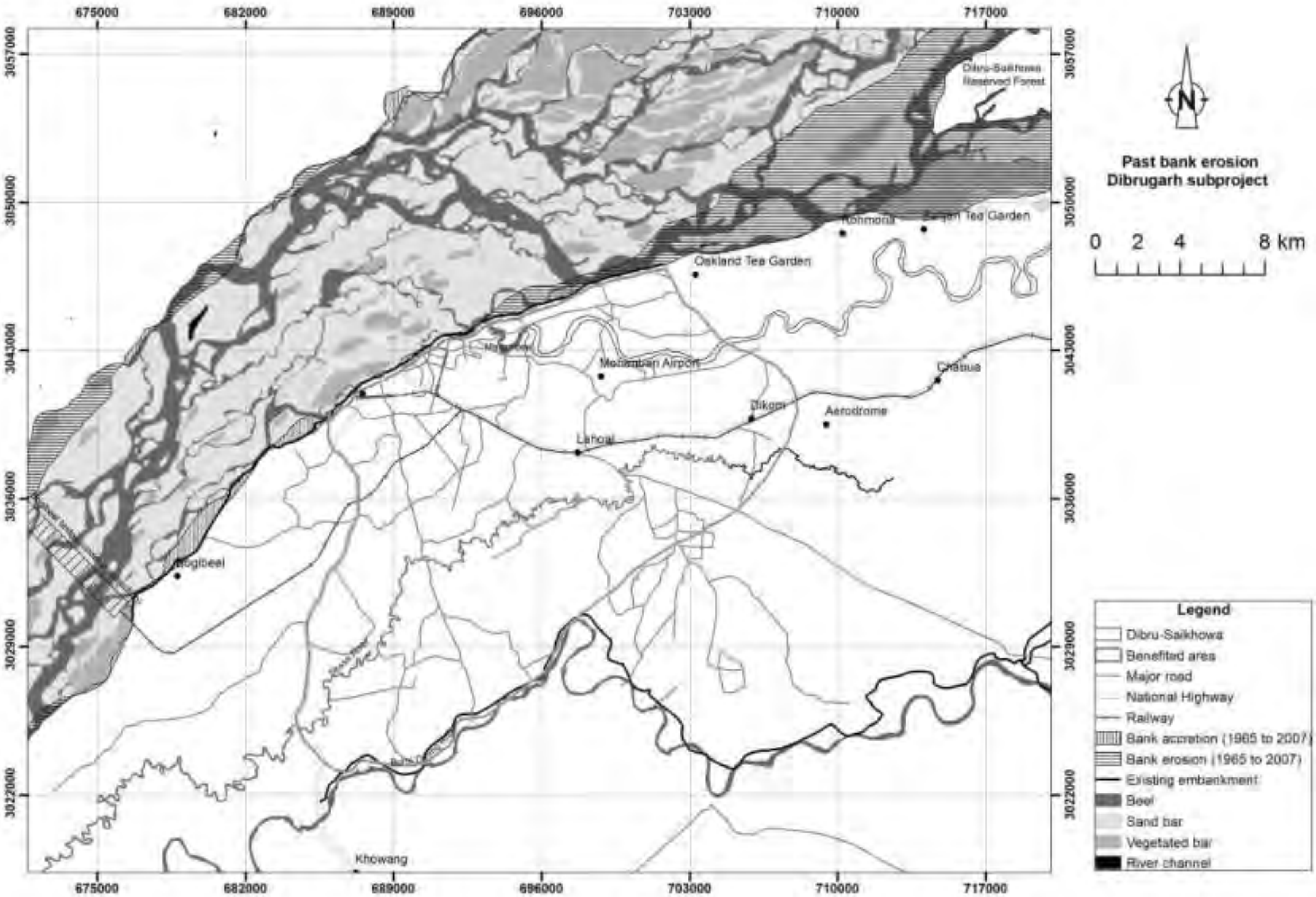
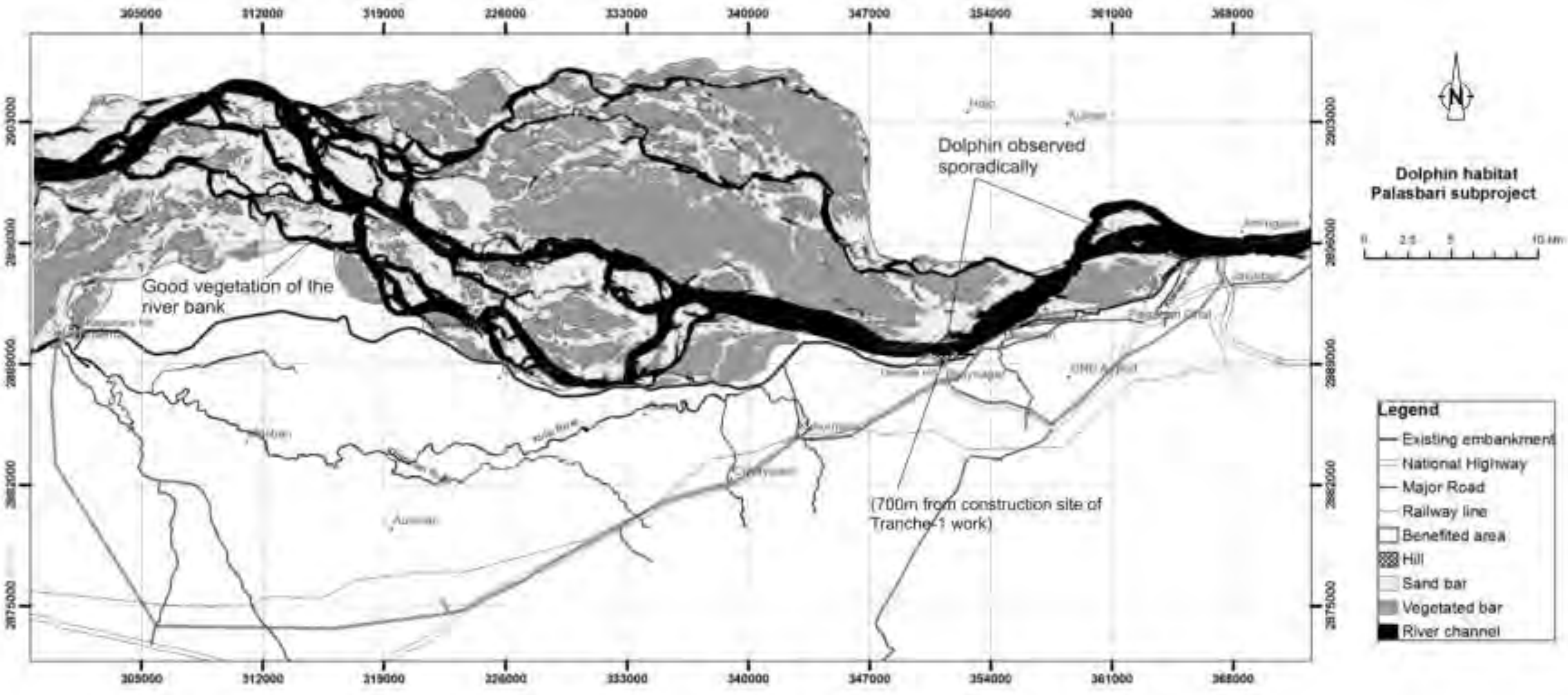


Figure A4.3: Geomorphic Features and Past Bank Erosion along Dibrugarh Subproject



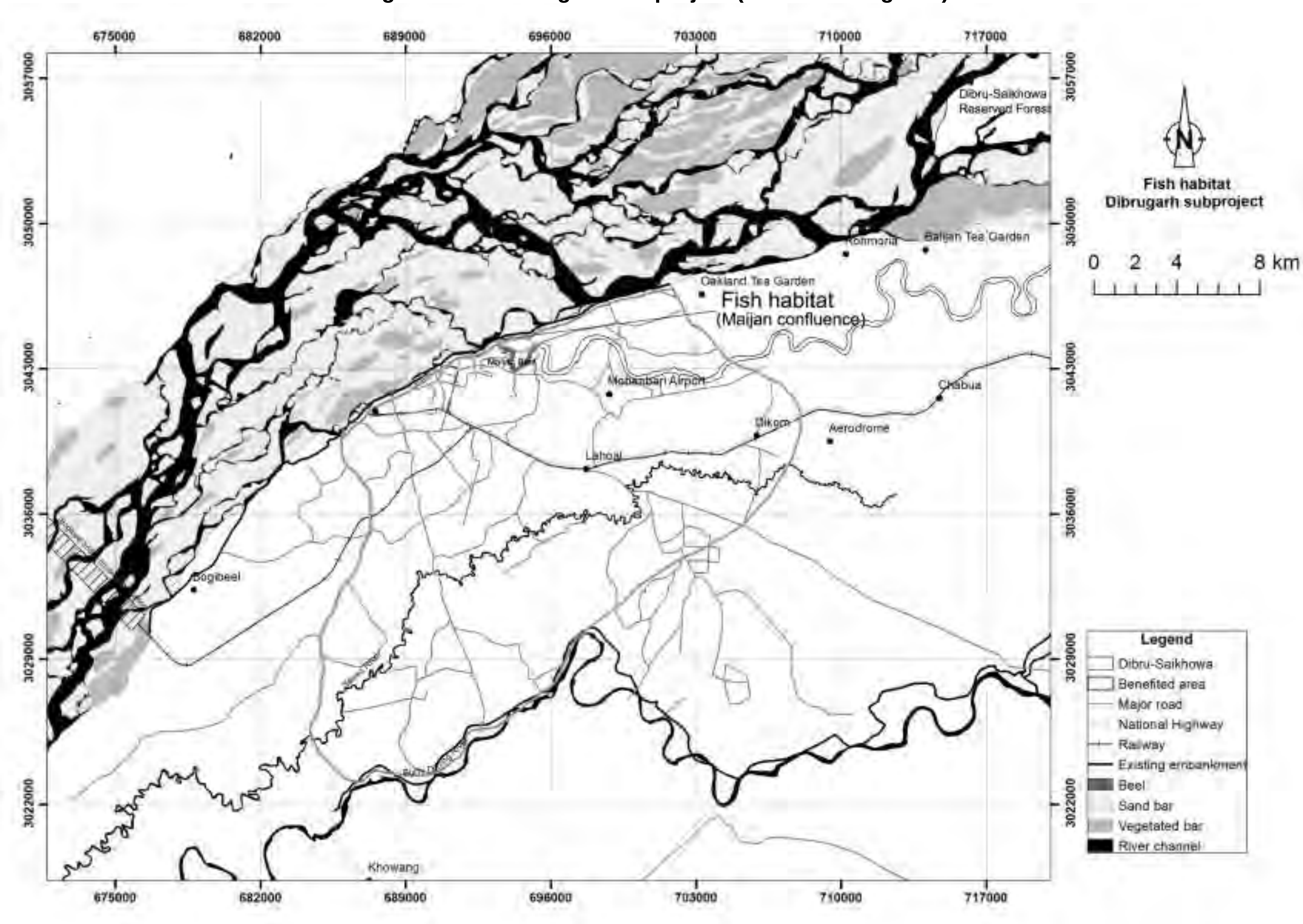
OBSERVED RIVER DELPHINE AND FISH BREEDING SITES [1]

Figure A5.1: Palasbari Subproject (River Dolphin and Fish Breeding Sites)



[1] No river dolphine or fish breeding sites were observed along the Kaziranga subproject reach.

Figure A5.2: Dibrugarh Subproject (Fish Breeding Site)



ENVIRONNEMENTAL MANAGEMENT PLAN

Activity	Environmental Issue/ Component	Remedial Measures	Legislative Requirement/Framework	Approximate Location	Time Frame	Mitigation Cost (Rs)	Institutional Responsibility	
							Implementa-tion	Super-vision
Climate Change	• No direct impact but an increase in temperature due to construction activities and trees to be cut	• Minimization of tree cutting while designing the embankment • Compensatory tree planting, preferably on the basis of three trees planted for each tree cut	• Kyoto Protocol	• Throughout the stretch of the reach	Throughout the construction period	–	Contractor with guidance of Forestry Department	WRD and AIFRERM Ageny
Change in Land Use	• Loss of agricultural land	• Use of uncultivated areas near embankments only for storage and/or handling of construction materials		• Construction sites and service areas throughout the reach	During design and construction phase	Included in construction cost	Contractor	WRD and AIFRERM Agency
		• Construction camps on uncultivated areas only with requisite facilities of drinking water, sanitation, waste collection, and fuel supply		• Identified locations of construction camps • Palasbari reach 4–5 camps; • Dibrugarh reach 2–3 camps; • Bonkuwal reach 2–3 camps		Included under soil contamination prevention costs	Contractor	WRD and AIFRERM Agency
		• No dumping of construction waste on agricultural land					Contractor	WRD and AIFRERM Agency
		• Adequate compensation for loss of land and/or loss of crops	• As per social assessment and R&R	• Identified as per the social assessment		Included in R&R Cost	WRD-SIO	WRD and AIFRERM Agency
		• Land used for construction camps shall made reusable and/or cultivable construction		• Sites used as construction camp	After completion of construction	Included in construction cost	Contractor	WRD and AIFRERM Agency

Activity	Environmental Issue/ Component	Remedial Measures	Legislative Requirement/Framework	Approximate Location	Time Frame	Mitigation Cost (Rs)	Institutional Responsibility	
							Implementa-tion	Super-vision
		• All efforts during the design stage shall be made to minimize the tree felling requirement		• Entire program area	During complete construction phase	Included in design engineering cost	WRD-SIO	WRD and AIFRERM Agency
	• Loss of homestead plantation	• Compensatory plantation shall be started during the construction phase parallel to the construction activities (1:3)		• Entire program area	During construction	2,340,000	WRD-SIO	WRD and AIFRERM Agency
		• Monitoring of tree felling (census of trees, their numbering etc. based on engineering design)		• Entire program area	During complete construction phase	Included in the Monitoring Costs (refer Monitoring Plan)	Independent agency	WRD and AIFRERM Agency
Borrow Area Location and Rehabilita-tion	• Loss of agricultural land and homestead plantation due to borrowing ofearth from country side of embankment	• Borrow pits shall be preferred on river side to embankment as these can get silted over time or earth from a retired embankment	• WRD guidelines	• Identified locations for borrowing of earth	During complete construction phase	Included in construction cost	WRD-SIO	WRD and AIFRERM Agency
	• Permanent disfiguration of land	• Use of waste land or excavation or enlargement of existing land or any hump above ground level for borrowing of earth • No land acquisition for borrow areas • Follow WRD guidelines for borrowing earth and borrow area management		• Identified locations for borrowing of earth	During complete construction phase	Included in construction cost	Contractor	WRD and AIFRERM Agency

Activity	Environmental Issue/ Component	Remedial Measures	Legislative Requirement/Framework	Approximate Location	Time Frame	Mitigation Cost (Rs)	Institutional Responsibility	
							Implementation	Supervision
	• Seepage into the foundations of embankment	• Use of dredge material from Kulsi and Jaljali rivers in Palasbari reach • Use of mixture of sand and earth in Dibrugarh reach, and borrowing of earth away from the embankment • Use of dredge material from Dhansiri River in Bonkuwal reach		• Dredge material from the banks the Kulsi, Jaljali, and Dhansiri rivers • Borrowing of earth from the riverside of the embankment in Palasbari and Kaziranga • Borrowing of earth away from the embankment in Dibrugarh	During construction	Included in construction cost	Contractor	WRD and AIFRERM Agency
		• Strictly following WRD guidelines with respect to borrow area location and rehabilitation		• Entire program area	During construction phase and after construction	Included in construction cost	Contractor	WRD and AIFRERM Agency
Change in Land Use and Borrow Area Rehabilitation	Encroachment on embankment for habitation and cultivation Cutting of embankment to create approach to the riverside Non-rehabilitation of borrow areas	• Provision shall be made in the embankment design for providing access to the riverbank close to the habitats • Construction contractors shall ensure rehabilitation of borrow areas before handing over the program		• Entire program area and borrow areas	Operations Phase	Included in construction cost	Contractor and WRD-SIO	WRD and AIFRERM Agency
Construction Material Sourcing (Quarrying)	• Illegal quarrying may lead to land use change, unstable rock formation, air and noise	• Aggregates required for construction of embankment and roads will be procured from quarries approved by SPCB	• Environmental Protection Act and Rules, 1986; Water Act 1974, Air Act 1986	• River and hill quarries approved by Assam state government	During complete construction phase	Included in construction cost	Contractor	WRD and AIFRERM Agency

Activity	Environmental Issue/ Component	Remedial Measures	Legislative Requirement/Framework	Approximate Location	Time Frame	Mitigation Cost (Rs)	Institutional Responsibility	
							Implementa-tion	Super-vision
	pollution	• Air and noise emissions from quarries shall be within the prescribed limits for the protection of workers health		• Quarrying sites	During complete construction phase	–	WRD -SIO	WRD/ AIFRERM Agency and SPCB
		• Stone crushers, if required, shall be set up only after consent from SPCB and taking adequate measures for air pollution control.		• Location of stone crushers	During complete construction phase	Included in construction cost	Contractor	WRD/ AIFRERM Agency and SPCB
		• Land earmarked for dumping of construction waste shall be free from any social and R&R issue and away from settlements • In Dibrugarh, dumping shall be avoided at the municipal waste dumping site as it is close to the riverbank.		• Identified dumping sites	During complete construction phase	Included in construction cost	Contractor	WRD and AIFRERM Agency
Soil Erosion	• Soil erosion from construction sites during monsoon season	• Opening of borrow areas near the embankments shall not be done during monsoon season		• Identified areas for borrowing earth	Except monsoon season during construction phase	Included in construction cost	Contractor	WRD and AIFRERM Agency
	• Loss of topsoil	• Identification of potential erosion zones during the construction phase • Piling of topsoil for later use as landscaping and turfing embankments		• In all three subproject reaches	Especially during monsoon season	Included in construction cost	WRD Field Officers	WRD and AIFRERM Agency

Activity	Environmental Issue/ Component	Remedial Measures	Legislative Requirement/Framework	Approximate Location	Time Frame	Mitigation Cost (Rs)	Institutional Responsibility	
							Implementation	Supervision
		• Stabilization of soil around the approach roads/ slopes by turfing and tree plantation in ROW		• Along the embankment and approach roads	Especially before monsoon starts	Included in construction cost	Contractor	WRD and AIFRERM Agency
		• Slope stabilization measures on the embankment, e.g., selection of less eroding materials		• As suggested by the engineering team	During the construction period	Included in construction cost	Contractor	WRD and AIFRERM Agency
	Net benefits due to construction of embankment and anit-erosion measures in riverbanks Erosion due to watershed of Dhansiri River • Erosion due to lower watershed of Kulsi River	• Requirement of watershed management of Dhansiri and Kulsi rivers and their tributaries • Periodic checking of the stabilization measures		• Program benefit area	Post-operations phase	Included in Monitoring Costs. Water Shed Management to be coordinated by WRD with Soil Conservation Department Separately	WRD-SIO	WRD and AIFRERM Agency
Soil Compaction	• Soil compaction around construction sites, haulage roads, construction camps, and workshops due to transportation of people, machines, and materials	• Movement of construction vehicles, machinery, and equipment in embankment site and pre-defined haulage road		• Construction material dumping sites and construction sites	During the entire construction period	Included in construction cost	Contractor	WRD and AIFRERM Agency
	• Construction waste handling	• Provision for approach roads capable of handling movement and haulage of heavy vehicles		• Approach roads used for material handling	During the entire construction period	Included in construction cost	Contractor	WRD and AIFRERM Agency

Activity	Environmental Issue/ Component	Remedial Measures	Legislative Requirement/Framework	Approximate Location	Time Frame	Mitigation Cost (Rs)	Institutional Responsibility	
							Implementation	Supervision
Soil contamination	Soil contamination around construction sites, machine maintenance areas, fuelling stations, construction camps, hot mix plant, and haulage roads	• Fueling and maintenance of construction machinery and vehicles shall be carried out at designated place with proper arrangement of waste collection and disposal		• Fuel storage and workshop areas	During the entire construction period	320,000	Contractor	WRD and AIFRERM Agency
		• Fuel storage and refueling sites to be kept away from drainage channels		• Fuel storage and workshop areas	During the entire construction period	Included in construction cost	Contractor	WRD and AIFRERM Agency
		• Unusable debris to be dumped in designated places		• Identified inert material dumping sites	During construction phase	Included in construction cost	Contractor	WRD and AIFRERM Agency
		• Oil interceptors shall be provided		• At fuel handling and workshop areas	During construction phase	Included in construction cost	Contractor	WRD and AIFRERM Agency
		• Waste oil shall be sold to recyclers authorized by SPCB		• At fuel handling and workshop areas	During construction phase	Earning from selling	Contractor	WRD and AIFRERM Agency
Site Clearing etc	Contamination of soil from construction wastes and quarry materials	• All spoils to be disposed off as desired and the site to be restored to its original conditions before handover		• Construction material handling areas and construction sites	After completion of construction phase	Part of construction costs	Contractor	WRD and AIFRERM Agency
		• Non-bituminous wastes from construction activities to be dumped in borrow pits and covered with a layer of the conserved topsoil.		• Inert material dumping sites	After completion of construction phase	Included in construction cost	Contractor	WRD and AIFRERM Agency
		• Bituminous wastes to be disposed of in dumping sites.		• Identified dumping sites	After completing construction	Included in construction cost	Contractor	WRD and AIFRERM Agency

Activity	Environmental Issue/ Component	Remedial Measures	Legislative Requirement/Framework	Approximate Location	Time Frame	Mitigation Cost (Rs)	Institutional Responsibility	
							Implementa-tion	Super-vision
Flood	Inundation during heavy flood	• Natural drainage systems shall not be disturbed		• In proposed embankment	During the construction phase	Included in construction cost	WRD-SIO and contractor	WRD and AIFRERM Agency
		• Adequate number of sluice gates shall be provided		• In proposed embankment	During the construction phase	Included in construction cost	WRD-SIO and contractor	WRD and AIFRERM Agency
		• Wetlands and other water bodies shall be enlarged and deepened		• Countryside of embankment in the buffer zone	During the construction phase and operations phase	Included in construction cost	WRD-SIO and contractor	WRD and AIFRERM Agency
		• Adequate provisions shall be made in engineering design to withstand extreme meteorological and geophysical events		• Southern part of the reach	During the construction phase and operations phase	Included in construction cost	WRD-SIO	WRD and AIFRERM Agency
Drainage System	• Embankment acts like a barrier for the drainage of accumulating country side water into the Brahmaputra during monsoon season.	• Provision shall be made to the extent possible not to obstruct the natural drainage • In Dibrugarh, WRD and local authorities shall modify the drainage system and rehabilitate the drains		• Entire program area	During the detailed engineering design stage	Included in construction cost	WRD-SIO	WRD and AIFRERM Agency
Upstream and Down-stream Effects on River Morphol-ogy	Impact on charlands near to bankline	• Erosion monitoring shall be carried out downstream • In case of impact on fringe areas of char, passive measures such as porcupine screens shall be used.		• Entire program area	Operation Phase	Included under monitoring cost Included contingency of construction cost	WRD-SIO	WRD and AIFRERM Agency
Effect on Flow Velocity and	• No significant change because of program intervention	• Monitoring of flow shall be carried out at regular intervals using field data as well as		• At upstream and in between the reach	During the lifespan of the program	Included under monitoring cost	WRD-SIO	WRD and AIFRERM Agency

Activity	Environmental Issue/ Component	Remedial Measures	Legislative Requirement/Framework	Approximate Location	Time Frame	Mitigation Cost (Rs)	Institutional Responsibility	
							Implementation	Supervision
Discharge Intensities		satellite remote sensing data						
Silt Deposition and Bed Level Change	• Prevention of silt deposition on agricultural land because of breach of embankments	• Monitoring of anti-erosion and river training works at regular intervals		• At upstream and in between the reach	During the lifespan of the program	WRD shall take initiative	WRD-SIO	WRD and AIFRERM Agency
Hydrology	• Design parameters may need to be changed over the years • Impacts may include minor change in discharge and sediments	• Systematic monitoring of hydrology, morphology, and sediment transport with acquisition of data • Establishment of information network of discharges from upstream reservoirs • Developing capacities in WRD to cope with changes in environment		• Subproject reach in particular, but also including basin-wide information and tributaries	During the lifetime of the program	Included in data and knowledge development component of Program	WRD-SIO, external specialist organizations	WRD and AIFRERM Agency
Morphological Change due to Structures	• Downstream erosion processes may be affected by the subproject structures	• Systematic monitoring of morphology and river planform, through bathymetric surveys and satellite imagery based studies • Preparation and implementation of protection measures to mitigate downstream erosion		• Subproject reach in particular, but also including upstream and downstream areas	During the lifetime of the program	Included in data and knowledge development component of Program	WRD-SIO, external specialist organizations	WRD and AIFRERM Agency
Impacts of Morphological Changes to Subproject Areas	• Upstream and downstream erosion process may affect the sustainability of subproject structures	• Systematic monitoring of morphology and sediment transport, with establishment of short-term prediction models		• Subproject reach in particular, but also including basin wide information and tributaries	During the lifetime of the program	Included in data and knowledge development component of Program	WRD, external specialist organizations	WRD and AIFRERM Agency

Activity	Environmental Issue/ Component	Remedial Measures	Legislative Requirement/Framework	Approximate Location	Time Frame	Mitigation Cost (Rs)	Institutional Responsibility	
							Implementation	Supervision
		• Preparation and implementation of protection measures to prevent outflanking of structures						
Water Quality	• Impact on surface and ground water quality	• Adequate supply of drinking water to workers	• The Water (Prevention and Control of Pollution) Act, 1974 and amendments thereof	• At construction camps and construction sites	During construction phase	360,000	Contractor	WRD and AIFRERM Agency
	• Contamination of water by construction waste	• Provision of septic tanks to treat the domestic sewage from construction camps		• At construction camps	During construction phase			
	• Contamination of water by fuel and lubricants	• Provision of mobile toilets for use at flood platforms		• At high altitude areas	During Operation Phase	Included in construction cost	WRD-SIO	WRD and AIFRERM Agency
		• Construction work close to the channels or other water bodies to be avoided			During construction phase	–	WRD-SIO	WRD and AIFRERM Agency
		• All necessary precautions to be taken to construct temporary devices to prevent water pollution due to increased siltation and turbidity			During construction phase	Included in construction cost	Contractor	WRD and AIFRERM Agency
		• Oil and grease traps to be provided at fuelling locations, to prevent contamination of water		• Fuel handling and workshop areas	During construction phase	Included in construction cost	WRD-SIO	WRD and AIFRERM Agency
		• Slopes of embankment leading to water bodies to be modified and screened so that contaminants do not enter the water channel and/or water body.		• Along the reach	During construction phase	Included in construction cost	WRD-SIO	WRD and AIFRERM Agency

Activity	Environmental Issue/ Component	Remedial Measures	Legislative Requirement/Framework	Approximate Location	Time Frame	Mitigation Cost (Rs)	Institutional Responsibility	
							Implementa-tion	Super-vision
		• Water quality to be monitored as envisaged in the environmental monitoring plan.		• As per monitoring plan	During construction phase	Included in the monitoring costs	WRD-SIO	WRD and AIFRERM Agency
	• Discharge of domestic effluents from nearby villages to the river	• Sanitation facilities shall be provided		• Entire Program Benefit Area	Operation phase	WRD to Initiate with concerned civic authorities	WRD-SIO	WRD and AIFRERM Agency
Air Environ-ment	• Change in air quality because of construction activities	• Approach roads shall be paved and widened	• Environmental Protection Act, 1986; The Air (Prevention and Control of Pollution) Act, 1981 and amendments thereof	• Approach roads to construction sites	At the start of construction activity	Included in construction cost	Contractor and WRD-SIO	WRD and AIFRERM Agency
		• All slopes and embankments to be turfed as per best engineering practices to minimize dust generation		• Construction area	During construction phase	Included in construction cost	Contractor	WRD and AIFRERM Agency
		• All machinery and plants to be placed downwind from the human settlements		• Construction area	During construction phase	Included in construction cost	Contractor	WRD and AIFRERM Agency
		• All vehicles, equipment, and machinery used for construction to be regularly maintained		• Workshop areas	During construction phase	Included in construction cost	Contractor	WRD and AIFRERM Agency
		• The hot mix plants, crushers, and batching plants to be sited at least 500 m downwind from the nearest human settlement		• Workshop areas	At the start of construction activity	Included in construction cost	Contractor	WRD and AIFRERM Agency

Activity	Environmental Issue/ Component	Remedial Measures	Legislative Requirement/Framework	Approximate Location	Time Frame	Mitigation Cost (Rs)	Institutional Responsibility	
							Implementa-tion	Super-vision
		• Fugitive emissions from handling, storage, and transportation of construction material shall be taken care		• Construction and storage sites	During construction phase	Included in construction cost	Contractor	WRD and AIFRERM Agency
		• Dust suppression by water sprinkling		• Construction and storage sites	During construction phase	Included in construction cost	Contractor	WRD and AIFRERM Agency
		• Monitoring of ambient air quality		• Near sensitive locations/ human settlements near to construction sites, crushers and hotmix plants	During the construction phase, as per environ-mental monitoring plan	Included in the monitoring costs	WRD-SIO	WRD and AIFRERM Agency
		• Speed restriction, surface improvement, and surface treatment shall be taken as options for control of emissions from unpaved roads		• Approach roads	During the construction period	Included in program cost	WRD-SIO	WRD and AIFRERM Agency
	• Change in air quality because of traffic	• Plantation along the embankment • Turfing of the embankment slopes • Regular maintenance of the road on the top of embankment as well as approach roads		• Entire Program Area	Operation Phase	Included as part of regular Maintenance costs	WRD-SIO	WRD and AIFRERM Agency
Noise	• Increase in sound pressure levels due to construction	• Options of noise control by site controls, scheduling of program activities	• Noise Pollution (Regulation and Control) Rules, 2000 and	• At all construction sites	During the construction period	Included in engineering cost	Contractor	WRD and AIFRERM Agency

Activity	Environmental Issue/ Component	Remedial Measures	Legislative Requirement/Framework	Approximate Location	Time Frame	Mitigation Cost (Rs)	Institutional Responsibility	
							Implementa-tion	Super-vision
	machineries, vehicles etc.	• Protection devices (ear plugs or ear muffs) to be provided to the workers operating in the vicinity of high noise generating machines	amendments thereof	• At all construction sites of high noise intensities	During the construction period	Part of Contractor Obligation	Contractor	WRD and AIFRERM Agency
		• Construction equipment and machinery shall be fitted with silencers and maintained accordingly		• At all construction sites	At the start of construction activity and also during the construction phase	Included in construction cost	Contractor	WRD and AIFRERM Agency
		• Construction of temporary noise barriers near sensitive areas, e.g. schools		• At identified sensitive locations near the construction sites	Before start of construction activities near sensitive locations	Included in construction cost	Contractor	WRD and AIFRERM Agency
		• Noise and vibration level monitoring as per monitoring plan		• As per monitoring plan	Once in every year	Included under monitoring costs	WRD-SIO	WRD and AIFRERM Agency
	• Increase in sound pressure levels because of traffic	• Adequate signage to restrict use of pressure horns particularly in noise sensitive locations • Tree barriers between the road and village/ semi urban/ and urban areas		At identified sensitive locations near the construction sites	During construction phase	Included in construction cost	WRD-SIO	WRD and AIFRERM Agency
Distur-bance to Vegeta-tion	• Cutting of trees in core zone during program	• Minimization of tree cutting while designing the embankment		• Entire program site	During complete construction phase	–	WRD-SIO	WRD and AIFRERM Agency

Activity	Environmental Issue/ Component	Remedial Measures	Legislative Requirement/Framework	Approximate Location	Time Frame	Mitigation Cost (Rs)	Institutional Responsibility	
							Implementation	Supervision
	intervention	• Compensatory tree planting, preferably on the basis of three trees planted for each tree cut		• Entire program site and nearby areas	Starting from construction phase	Already indicated above	WRD-SIO	WRD and AIFRERM Agency
Animal Distribution and Migratory Route of Endangered Species	Impact on wildlife and dolphin No adverse impact on endangered species	• No encroachment on KNP • Construction activities shall be restricted during dolphin breeding period (May to August) at breeding sites • Because of the sensitivity of the dolphins to polluted water, construction waste should not be dumped near the riverbank		• Identified breeding sites	During construction phase		WRD-SIO	WRD and AIFRERM Agency
Fishing Activities and Productivity, Migratory Route	• Impact on boat ghats • No migratory route near the embankment	• Adequate provision shall be made in the design to ensure access to the fish landing sites and boat ghats		• Identified sites along the reaches	During construction phase itself	Included in engineering design cost	Contractor	WRD and AIFRERM Agency
	• Temporary flushing of fish species towards deeper parts of the river	• Undisturbed movement of the fishers shall be provided		• Along the riverbank	During construction phase itself	Included in engineering cost	WRD-SIO	WRD and AIFRERM Agency
Wetlands and Beels	• Eutrophication of wetlands • No direct adverse impact on wetlands in any reach • No adverse	• Clear weeds • Improve the fish productivity of wetland and beel through institutional support		• Program Benefit Area	Operation phase	–	WRD-SIO	WRD and AIFRERM Agency

Activity	Environmental Issue/ Component	Remedial Measures	Legislative Requirement/Framework	Approximate Location	Time Frame	Mitigation Cost (Rs)	Institutional Responsibility	
							Implementation	Supervision
	impact on pond fisheries							
Habitat Fragmentation	• Inappropriate opening of the sluice gate	• Appropriate management to be made for the operation of sluice gates		• Program Benefit Area	Operation phase	–	WRD-SIO	WRD and AIFRERM Agency
Demography	• Pressure on natural resources because of establishment of construction camps	• Construction camps shall be supported with all basic amenities such as drinking water, fuel and sanitation facilities.		• Construction camps	During construction phase	Included in construction cost	Contractor	WRD and AIFRERM Agency
Establishments	• Impact on houses and establishments near core zone	• Efforts shall be made to prevent any relocation or demolition		• Near embankment sites	During construction phase	Included in R&R Cost	Contractor	WRD and AIFRERM Agency
		• Social infrastructure shall be rehabilitated with social and cultural values		• Near embankment sites	During construction phase	Included in construction Costs	WRD-SIO	WRD and AIFRERM Agency
		• Temporary noise barriers shall be installed close to schools and places of worship		• Near identified sensitive sites	During construction phase	Included in construction Costs	WRD-SIO	WRD and AIFRERM Agency
		• Thick plantation shall be made close to these establishments		• Near identified sensitive sites and human settlements	During construction phase	Already included above	WRD-SIO	WRD and AIFRERM Agency
Socio-economic Impact	• Impact on fish landing sites	• Training programs for agriculture and fish production improvement		• Program buffer zone	During construction phase	Already included above	WRD-SIO	WRD and AIFRERM Agency

Activity	Environmental Issue/ Component	Remedial Measures	Legislative Requirement/Framework	Approximate Location	Time Frame	Mitigation Cost (Rs)	Institutional Responsibility	
							Implementation	Supervision
		• Appropriate provisions shall be made to provide alternate fish landing stations so that economic activities of the fishers are disturbed during program intervention		• Identified fish landing sites	During construction phase	Included in construction cost	Contractor and WRD-SIO	WRD and AIFRERM Agency
Safety	• Risk of accidents and safety because of narrow roads and encroachment of people near construction areas	• Adequate lighting and fluorescent signage shall be provided at construction sites.		• Construction sites and approach roads	During construction phase	Included in construction cost	Contractor	WRD and AIFRERM Agency
		• Signage in local language		• Construction sites and approach roads	During construction phase	100,000	Contractor	WRD and AIFRERM Agency
		• Setting up of speed limits and speed brakers		• Construction sites and approach roads	During construction phase	50,000	Contractor	WRD and AIFRERM Agency
		• Personal protective equipment for workers		• At construction sites	During construction phase	Included in construction cost	Contractor	WRD and AIFRERM Agency
		• Health check up camps for workers		• At construction camps	During construction phase	600,000	WRD-SIO	WRD and AIFRERM Agency

AIFRERM = Assam Integrated Flood and River Erosion Risk Management, SIO = subproject management office, R&R = resettlement and rehabilitation, ROW = right of way, SPCB = State Pollution Control Board, WRD = Water Resources Department.

Source: Water Resources Department, State Government of Assam.

MITIGATION MEASURES IMPLEMENTATION SCHEDULE

Environmental Issue	EMP	Time line															
		Construction Phase					Operation Phase										
		1	2	3	4	5-6	1	2	3	4	5	6	7	8	9	10	11 -
Technical Support	Preparation of environmental guidelines																
Flora	Compensatory aforestation (minimum 1:3) (plantation and maintenance for one year)																
Agriculture	Technical support to farmers																
	Monitoring of cropping pattern																
Fisheries	Institutional support for productivity improvement for Wetland, beel, and pond fisheries																
	Monitoring of fisheries, breeding and spawning grounds																
	Maintenance and operation of sluice gates																
Drainage Congestion	Provision of adequate opening																
	Monitoring analysis of drainage congestion if any																
Hydrology and Morphology	River bank protection measures																
	Soil conservation																
	Monitoring of river erosion, water levels, and sediments																
Land	Compensation against land acquisition																
	Provision of access to riverbank near habitat areas, Construction of flood platforms																
	Rehabilitation of borrow areas																
Water & Drinking Water Supply	Installation of grease traps at construction sites																
	Construction of soak pits at construction sites																
	Monitoring of surface and ground water quality																
	Ensuring availability of arsenic free drinking water for construction camps																
Air Quality & Dust Management	Water spraying and watering																
	Monitoring of ambient air quality																
Work Safety	Provision of personal protective equipment																
Health Issues	Health checkup camps																
Tree & noise Barriers	Monitoring of tree felling and plantation																
	Maintenance of tree (additional two years)																
	Provision of additional tree plantation																
	Provision of noise barriers																
	Monitoring of noise and vibration																
Establishments	Construction stage																
Training	Environmental training and awareness																
MIS	Establishment and operation																

Legends

- Critical
- High priority
- Medium priority
- Low priority

Source: Water Resources Department, State Government of Assam.

ENVIRONMENTAL MONITORING PLAN

Environmental Component	Program Phase	Parameter	Standards	Location	Duration / Frequency	Cost (Rs)	Implementation	Supervision
Terrestrial and Aquatic Fauna	Construction	Surveillance audit for status of fish species, their movement and breeding grounds	None specific	Near the identified spawning and breeding grounds along the reach	Before breeding season and during the breeding season (During construction stage)	200,000	Independent fisheries expert	WRD and AIFRERM Agency
	Operation	Terrestrial and aquatic fauna status benefit assessment of the support during the Program as a whole	None Specific	Fish landing sites, breeding grounds, and near the core zone of the embankment	First 2 years after construction	200,000	Independent terrestrial and aquatic experts	WRD and AIFRERM Agency
Fisheries	Construction	Fish productivity	None Specific	Floodplains, beels, rivers, and ponds	Once a year throughout the construction	300,000	Survey by fisheries experts	WRD and AIFRERM Agency
	Operation	Fish productivity	None Specific	Floodplains, beels, rivers, and ponds	Once a year	100,000	Survey by fisheries experts	WRD and AIFRERM Agency
Cropping Pattern	Construction and Operation	Survey of existing cropping pattern and effect of change in cropping pattern in the impacted areas	None Specific	Construction areas, service areas, rehabilitation sites	Once during construction and once 6 months after completion of Program	Program Management Costs	Collected by agriculture department and verified by SIO staff	WRD and AIFRERM Agency
Air Quality	Construction	SPM, RSPM, SO_2, NO_x, CO, Pb	National ambient air quality standards	Within 100 m of hot mix plant, construction camp, crusher, and near sensitive locations and settlement	Continuous 24-hourly, twice a week, for 2 weeks once every year (summer)	750,000 (Rs125,000/ year for six year)	Independent environmental laboratories approved by SPCB	WRD and AIFRERM Agency
	Operation	SPM, RSPM, SO_2, NOx, CO, Pb	National ambient air quality standards	3–4 locations near the embankment sites	Continuous 24-hourly, twice a week, for a week, once in winter and summer	50,000	Independent environmental laboratories approved by SPCB	WRD and AIFRERM Agency
Hydrology	All phases	Water level, discharge, river cross sections	Central W. Commission, adapted to program needs	At program-specific locations	Regularly (monthly) during the flood season, in October and April, and as per adjusted CWC guidelines	Data and knowledge component	WRD	WRD and AIFRERM Agency

Environmental Component	Program Phase	Parameter	Standards	Location	Duration / Frequency	Cost (Rs)	Implementation	Supervision
Morphology	All phases	River bathymetry, bank line developments, sediment transport, flow velocity (through float tracking and cross-sectional surveys)	Same as above extended to progam needs at the different sites	Same as above	Same as above	Same as above	WRD	WRD and AIFRERM Agency
Surface Water Quality	Construction	pH, BOD, COD, TDS , TSS, DO, oil and grease	As per IS 10500:1991	Brahmaputra River and wetlands and ponds	Once during the dry season.	300,000 (@ Rs50,000/year for six year)	Independent environmental laboratories approved by SPCB	WRD and AIFRERM Agency
	Operation	pH, BOD, COD, TDS , TSS, DO, oil and grease	As per IS 10500:1991	Brahmaputra River and wetlandsand ponds	Once during the dry season.	30,000	Independent environmental laboratories approved by SPCB	WRD and AIFRERM Agency
Ground water and Drinking Water Quality	Construction	pH, BOD,DO, total coliform, As, Cd, Mn, and groundwater levels	As per IS 10500:1991	Construction site, rehabilitation site, service areas,	Once at the start of construction	30,000	Independent environmental laboratories approved by SPCB	WRD and AIFRERM Agency
	Operation	pH, BOD,DO, total coliform, As, Cd, Mn, and water levels	As per IS 10500:1991	Construction site, rehabilitation site, service areas,	Once at the start of construction	30,000	Independent environmental laboratories approved by SPCB	WRD and AIFRERM Agency
Noise and Vibration	Construction	Noise level in dBA	As per national standards for noise	Near the construction sites and sensitive locations close to embankment	One day hourly measurement, once in 6 months	30,000	Independent monitoring agency	WRD and AIFRERM Agency
	Operation	Noise level in dBA	As per National Standards for Noise	Near the habitats close to embankment	One day hourly measurement at 3–4 locations once	10,000	Independent monitoring agency	WRD and AIFRERM Agency
Soil Erosion (inland erosion) and siltation	Construction	Visual check for soil erosion and siltation	–	Riverbank and river training structure	After first precipitation	Part of routine action of engineering team	WRD-SIO	WRD and AIFRERM Agency

Environmental Component	Program Phase	Parameter	Standards	Location	Duration / Frequency	Cost (Rs)	Implementation	Supervision
	Operation	Study of soil erosion and siltation	–	River training structure, upstream and downstream of the reach	Once during first year of operation	Part of routine action of engineering team	WRD-SIO	WRD and AIFRERM Agency
Drainage Congestion	Construction	Visual check	–	Program benefit area	After 1 year of construction	Part of routine action of engineering team	WRD-SIO	WRD and AIFRERM Agency
	Operation	Visual check	–	Program benefit area	Once during first year of operation	Part of routine action of engineering team	WRD-SIO	WRD and AIFRERM Agency
Tree Plantation	Construction	Surveillance monitoring of trees felling	As laid out in the detailed design for Program	Entire stretch of the program reach	During site clearance in construction phase	600,000	WRD-SIO	WRD and AIFRERM Agency
	Operation	Survival rate of trees and success of re-plantation	The survival rate should be at least 70%, below which re-plantation shall be done.	Entire stretch of the program reach	Every year for 3 years	300,000	WRD field officers with the help of Social Forestry Program	WRD and AIFRERM Agency
Total Costs of monitoring construction stage								**Rs2,210,000**
Total Costs of monitoring operation Stage								**Rs720,000**
Transportation for sample collection, contingencies and other logistic support (Rs2,00,000 construction stage, and Rs1,00,000 Operation stage)								**Rs300,000**
Total cost of monitoring								**Rs3,230,000**

AIFRERM = Assam Integrated Flood and River Erosion Risk Management, CWC = Central Water Commission, dbA = decibel, IS = Indian Standard, SIO = subproject management office, SPCB = State Pollution Control Board, WRD = Water Resources Department.

Source: Water Resources Department, State Government of Assam.

ENVIRONMENTAL TRAINING PROGRAMS[1]

No.	Target group	Subject(s)	Method	Time Frame
Planning, and Construction Phase[2]				
1	All WRD program staff	**Environmental Overview:** Environmental regulations and national standards, process of impact assessment and identification of mitigation measures, importance of EMP and monitoring, and monitoring methodology	Lectures (by consultants and local training institutes)	Before implementation of the program
2	Environmental engineers, field officers, contractors, supervision consultants	**Implementation of EMPs:** Basic features of an EMP, planning, designing and executing of environmental mitigation and enhancement measures, monitoring and evaluation of environmental conditions during construction and operation	Workshops and seminars (by consultants and trained PMU staff)	Before the construction begins
3	Environmental engineers, field officers, contractors, supervision consultants	**Environmentally Sound Construction Practices:** Soil conservation; vegetation protection; waste management and minimization in construction; pollution control at construction camps, construction sites, hot mix plants, and material transportation; devices and methods for construction sites and equipment; environmental clauses in contract documents and their implications; environmental monitoring during construction	Seminars, lectures and site visits (by consultants and trained PMU staff)	Before the construction begins
4	Environmental engineers, field officers, contractors, supervision consultants	**Monitoring Environmental Performance during Construction:** Monitoring air, water, soil erosion, noise, and their effect on vegetation and fisheries; evaluation and review of results; performance indicators and their applicability; possible corrective actions; reporting requirements and mechanisms	Lectures, workshop, and site visits (by consultants and trained PMU and SIO staff)	During initial phases of construction
5	Construction laborers	**Waste Handling and Sanitation at Construction Sites and Construction Camps:**	Workshops and signage (by consultants and trained SIO staff)	During initial phases of construction

[1] The training programs are to be conducted through in house trainers and hired consultants/professionals. The train the trainer mode delivery may also be considered for in house training capacity development.

[2] During construction phase training/awareness programs will be organised twice a year. During operational phase one workshop/awareness program should be organised every year for the first 3 years. This workshop should highlight the details of environmental condition monitored and tips for environmental protection.

No.	Target group	Subject(s)	Method	Time Frame
During Operation Phase				
6	Environmental engineers, field officers, contractors	**Long-Term Environmental Issues in Program Management:** Designing and implementing environmental surveys for ambient air, noise, biological, and water quality; data storage, retrieval, and analysis; contract documents and environmental clauses; risk assessment and management; contingency planning and management; and value addition	Workshops and seminars (by consultants and local trainint institutes	During implementation of the program
7	Farmers of the area program benefit area, fishers associated with beel and pond fisheries	Cropping Pattern and high yielding crop production techniques	Workshops and seminars (by consultants, and resource persons from research institutes and line departments)	Construction and operations phase
8	Public	Environmental protection awareness program	Workshops and seminars (by consultants and trained PMU and SIO staffs)	Construction and operations phase

EMP = environmental management plan, PMU = program management unit, SIO = subproject implementation office, WRD = Water Resources Department.

Source: Water Resources Department, State Government of Assam.

ENVIRONMENTAL BUDGET

Component	Item	Unit	Quantity	Rate	Amount (million Rs)
Construction Phase					
Technical Support	• Preparation of environmental guidelines and performance indicators	Lumpsum	–	Rs0.5 million	0.50
Flora	• Clearing of plantation	km		Covered in engineering costs	
	• Compensatory afforestation (minimum 1:3) (plantation and maintenance for 1 year)	No of tree	45,000 for Palasbari	Rs20 per sampling and Rs500 for maintenance	23.40
			6,000 for Kaziranga	Rs20 per sampling and Rs500 for maintenance	3.12
			30,000 for Dibrugarh	Rs20 per sampling and Rs1500 for maintenance	15.60
	• Support to farmers for change in cropping pattern and monitoring agriculture productivity	Lump sum		Included in the overall program management costs	
Fisheries	• Support for improving fish productivity at wetlands and beel and pond fisheries.)	Rs per reach	3 reaches	Rs1.0 million per reach	3.00
	• Monitoring of fish productivity	Rs per reach	3 reaches	Rs0.4 million per reach	1.20
Drainage Congestion	• Provision of adequate opening	Covered in engineering cost			
Navigation	• Adequate lighting and signals	Covered in engineering cost			
Erosion and Sedimentation	• Riverbank protection measures	Covered in engineering cost			
Land	• Compensation against land acquisition and development of rehabilitation sites	Covered in R&R Budget			
Soil	• Maintenance cost in soil conservation	Covered in engineering cost			
Noise	• Provision for noise barriers	Covered in engineering cost			
Water	• Installation of oil and grease traps at construction sites and wastewater collection and disposal system	No	4 per reach for three reaches	0.080 million per system	0.96
	• Construction of soak pits at construction sites	No	4 per reach	Rs0.090 million per soak pit	1.08

Component	Item	Unit	Quantity	Rate	Amount (million Rs)
Dust Management during Construction	• Water sprayer and watering	Covered in Engineering cost			
Construction Safety	• Accident risks in construction activity	Covered in engineering cost and insurance			
	• General safety (provision of PPE, e.g., ear muffs, gloves etc.)	To be part of contractors costs			
Health	• Health check up camps for construction workers	camps	1camp per year per reach	Rs0.1 million per camp for six years	1.80
Environmental Monitoring in the Construction Phase	• Terrestrial and aquatic fauna, including fisheries • Cropping pattern • Ambient air quality • Surface water quality • Groundwater and drinking water quality • Noise and vibration • Soil erosion and siltation • Drainage congestion • Monitoring tree felling and plantation	Cost as mentioned in monitoring plan. Monitoring Costs considered on an average same for each reach. (@ Rs2.41 Million per reach for entire construction period)			7.23
		SUB TOTAL (CONSTRUCTION STAGE)			57.89
Operations Phase					
Erosion Control and Landscaping	• Reserve Fund for Erosion Control and Embankment Protection.	Lump Sum	To be part of regular maintenance and operation costs		
Tree Survival	• Survival monitoring and Provision of additional tree plantation	Lump sum	Costs towards survival monitoring are included in the monitoring budget.		3.00
Monitoring of Performance Indicators	• Terrestrial and aquatic fauna, including Fisheries • Ambient air quality • Surface water quality • Groundwater Quality and levels • Noise and vibration • Soil erosion and siltation • Drainage congestion • Monitoring tree plantation and cropping pattern	Cost as mentioned in the monitoring plan. Monitoring costs considered on an average same for each reach (@ Rs0.82 million per reach for entire construction period)			2.46

Component	Item	Unit	Quantity	Rate	Amount (million Rs)
		SUB TOTAL (OPERATION PHASE)			5.46
ESTABLISHMENT & TRAINING					
Establishment	• Construction Stage	Person - months	12	Rs75,000 per person month plus expert advise support lump sum Rs1.0 million	1.90
	• Operation Stage	Person - months	15	Rs75,000 per person-month (@ 2 person-months for 5 years and 1 person-month for additional 5 years) plus additional experts support lump sum Rs0.5 million	1.60
Training	• Environmental training and awareness	Lump sum	As per training details	-	3.00
Management Information System		Lump sum	-	-	1.00
Subtotal (Establishment & Training)					7.50
Subtotal (Construction, and Operation and Mobilization)					70.85
Contingencies @ 10 % on total environmental costs					7.09
Grand Total (in Rs)					77.94

PPE = personal protective equipment, R&R = resettlement and rehabilitation.

Source: Water Resources Department, State Government of Assam

PHOTOGRAPHS

1. Palasbari Subproject

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Plate 4: Kanjan River near Brahmaputra Confluence (river dolphine breeding site)

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Environmental Assessment Report

Environmental Impact Assessment
Project Number: 38412
June 2009

INDIA: ASSAM INTEGRATED FLOOD AND RIVERBANK EROSION RISK MANAGEMENT INVESTMENT PROGRAM

DIBRUGARH SUBPROJECT
DIBRUGARH DISTRICT

Prepared by the Water Resources Department of the State Government of Assam for the Asian Development Bank

CURRENCY EQUIVALENTS

(As of 1 June 2009)

Currency Unit – rupee (Re/Rs)
Re1.00 = $0.02122
$1.00 = Rs47.11

ABBREVIATION

ADB	–	Asian Development Bank
DMO	–	disaster management organization
EA	–	executing agency
EARF	–	environmental assessment and review framework
EIA	–	environmental impact assessment
EIRR	–	economic internal rate of return
EMOP	–	environmental monitoring plan
EMP	–	environmental management plan
FRERM	–	flood and riverbank erosion risk management
IUCN	–	International Union for Conservation of Nature
IWAI	–	Inland Water Transport Authority
KNP	–	Kaziranga National Park
MFF	–	multitranche financing facility
NGO	–	nongovernment organization
PMU	–	project management unit
PPTA	–	project preparatory technical assistance
SEIA	–	summary environmental impact assessment
SIO	–	subproject implementation office
SPCB	–	State Pollution Control Board
WRD	–	Water Resources Department

WEIGHTS AND MEASURES

dBA	–	decibel
Ha	–	hectare
Km	–	kilometer
km^2	–	square kilometer
m	–	meter
mm	–	millimeter
m^3/s	–	cubic meters per second

GLOSSARY

porcupine	–	Tetrahedron-shaped concrete frames commonly made of six concrete members, each 3 meters long connected with bolts, which are placed in an arrayed manner in the riverbed to retard river water flow and induce sedimentation.

revetment	–	A riverbank protection structure constructed on the bottom or banks of a river by placing a layer of material, such as rock, stones, concrete blocks, or mattresses including sand-filled geo-textile containers.
spur	–	A river training structure built from the bank of a river in a direction transverse to the current, by placing a large quantity of rocks, stones, or concrete blocks (or earth armored with these heavy materials).

NOTES

(i) The fiscal year (FY) of the Government of India ends on 31 March. FY before a calendar year denotes the year in which the fiscal year ends, e.g., FY2009 ends on 31 March 2009.

(ii) In this report, "$" refers to US dollars.

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1. INTRODUCTION

1. The Water Resources Department (WRD) of the state government of Assam, India engaged consultants to undertake an environmental impact assessment (EIA) of a multitranche financing facility (MFF) for the Assam Integrated Flood and Riverbank Erosion Risk Management Investment Program. The Program aims to enhance the effectiveness and reliability of flood and riverbank erosion risk management (FRERM) systems in three existing flood embankment systems (or subprojects) protecting urban, suburban, and other strategic areas of Assam: (i) Palasbari reach (74 kilometers [km]) in Kamrup (south) district; (ii) Kaziranga reach (29 km) in Golaghat district, adjacent to the Kaziranga National Park (KNP); and (iii) Dibrugarh reach (25 km) in Dibrugarh district. The Program also aims to strengthen the policy, planning, and institutional bases to support better FRERM operations. Comprehensive and adaptive structural and nonstructural FRERM measures will be provided in the three subproject areas. These are provided in two tranches during the 7-year implementation period, based on the local priorities.

1.1. Background

2. The state government of Assam submitted an investment proposal to ADB in 2006 for strengthening key existing FRERM infrastructure along the vulnerable reaches of the Brahmaputra River that is protecting the vital economic, social, and ecological interests of the state. The Brahmaputra River is the main cause for erosion and flooding in the Assam. This river instability (river bank erosion and flooding) hampers development and poverty reduction in the state. In response to the proposal, Technical Assistance (TA No. 4896-IND) has been provided to WRD in two phases. Phase I (May through September, 2007) covered the strategy and options studies included in the pre–feasibility of four priority sites. Phase II (November 2007 through June 2008) included subproject option finalization and feasibility studies, institutional assessments, and project packaging.

1.2. IFRERM Assam Subproject Locations and Dibrugarh Subproject

3. Under this TA three most vulnerable reaches located in the State of Assam (Latitude 24°08' N and 27°59' N and Longitude 89°42' E and 96°01' E) along the bank of Brahmaputra River have been selected. The locations of the subproject reaches are (i) Majirgaon - Nagarbera (Palasbari Reach) in south bank of Kamrup district, (ii) Oakland-Bogibeel (Dibrugarh Reach) in Dibrugarh district, (iii) Bankoal-Moriholla-Diffalupathar (Kaziranga Reach) in Golaghat district are shown in Figure 1.1. This report covers the environmental assessment of sub-project - Dibrugarh Reach.

1.3. Nature, Size and Location of Sub-Project – Dibrugarh Reach

4. The proposed sub project – the Dibrugarh Reach is approximately 40 km long from Oakland to Bogibeel. It involves rehabilitation and strengthening of Dibrugarh Town Protection (DTP) dyke, maintainance of 7 existing spurs in front of the DTP, rehabilitation and strengthening of Hiloidhari Bundh/ Titadimaru dyke, construction of inspection road over DTP dyke, construction of 2 gated drainage sluices, and the provision of river protection/pro-siltation measures from Oakland to Bogibeel. The riverbank anti-erosion measures will involve revetment works with bed bar/porcupine screen, renovation of existing land spurs as well as renovation of existing sluice gate. The priority shall be given to rehabilitation and strengthening

of DTP dyke and maintenance of existing land spurs. The sub-project alignment is shown at Figure 1.2.

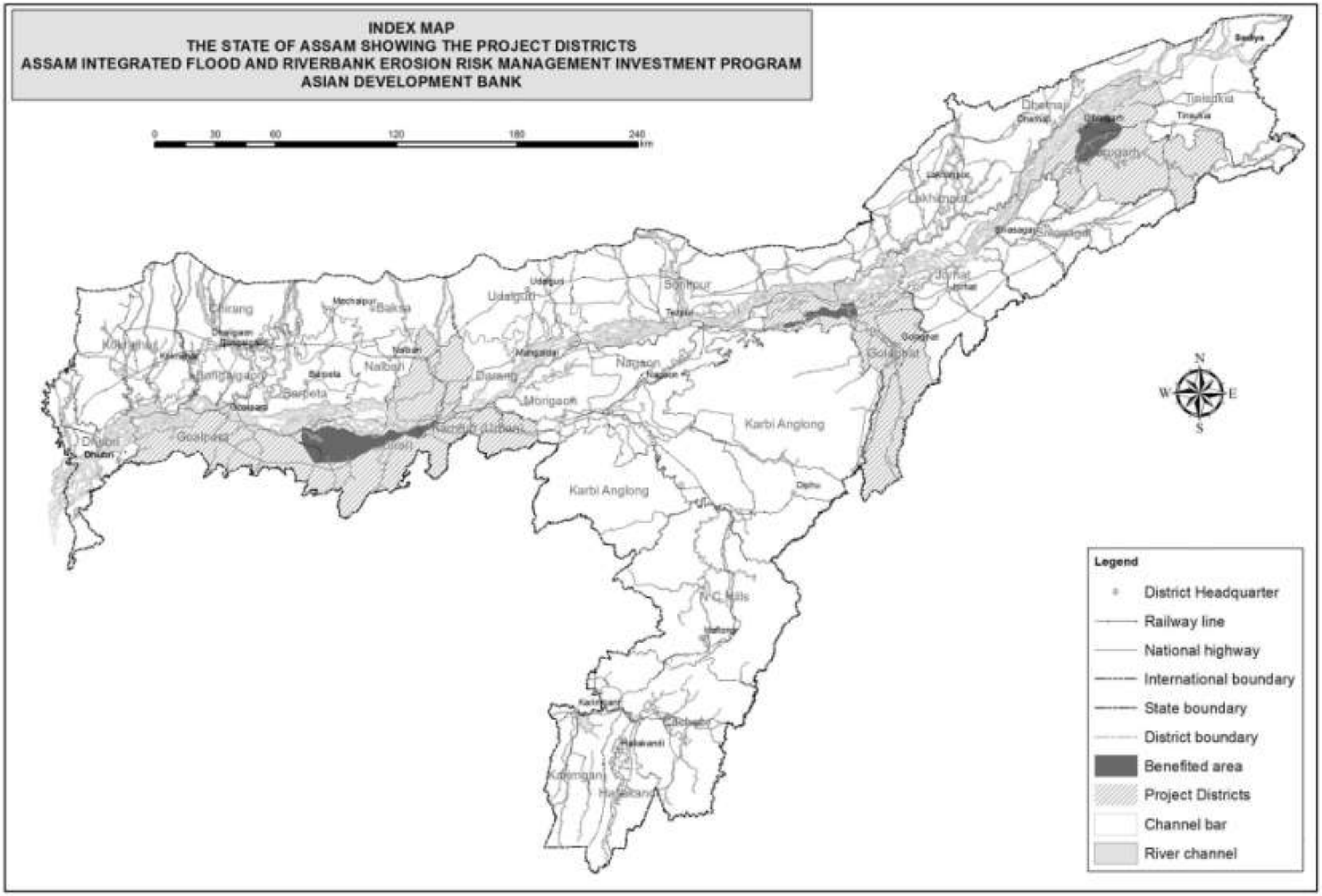

Figure 1.1 Location Map of the Project (Selected Sub-projects)

Satellite image of the Dibrugarh sub-project site IRS LISS III image of November, 2007

Figure 1.2 Alignment of Sub-project (Dibrugarh Reach)
(Source: IRS Image, 2007)

1.4. Purpose of the Report

5. This report primarily focuses on the environmental impacts of the structural components of the IFRERM Assam, public consultations conducted, and recommended mitigation and monitoring measures.

6. The sub-project focuses on Dibrugarh Reach located in Dibrugarh District, about 530 kilometers from Guwahati and 580 kilometers from the Bangladesh border. The sub-project area investigated under this study is consist of 27,970 hectares of mostly agricultural, homesteads, and tea garden areas confined between elevation 715-95 meters above mean sea level. Dibrugarh is an old settlement – known as the tea “capital” of India – which started with the British *raj.*

7. Originally the Dibrugarh town was located on the banks of Dibru River, a small river and its outfall was at Mohanaghat into the Brahmaputra River. The Brahmaputra was originally flowing a couple of miles away from Dibrugarh town. At present, the outfall of river is 60 to 70

km upstream from the Dibrugarh town. The gradual trend towards south bank and eventually by the process of erosion, the Dibru River merged to the river Brahmaputra

8. The town of Dibrugarh was at the verge of extinction from riverbank erosion and increased flooding in the early 1950s, as a consequence of dramatic, and still ongoing, river changes after the 1950 earthquake. At that time, the Indian government, led by then Prime Minister Jawaharlal Nehru, had riverbank protection and flood protection works constructed over a two-year period, works which are still functioning today to keep the town safe.

9. The town of Dibrugarh is protected from flooding for more than 50 years with the existing work performing without failure to date. Over time significantly increased river bed levels with associated increasing flood levels have increased the risk of failure of the existing flood protection. In addition rising riverbed level indicate the need for pump drainage during periods of high water levels. The resulting higher water level difference increases the pressure on the existing embankment system further. This situation will deteriorate in future after Bogibeel Bridge is built with Dibrugarh being in the backwater zone, where increased deposition of silt will take place. The Project suggests putting major focus on the raising and strengthening of the embankment. Supporting riverbank protection is suggested in order to secure the embankment at the town, but in future also to respond to upstream erosion, if required. This means that the upstream area does not get benefits from flood protection but only erosion protection

1.5. Extent of the EIA Study

10. The environmental assessment was done in tandem with the preparation of the feasibility report. The EIA is based on most up-to-date subproject details/ concept design provided by the Design Team during the preparation of this report. Minor changes may occur in the sub-projects structural component, but these changes are expected to be limited to implementation schedule. References have also been made on the pre-feasibility and feasibility reports.

11. The EIA study covered all activities proposed for the integrated flood and riverbank erosion management in Dibrugarh Reach. The impact area covers section of river Brahmaputra (complete reach length, its immediate upstream and downstream sections, area within 100 m either side of the reach[1], project benefit area, and beels/wetlands/ tributaries connected with the river in the reach area). The study area has been extended to cover a buffer zone of 8 km wide[2] on either side of the embankment to analyse the land use, identify environmentally sensitive locations, if any, and understand the overall drainage pattern of the area. Geographical Information System (GIS) techniques have been used based on recent satellite data of the project area to analyse the baseline physical, ecological and cultural landscapes and to gather the relevant data for EIA purpose. Impact on aquatic life including Dolphin, their breeding/spawning areas, migratory route of fishes have also been assessed. Assessment of

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[1] Core zone of the impact was taken as 100m on either side of the reach based on the expert judgement as most of the project activities related to embankment renovation and/or new construction, bank protection will primarily be limited to this zone.

[2] The study area has been selected based on the following two considerations:

(i) The sub-project specific benefit area which is varying up to about 7 km from the embankment in case of Kaziranga reach

(ii) The practice adopted by Ministry of Environment and Forests (MoEF), Government of India for delineating environmental assessment of the project, which is 10 km around the project boundary (Though we have followed MoEF guidelines but this project will not require any formal clearance from MoEF as detailed under Section 2.2.1) vegetation cover, migratory route of animals, and sourcing of construction material particularly borrow earth and aggregate has also been undertaken.

12. The report has been prepared by:

- **S K Jain**, Environmental Expert, EQMS India Pvt. Ltd.
- **Prof. D C Goswami**, Environmental and Geo Hydrology Expert
- **Naval K Chaudhary**, Environmental Specialist

13. Additional inputs have been provided by:

- **Dr. P K Saikia**, Reader, Department of Zoology, Gauhati University for Terrestrial Ecology
- **Dr. Amalesh Dutta**, Professor, Department of Zoology, Gauhati University for Aquatic Ecology
- **Environmental Science Deptartment**, Gauhati University for Ambient Air Quality, Ambient Noise Monitoring, Soil and Water Quality Testing
- **Dr. Sarat Phukan** and **Ms. Chinmoyee Gogoi**, Gauhati University for Remote Sensing and GIS Related Inputs

1.6. EIA Content

14. This EIA report is presented in nine chapters, consistent with he ADB's Environmental Assessment Guidelines (2003). This includes this introduction, and individual chapters describing the subproject, environment, alternatives, anticipated environmental impacts and mitigation measures, economic assessment, environmental management plan, public involvement and disclosure, and conclusion.

1.7. Methodology

15. The EIA study was carried out using reconnaissance survey, review of previous studies, field visits, consultation with stake holders and NGOs, review of existing data, assessment to identify adverse impacts, and the preparation of environmental management plan (EMP). Extensive use was made of geographic information system established by the project as part of the engineering and knowledge base component. The EIA also builds on the Brahmaputra morphology study using satellite imagery, risk maps, and studies on the influence of spurs and anti-erosion activities of the Water Resources Department (WRD) in Assam. The scope of the EIA extends well beyond the vicinity of the proposed structural measures and covers the entire Brahmaputra River section fronting the existing and proposed measures, and to the extent possible, 8 kilometers radius as the general impact zone. While, the immediate 100-meter corridor centered along the existing and proposed embankment alignments as the primary impact zone where most of the adverse impacts may occur. The decision to expand the environmental assessment impact zone to 8-kilometer radius is based on the following: i) to ensure that environmental impacts attributable to the project are comprehensively identified and assessed, ii) allow flexibility in the detailed design of Tranche II measures, which will adapt to the rapid changes in Brahmaputra River morphology, by providing a comprehensive environmental baseline information, and iii) recognizes that FRERM measures to influence the flow direction and promote siltation in strategic areas may have environmental impacts downstream.

1.7.1. Data Collection

16. The objective of data collection was to provide a database on existing conditions, to be used for predicting the likely changes that are expected and for monitoring such changes. The first step was to undertake a subproject scoping exercise, identify the parameters to be considered, and outline the activities for collecting data on identified parameters. Sources of data were identified and relevant existing data on the physical, biological, and socio-economic aspects of the environment from authentic secondary sources were collected. Data collected, sources, and application are summarized in the succeeding Table.

Table 1.1 Information Collected and Sources

Information Collected	Sources	To be Used in
Project location, project objectives, project designs, and sourcing of construction materials	Pre-feasibility Report; Concept design prepared by TA Consultant team and WRD	Project description and impact assessment
Wildlife, forest areas in project vicinity, flora and fauna details, and possible ecological impacts and mitigative actions	Department of Zoology, Gauhati University; District Forest Office; Department of Environment and Forests, Govt. of Assam	Project description, impact assessment and mitigative actions, alternative analysis, and economic assessment
Engineering details	TA consultants	Project description, impact assessment, and mitigative actions
Existing quality of the environment, land use, meteorological data, possible impacts because of the project and proposed action plans, identification of ecologically sensitive locations, regulatory compliance	Primary data collection; Department of Environment and Forests; Department of Fisheries; District Forest Office; Census Report, Govt. Of Assam; IMD Regional Office, Guwahati; Gauhati University Library, State Pollution Control Board, Assam	Project description, impact assessment and mitigative actions, management plan, and environmental economic assessment
River geomorphology, hydrology, and flood pattern	Published Research; Govt. Reports; Unpublished Doctoral thesis's, ARSAC reports, Brahmaputra Board, WRD, and GSI Reports	Project and environmental descriptions, and impact assessment

17. Primary data was also collected for noise, water quality, air quality, and soil. Since Dolphin is an endangered species, special efforts were made to identify areas where they are frequently sighted including their breeding grounds.

1.7.2. Public Consultation

18. Local knowledge about the ecosystem and problems associated with river behaviour and existing flood protection and erosion control measures were carefully recorded and used in impact assessment and developing mitigation plan. Consultations were held focusing on aquatic and terrestrial flora and fauna to identify sensitive ecosystems that may be affected by the

subproject. Formal institutional level public consultation and opportunistic informal meetings involving local villagers, fishermen, and those who are likely to be affected due to the proposed projects were organized to determine potential socio-economic impacts. Finally, interactions were made with various NGOs and concerned government officials.

19. Public consultations were held with the stakeholders during the two state workshops, on December 2007 and June 2008 in Guwahati. Taking into consideration the environmental importance of the project, a number of environmental NGOs were invited during these state workshops, with the advance sharing of the executive summaries of the study findings in each stage, and post-workshop posting of the presentations in the ADB's website on the project information. However, only a few had turned up. A detailed description of the public consultation has been presented in Chapter 8.

2. DESCRIPTION OF THE PROGRAM AND SUBPROJECT

2.1. Rationale

20. India is one of the most disaster-prone countries in the world. Flooding is a major recurrent natural disaster, causing damage of average $450 million annually with increasing incidence in the recent years. The country has a flood prone area of 46 million ha (accounting for some 14% of the geographical area and 25% of cultivable area). A national level policy framework for flood management is promoting short- to long-term programs for both structural and non-structural measures with a basin wide approach with improved catchment management. About 18 million ha in flood prone area has so far been protected with flood embankments and other structures, whereas nation wide flood forecasting and warning system has been set up. However, large gaps still exist between the policy framework and operations at the individual state level.

21. Flooding in the Brahmaputra plain in Assam is a complex phenomenon with different factors often changing roles. These factors are: (i) the Brahmaputra River in high spate has the potential to flood major parts of the plain for extended period of time; (ii) tributaries flood their adjacent plains, but for shorter periods being of short term character in steeper hilly parts with longer-term flooding, influenced by Brahmaputra water levels, in their lower floodplains; and (iii) local rainfall can cause flooding (local floods associated with drainage congestion) even when rivers not over spilling, but commonly drain away after hours or days. Overall, the effective FRERM requires a long-term basin wide approach with a sound planning framework integrating short- to longer-term programs including (i) improved catchment management, (ii) multipurpose reservoirs including flood cushion where feasible, and (iii) balanced combination of structural and non-structural measures to cope with immediate annual risks.

22. Assam remains one of the poorest states in India, with per capita income 45% below the national average in 2005. An inability to minimize the impacts of frequent flooding remains one of the serious development constraints.[3] Flooding and river erosion have devastating impacts each year. The floods are caused by the runoff of extremely heavy rainfall during the monsoon and high sediment loads from upper watersheds that are geologically unstable and degraded because of deforestation and changing land use. Their effective management requires a long-term, basin-wide approach with a sound planning framework integrating short- to longer-term programs, including (i) better catchment management, (ii) multipurpose reservoirs where feasible, and (iii) a balanced combination of structural and nonstructural measures to cope with immediate annual flood and erosion risks.

23. While the state has flood embankment systems protecting 50% of its flood-prone areas, their reliability is constrained by deterioration associated with poor maintenance, failure from river erosion, and local riverbed rising. The improvement of the existing embankments needs to be prioritized, particularly along high-value locations with assured maintenance, supported by riverbank protection where feasible. More cost-effective and flexible options that can adapt to the dynamic river process should be explored. Alternative risk management measures need to be pursued in other areas, such as flood proofing, strategic retirement of embankments, and a range of nonstructural measures including flood and erosion risk prediction and mapping, advance warning, and safety nets for the people threatened and displaced by flooding and river

[3] The Brahmaputra Valley in Assam is one of the most acutely hazard-prone regions of the country, with more than 40% of its land (3.2 million hectares) susceptible to flood damage. This is 9.4% of the country's total flood-prone area. The erosion hazard is also extremely severe in several vulnerable reaches. About 7% of land in the state's 17 riverine districts has been lost because of river erosion over the past 50 years.

erosion. Comprehensive strengthening of the policy, planning, and institutional basis, data, and knowledge base are also required, along with the effective participatory mechanisms to ensure accountable program management.

24. The Government, in its Eleventh Five Year Plan,[4] has prioritized flood management, in line with the paradigm shift of the country's disaster management strategy to focus more on preparedness than responses. This is also in line with a growing concern about the impacts of climate change. The state government has also initiated steps to establish a sound policy, planning, and institutional framework for water resources management, including drafting a state water policy and a vision for holistically managing flood and riverbank erosion from a basin perspective. The Program is designed to support the state government's initiatives by promoting necessary reforms and strengthening key sector organizations, such as the WRD and local participatory disaster management organizations (DMOs). Structural measures will focus on the three existing embankment systems protecting key urban and productive rural areas, which were selected as the priority sites for putting into operation effective FRERM systems. The establishment of a sound data and knowledge base to effectively manage or respond to the dynamic natural river processes will be emphasized.

25. The IFRER Assam is needed to support the SGOA's initiatives to start taking the specific steps towards more effectively managing the risk of flood and river erosion problems with long-term integrated perspective. Support is to be provided to promote the necessary reforms and capacity strengthening in terms of policy and institutional bases and a sound planning framework placed within a long-term basin context while institutionalizing comprehensive and effective structural and non-structural measures in strategic locations of the state. Structural measures will focus on proper functioning as per the intended design of the existing embankment systems protecting key urban and productive rural areas and requiring upgrading and protection against river erosion exploring alternative (cost effective and sustainable) designs, whereas non-structural measures will extend to the most vulnerable locations to the impacts of chronic flooding. Significant emphasis will also be placed on establishing sound data and knowledge base to effectively manage or respond to the dynamic natural river processes while not disturbing them as much as possible.

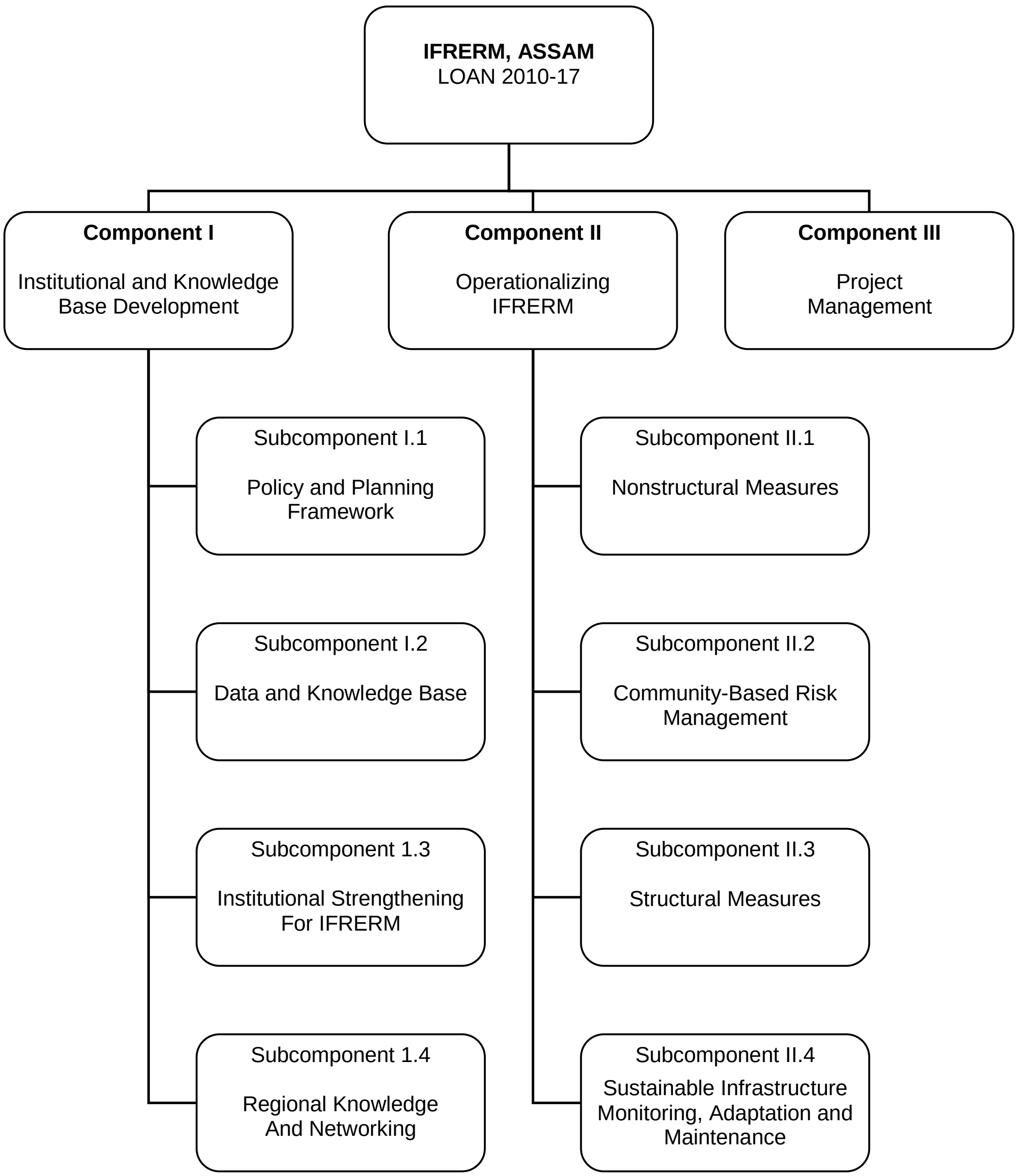
2.2. The Program

26. The Program intends to (i) improve the state's ability to mitigate flood and erosion damage at three priority subprojects that have embankment systems, (ii) increase economic development, and (iii) reduce poverty. Recognizing the need for a holistic approach to FRERM, the Program has several components that mix structural and nonstructural measures, as shown in Figure 1. Component I will address the enabling environment and institutional framework, particularly the policy and planning framework, institutional strengthening, and capacity building. Component II will address the operationalization of integrated FRERM through structural, nonstructural, and community-based risk management measures. Structural measures include the renovation of existing embankments, including their retirements, to maintain their intended design functions; provision of riverbank protection; and associated drainage structures, such as sluice gates along the embankments, to improve local drainage. Component III will address project management and training of project organizations. It is estimated to cost $149 million including financial charges. The Program is described in more detail in Appendix 1.

[4] Government of India. 2007. *Eleventh Five Year Plan (2007-2012). New Delhi*

27. The Program is to be implemented over 7 years, from 2010 to 2016 (including 1 year for maintenance support). Although designed as a project loan having three appraised subprojects, an MFF is adopted for the implementation of the Program to achieve higher quality implementation, progressively improve program design by incorporating lessons, and progressively develop institutional basis and capacities. Within the MFF framework, the implementation philosophy follows an adaptive approach to allow construction at the right place at the right moment. The flexible response largely applies to the implementation of riverbank protection measures. As such, the subproject works are divided into two tranches. The first tranche is more definitive for immediate implementation following local priorities, while the second tranche is indicative at this stage and a more definite scope will be defined at the time of its processing. An updated or revised EIA will be prepared at that time as required.

Figure 1: Program Components



28. A participatory and holistic FRERM will be used to implement the Program. For this purpose, a multidisciplinary project management unit (PMU) will be established under the Assam Integrated Flood and Riverbank Erosion Risk Management Agency, which is being established with registration under the Societies Registration Act. The PMU will provide stable leadership and strong coordination of technical, nonstructural, and participatory agendas. At the subproject level, multidisciplinary subproject implementation offices will be set up, combining technical, disaster management, and coordination functions. The established system of DMOs, implemented under the United Nations Development Program Disaster Risk Management Project, will be extended to include a wider range of stakeholders and jointly decide on and monitor implementation. The concerned state departments, including the WRD, will be held accountable to DMOs for sound program delivery.

29. The more specific scope of the IFRERM-Assam will include the following:

<u>Component I: Institutional and Knowledge Base Development</u>

(i) Policy and Strategic Planning Framework: (a) consultations towards finalizing State Water Policy and steps for initiating implementation; (b) long term state FRERM plan (building on existing plans, with integration to wider watershed issues)
(ii) Institutional Bases: (a) institutional development actions for WRD and line departments; (b) improved guidelines and manuals including nonstructural measures; (c) FRERM infrastructure asset management information system (MIS); (d) comprehensive capacity development
(iii) Data and Knowledge Base (linking with central and state institutions): (a) data base on hydrology, morphology, sediment transport, topography; (b) tools including flood risk mapping and short-term erosion prediction system; (c) strengthened flood warning system; (d) M and E and R and D system
(iv) Regional Knowledge Sharing and Networking: (a) international networks for FRERM and disaster risk management (DMS); (b) knowledge exchange

<u>Component II: Comprehensive FRERM Systems in Selected Subproject Sites</u>

(i) FRERM Nonstructural Measures: (a) flood and erosion risk mapping; (b) improved warning systems; (c) participatory flood emergency response system; (d) other flood adaptation measures (adaptive cropping, fish culture, etc.)
(ii) Community-based Risk Management: (a) participatory systems integrated with local disaster management committees (DMCs); (b) community FRERM plans; (c) plan implementation such as community awareness, flood shelters, associated flood coping and development programs, e.g., adaptive cropping, fisheries, and livelihoods
(iii) FRERM Structural Measures: (a) upgraded embankments with assured maintenance (with extended platforms as appropriate); (b) systematic riverbank protection exploring cost-effective, adaptive, and sustainable alternatives; (c) associated infrastructure (drainage sluices, canals, etc.)
(iv) Sustainable FRERM Infrastructure Maintenance

<u>Component III: Project Management and Associated Capacity Strengthening</u>

(i) Project management support with community participation (through disaster management systems) with incremental staffs including those hired from the market, implementation consultants, and other operations
(ii) Training for Project-related operations

30. The proposed program will be implemented in two Tranches at three sub-project sites with each Tranche having 3 year duration. Tranche I focus on the development and provision of urgent structural works, knowledge base development to add to the understanding of flood behaviour and riverbank erosion process in the subproject areas, and cost effective structural flood protection measures specific to Assam. Based on the lessons learned and developments of Tranche I, structural works will be finalized, taking into account the rapid changes of the river environment.

31. Structural measures will renovate and strengthen existing flood embankments as opposed to new construction, with a focus on the systems protecting the vital areas of economic interests. The existing system of flood embankments needs to be supported by riverbank protection measures where feasible, as the Brahmaputra is widening – eroding more and more embankments and posing the risk of large scale avulsion or channel migration in certain locations. Riverbank protection provides the additional benefit of safeguarding the valuable flood plain habitat between existing flood embankments and river. Flood plain land is higher in biodiversity than lower lying often sandy and less valuable amphibian river habitat into which the floodplains turn after erosion. In order to improve the water exchange on the floodplain, especially for drainage but also to allow targeted replenishment of beel areas, a large number of sluice gates will be constructed under this Project.

32. The project implementation philosophy follows an adaptive approach, which means being flexible to respond to unpredictable river changes in future and as such reducing structural work, especially riverbank protection measures, to only those areas immediately threatened. Recognizing the unpredictability of the Brahmaputra River and driven by the objective to minimize cost, the planning framework of structural component incorporates great flexibility in order to allow construction at the right place at the right moment. The flexible response largely affects the implementation of riverbank protection measures, but to a certain degree also the strengthening or rebuilding of embankments. In the case of riverbank protection, the work location might shift upstream or downstream than previously envisaged during planning, in response to the changes in the river channel pattern particularly if previously completed structures are at risk of being outflanked by the river. In case of embankments, this could mean the rebuilding of an embankment that was once envisaged for strengthening if it has already eroded.

33. In implementing the subprojects, IFRERM-Assam will put into operation participatory, effective, and comprehensive FRERM at the community and subproject levels. For this purpose, the SGOA will establish a multidisciplinary project management unit anchored to WRD and Disaster Management Department (DMD), to be registered under the Societies Registration Act as an autonomous agency, which will provide stable leadership and strong coordination of technical and non-structural agendas including safeguards required for integrated FRERM. At the subproject level, there will also be subproject implementation units (SIUs) comprising technical team (constituting the WRD's field offices) and disaster management and coordination team (constituting multidisciplinary staff in disaster risk management, social mobilization, and safeguards, who will be engaged locally). Existing disaster management committees at subdistrict and village local government levels will be extended and utilized to jointly decide on and monitor implementation, to which the concerned state departments including WRD will be held accountable.

2.3. The Dibrugarh Reach Sub-Project

34. The Diburgarh reach has considerable significance from the socio-economic, terrestrial ecological as well as hydrological perspectives. Although the protection of Dibrugarh town from erosion of the Brahmaputra River that started in 1960's is rightly being claimed to be a success story, yet over the years the problem resurfaces itself in new forms as the river configuration vis-à-vis the adjoining river bank areas have changed considerably and reaches upstream and downstream of the town are being affected by chronic erosion hazards eating away large chunks of productive tea cultivated lands. A dense settlement of permanent nature has come up on the river side of the embankment which has undergone considerable degradation and lowering over the years and often affected by seepage during high flood level. Strengthening of Titadimaru Dyke (4.70 km) along south bank of Maijan beel as per highest HFL is equally essential for the protection of vital installations like Airport, Medical College. Therefore, safeguarding the area and protection of tea and oil industries through integrated flood and riverbank erosion management is considered highly essential.

35. The Brahmaputra River in the vicinity of Dibrugarh is undergoing a process of aggradations (Figure 2.3). The related problems are channel widening accompanied by substantial bank erosion upstream of Dibrugarh and an increasing flood risk for the surrounding flood plains. Significant and sudden aggradations occurred immediately following the powerful earthquake of 1950, leading to the loss of approximately half of the town from bank erosion and flooding. Following this disastrous event, substantial money and effort was invested in constructing effective riverbank protection as well as flood protection works. The process of bed aggradations and channel widening is placing the existing flood embankments under increasing threat of erosion as well as the possibility of being overtopped by the upward-trending peak flood heights. Ongoing downstream work at the Bogibeel bridge crossing is encroaching into the river and is likely to exacerbate the present situation as the bridge backwater will lead to increased deposition rates. The succeeding shows the general geomorphic features of the area.

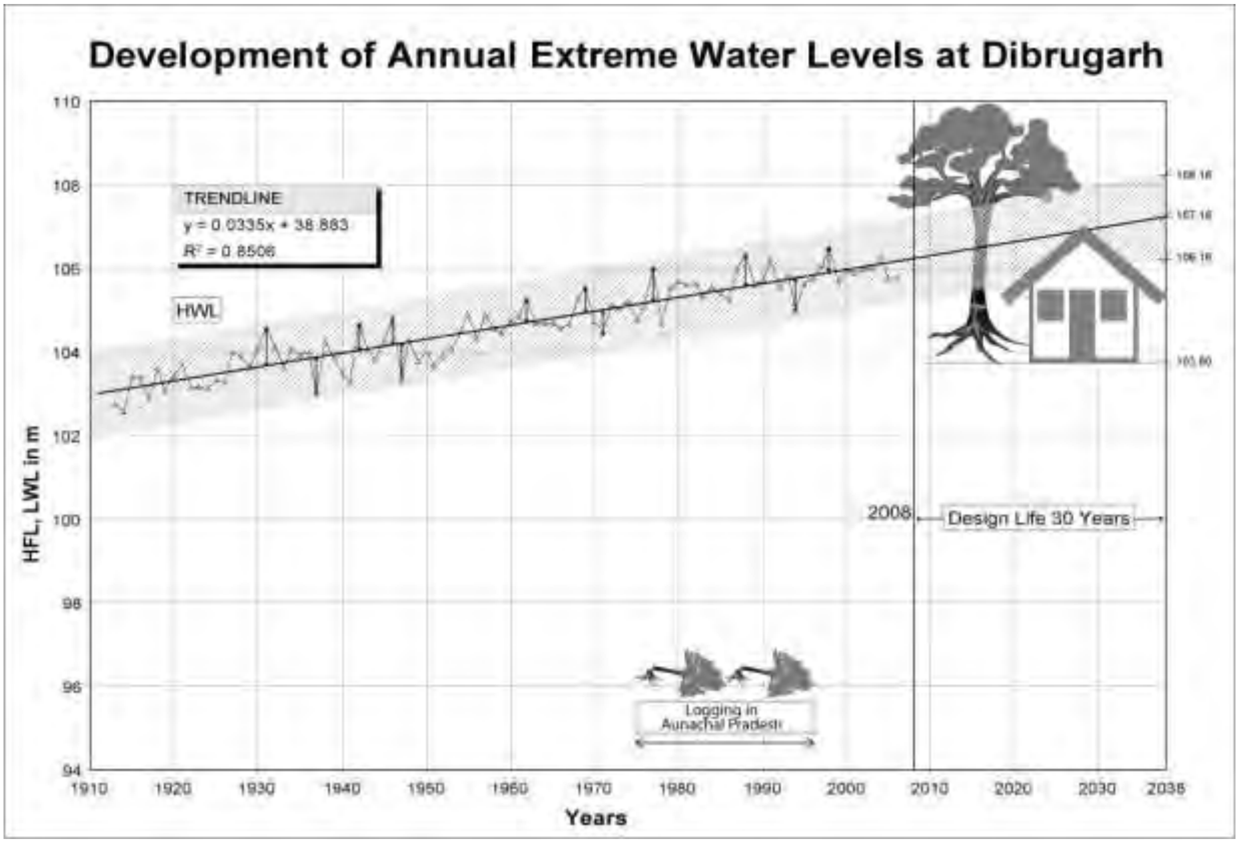


Figure 2.1 Water level development at Dibrugarh.

36. Based on the frequency distribution of water levels at Dibrugarh, the 2004 Flood had an average return period of 2-3 years and a flood level of 107 m would have a return period of about 35 years. Both these estimates are for the state of the bed level in 2010. If we are designing for a life span of 30 years (say to 2040), bed levels are projected to rise a further 1.00 m. Thus 107 m in 2040 corresponds to 106 m in 2010. This reduces the average return period to less than 2 years! The conclusion is that the embankment crest level has to be continually raised into the future to provide the same level of protection.[5]

[5] While this project assumes a crest level sufficient for the next 30 years, future construction space must be created/preserved for further raising, and incorporated into land-use zoning.

Figure 2.2 Geomorphic features and potential hazards of the Dibrugarh sub-project site. (Erosion and accretion from 1967 to 2008)

2.4. Sub-project Components and Activities[6]

2.4.1. Structural Measures

37. The Dibrugarh dyke was constructed in 1955-56 on the south bank of the Brahmaputra river in front of Dibrugarh town. The dyke known as DTP dyke has a length of 9.42 km from Maijan to Mohanaghat. This dyke was extended further upto Oakland on upstream (9.10 km) and Titadimaru along Maijan beel (4.70 km). The total length along river Brahmaputra was 18.52 km (9.42 + 9.10). A marginal bund exists along river near Maijan beel. The entire dyke along the river 20 km (18.52 + 1.5) will be renovated. This reach will cover important Dibrugarh town, vital installation in Dibrugarh town and Tea Gardens. The site plan of DTP from Oakland Ghat to Mohanaghat is shown in Figure 2.3.

38. The existing embankment system requires a higher level of water proofing and protection from overtopping. Due to the often limited space and in order to avoid large scale disturbance of the existing settlements, the project proposes specific technical solutions for the improvement of the existing embankment along the densely settled areas such as sheet piles, slurry walls, or grouting. In less populated places widening and raising of the embankment is envisaged. The embankment line will be straightened in close discussion with settlers, where feasible.

39. The existing embankment system will be protected from riverbank erosion by installing pro-siltation measures along the bank in order to reduce the flow and provide a buffer between main channel and embankment. Riverbank protection will extend to areas upstream of the town, in order to avoid outflanking of the town.

40. The structural measures proposed under this TA have been divided in two tranche. The details of structural measures are presented in the succeeding paragraphs and also shown in Figure 2.4.

2.4.1.1 Tranche 1, DPR year 1 to 3:

(i) **Rehabilitation and strengthening of 9.5 km of Dibrugarh town protection (DTP) embankment (Rs420 million).** The existing embankment section needs to be raised in response to the rising riverbed levels over the years. To reduce the impact on the existing settlement along urbanized areas, the design takes additional measures to minimize the width of the embankment and to stay as much as possible within the acquired width of 100 feet.

(ii) **DTP dyke bank protection (Rs15 million).** Along the DTP dyke, especially between 6.5 km and 8.3 km posts, channel erosion will be controlled through systematic placing of porcupine screens. The screens increase the friction of the channel, reduce the slope of the energy grade line, and encourage siltation. The placement of the porcupine screens is adaptive over 3 years, in general starting from the downstream end of the town and moving upstream.

6 The area on the west bank of Dhansiri River (a tributary of Brahmaputra River) is protected partly near the mouth by one embankment. This embankment is connected to one PWD road leading to NH 37. But on the eastern side of the said river, there is no embankment. Moreover, there is a branch river of Dhansiri, called Geelabeel river, flowing almost parallel to the Brahmaputra River (East-west direction), though Dhansiri river is flowing North-South originating from Mikir Hills in Karbi-Anglong State. During flood season, spilling occurs on the two sides of these rivers and full area is flooded. Therefore, flood embankments are necessary on the eastern side of Dhansiri river up to NH 37 along with one regulator across Geelabeel river for protecting the land from Dhansiri flooding.

(iii) **Mothola–Oaklands bank protection (Rs255 million).** Between 7.8 km and 5.4 km points (Spur No. 1 and Nagaguli Spur) along the Mothola–Oaklands dykes, bank protection will be implemented using sand-filled geotextile bags (below the low-water level) and concrete blocks (above the low-water level, for wave protection).

The total estimated cost for tranche 1 works is Rs690 million ($17.2 million).

Tranche 2 (years 4–6, subject to future verification):

(i) **Minor rehabilitation of seven existing spurs in front of the DTP dyke (Rs28 million).** The work comprises an extended under water carpet around the spur head consisting of geotextile bags and limited slope protection above water. The spurs will then be functional.

(ii) **Rehabilitation and strengthening of 4.7 km Hiloidhari Bundh–Titadimaru dyke (Rs68 million).** This dyke protects the upstream flank of Dibrugarh against flooding from the Maijan beel.

(iii) **Construction of 9.5 km inspection road over the DTP dyke (Rs39 million).** The crest of the existing embankment provides the only quick access during emergencies along the densely populated area of the town. To maintain this access, the subproject proposes black top carpeting.

(iv) **Construction of two gated drainage sluices at selected locations of the DTP dyke (Rs40 million).** Certain areas of the town need to be provided with additional rainwater drains to reduce pumping costs during the early monsoon season and to drain low-lying areas at the end of the flood season.

The total estimated cost of tranche 2 works is Rs175 million.

The total estimated cost for this subproject is Rs865 million. The work distribution over 6 years is estimated in Table 2.1.

Table 2.1 Summary of Tranche-wise Work at Dibrugarh Reach

Item	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
DTP dyke, 9.5 km		50	50			
DTP dyke bank protection, 1.8 km	50	30	20			
Mothola Oakland bank protection, 2.4 km	50	50				
Rehabilitation of 7 spurs				40	60	
Hiloidhari–Titadimary dyke, 4.7 km				50	50	
Inspection road 9.5 km				25	75	
2 gated drainage sluices					75	25

DTP = Dibrugarh town protection

Source: Water Resources Department, State Government of Assam.

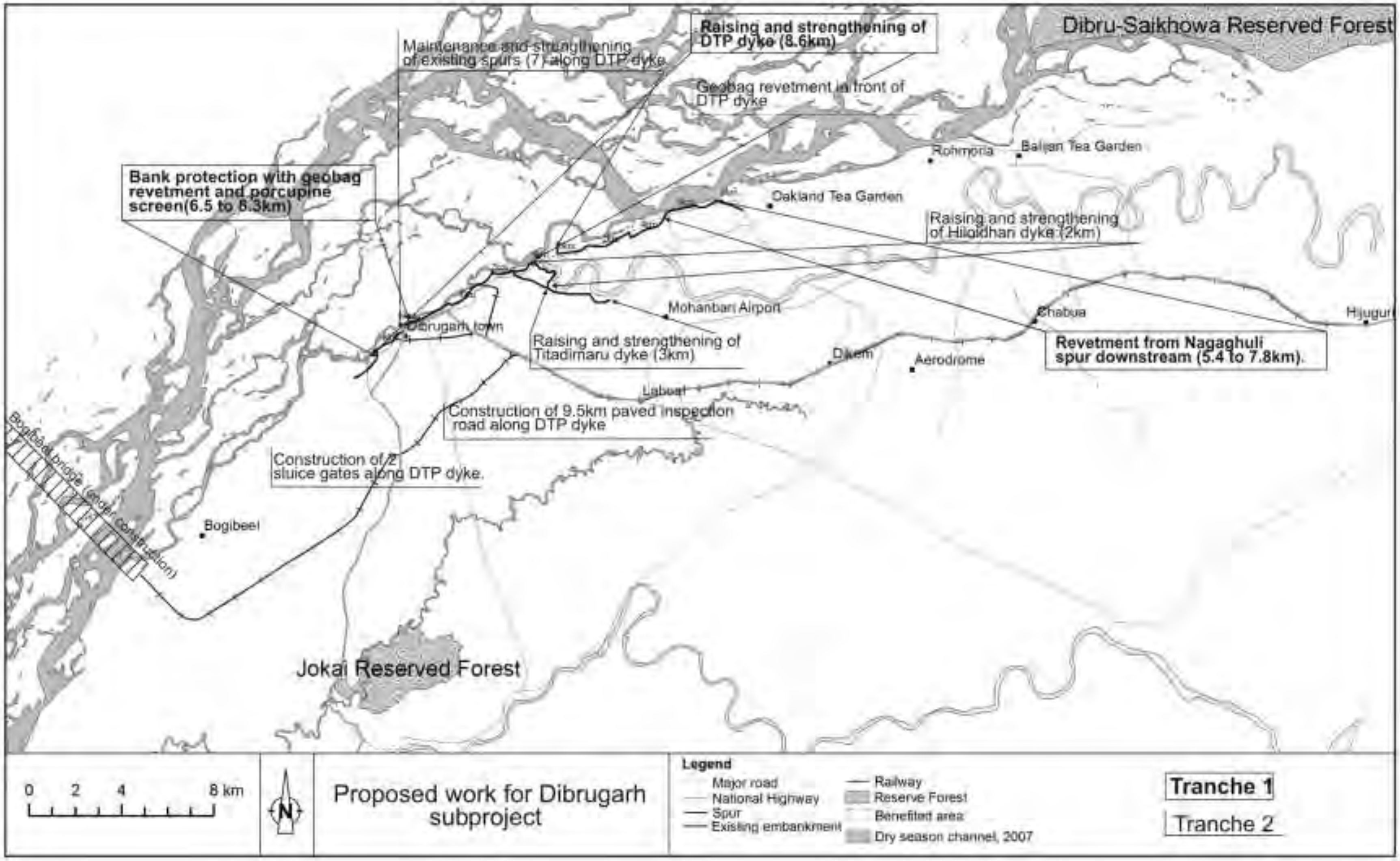


Figure 2.3 Proposed Flood and Bank Erosion Protection Works at Dibrugarh Sub-project Area

2.4.2. Non-structural and CBFRM Measures

41. **Land Use Guidelines**. Land use guidelines are aimed at ensuring that land use across the floodplain is consistent with the likelihood, risk, and hazard of flooding. For this purpose, current and likely future land use in flood-prone areas will be reviewed, especially the expected population growth and its impact on future flood risk and damage in higher-risk areas. In addition, the use of land use zoning to preserve wetlands and protect existing flood storage areas from further development will be assessed.

42. **Building and Development Guidelines*.*** While building and development controls are also not expected to provide a panacea for reducing flood risk and flood impacts in Assam, the flood proofing of public infrastructure is one area where improvements might be possible (to ensure it is ready and effective to return to service after a flood). The Program will assess flood damage to buildings and public infrastructure to identify possible improvements. The United Nations Development Program Sisaster Management Project has had work undertaken on the design and construction of flood-resilient buildings, which will be reviewed.

43. **Flood Forecasting and Warning*.*** Flood forecasting is a means to an end—to provide timelier and more accurate flood warnings. It is the warning that is essential, rather than the forecast. While a variety of public agencies participate in the flood forecasting and warning (FFW) process in Assam, most villagers receive no formal flood warnings—they generate their own warning by watching the river during the flood season, taking into account local rainfall. The Program will review the elements of FFW process, paying special attention to warning needs of villages and possible improvements in communities and flood emergency management. An important element of an improved FFW system is anticipated to be the provision of local forecasts by the Water Resources Department, i.e., the translation of regional forecasts by Central Water Commission (CWC) into clear and easily understandable warnings to villages. Local communities will be centrally involved in this process.

44. **Flood Emergency Planning and Management**. Flood emergency planning includes prevention, preparation, response, and recovery activities. Flood emergency planning and management (FEPM) is and will remain a central plank of flood risk management in Assam—flooding is a regular recurring natural event that cannot be prevented or entirely eliminated by structural measures. Flood emergency planning will to be reviewed and probably strengthened at the village, district, and state levels (e.g., through the use of the army for evacuation).

45. **Community-Based Flood Risk Management (CBFRM)*.*** CBFRM is one area where considerable opportunity exists to reduce the impacts of floods on village communities. Under the Program, comprehensive community surveys will be undertaken to address community concerns on flood risk management. Based on the responses, a CBFRM plan will be prepared, including raised platforms and associated facilities (e.g., permanent latrines, a raised tube-well for water supply, and permanent public buildings that are needed during flood emergencies, such as the local school and dispensary, and emergency shelter), along with community nonstructure programs, such as flood warning and flood education.

46. **Flood Education*.*** Villagers appear to be very aware of floods and highly flood resilient. The need for further flood education in villages will be assessed in the community surveys. Flood management in Assam is fragmented across many different agencies. The Program will promote cooperation and the exchange of ideas and information between the different agencies through workshops, seminars, etc. (a form of flood education).

47. **Financial Measures.** When in emergency accommodation during floods, flood-prone villagers cannot afford kerosene for cooking purposes. Relief payments—whether in cash or kind—are a financial measure (and a form of insurance) aimed at reducing the impacts of flooding. Under the Program, the system of flood relief payments, food, and stock fodder issue and other relief measures will be reviewed and possible improvements will be pursued

2.4.3. Construction Material for Bank Protection

48. Use of inert or natural material is proposed to be used for the same. Geo-textile bags filled with sand shall be the preferred option. It is very stable material and used worldwide. The engineered bags life is considered to be beyond 30 years. Use of geotextile rather is considered good even from aquatic fauna aspect. (Refer Appendix 2.1: which provides the extract of the research carried out by Hannes Zellweger on use of geotextile bags for river erosion control in Bangladesh).

2.5. Implementation Schedule and Project Cost

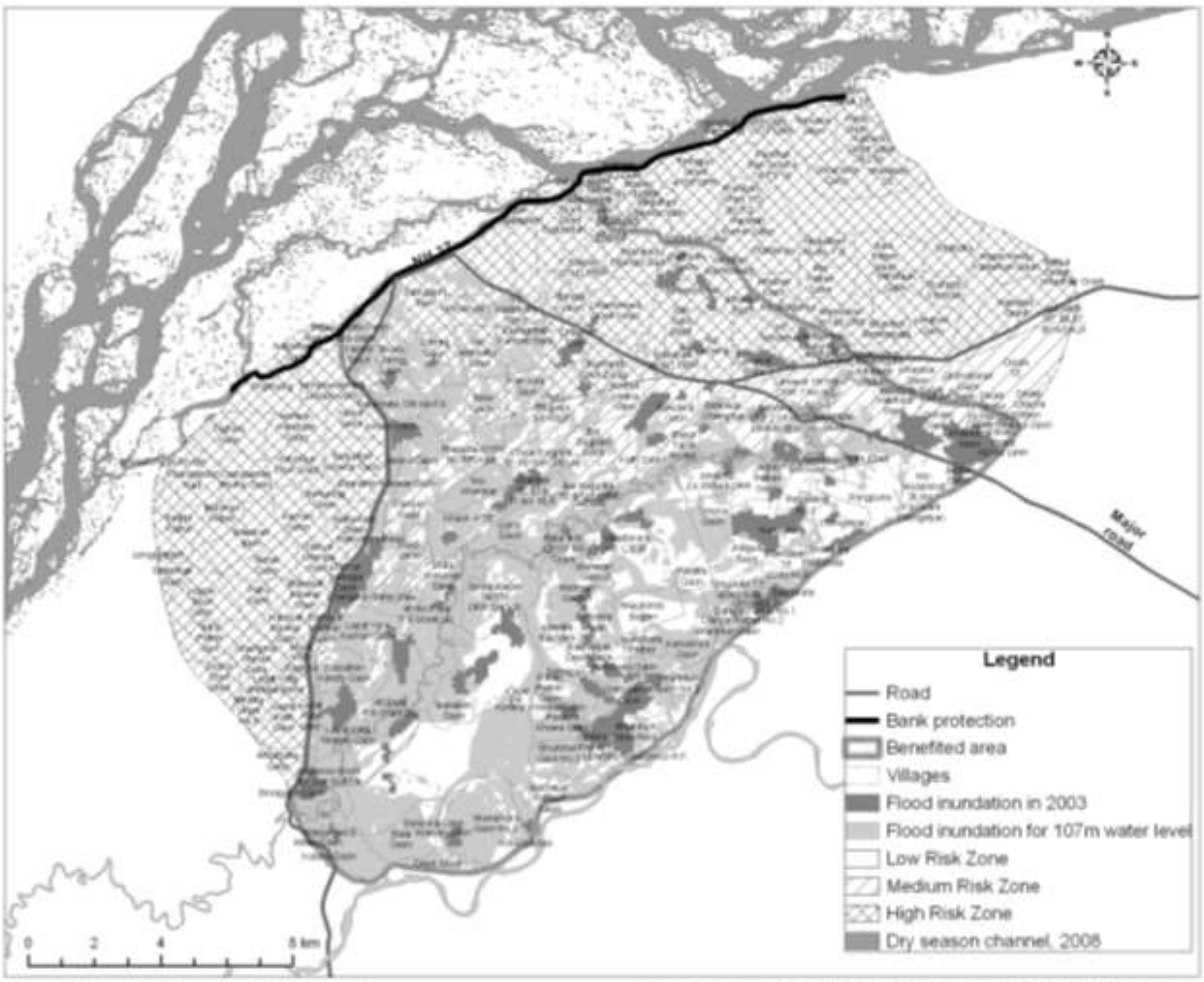
49. The project will be implemented over a period of six years and would seek Multi-tranche Finance Facility (MFF) which may comprise two sub-loans covering year 1-3 and 4-6, respectively. The total estimated cost of the sub-project for structural works is estimated as Rs. 30.2 Crores (i.e. US $ 7.6 Million).

50. The sub-project will provide improved flood and riverbank erosion risk management to achieve more stable living conditions for the existing population needs to be put into the larger context of land-use zoning to avoid future catastrophes due to overtopping of flood water. The boundary of the benefited area is provided in the succeeding Figures taking into account the recommended combination of flood and erosion protection measures. The upstream boundary follows the higher ground and is demarcated by the embankments at Dibrugarh downstream of Maijan Beel, whereas the downstream boundary follows the national highway, providing reasonable protection from flooding from any downstream embankment breaches. Riverbank protection extends beyond the boundaries of the flood protection, especially towards Oakland to provide a certain safety margin. The protected area (in grey) compared with the larger area of the socio-economic survey[7] suggest that project interventions benefit the Dibrugarh area in several ways compared to a “without project” scenario. The erosion in this reach will be reduced and the embankment system will be upgraded to avoid future overtopping causing disaster for the town and the adjacent areas. Dibrugarh Town but also parts of the flood plain will benefit from more reliable flood protection allowing in places changes in cropping patterns to higher yield varieties. The following considerations guide the selection of the benefits:

- Riverbank protection will be provided along eroding parts along a total reach length of around 21 km. The total proposed length of protective works covers the existing seven spurs and adds 9.5 km additional protection during tranche 2 in order to provide a stable bankline. Compared to a “without project” scenario, reliable riverbank protection will avoid future land loss in the area. Future provisions (for adaptation work, which means additional riverbank protection protecting the existing work from outflanking) have been incorporated into the economic feasibility study to respond to additional unpredictable erosion in this area.

[7] Note that the risk zones (high to low) were delineated at the site with WRD field staff.

- A stable riverbank and strengthening of the existing embankment system will avoid future flood losses in a larger area. This area covers 25,138 ha of the floodplain.
- Associated with bed level rise, there is a substantial difference between the area flooded at high flood level without embankment and with embankment. The succeeding Figure shows the areas flooded at different levels. While a projected HFL of 107 m would flood 14,892 ha or 59% of the total protected area, the maximum observed flooding during the 2003 flood inundated 2,144 ha, or 9% of the total protected area. Translating this to the agricultural area shows that out of 7,533 ha flooded without embankment 780 ha were flooded in 2003. This difference shows that the existing embankment system provides a certain safety from flooding at this moment.



Flood Inundation in Dibrugarh

Flood inundation: 13th July 2004 (as observed in RADARSAT image);

Figure 2.4 Comparison of 2003 Flooded Area with Existing Embankments and No Embankment Solution

51. To establish the feasibility of flood and riverbank erosion management measures for certain areas, interventions were planned based on the existing river situation. These measures were prioritized based on urgency, implementation costs, and benefits from reduced risk of flooding and riverbank erosion. Urgently needed work for stabilization is intended to be built

over the first three years where the chance of sudden dramatic river changes in river morphology is less, and consequently there is a higher likelihood that the presently outlined work can be implemented without major changes. Lower priority measures previously outlined in this report, are indicative plans and will undergo more detailed planning during the second year of project implementation to adapt to the rapid changes in the river morphology. To cover potential changes in location of future work, this EIA considered a larger area of assessment, beyond the scope of this subproject extending to the full (upstream and downstream) Brahmaputra River section where existing and proposed embankments and pro-siltation works will be installed. The area for which structural interventions are planned together with the benefited area is shown in the succeeding Figure. This area is more limited when compared with the area shown in the other maps in this report which cover the total area studied for this EIA.

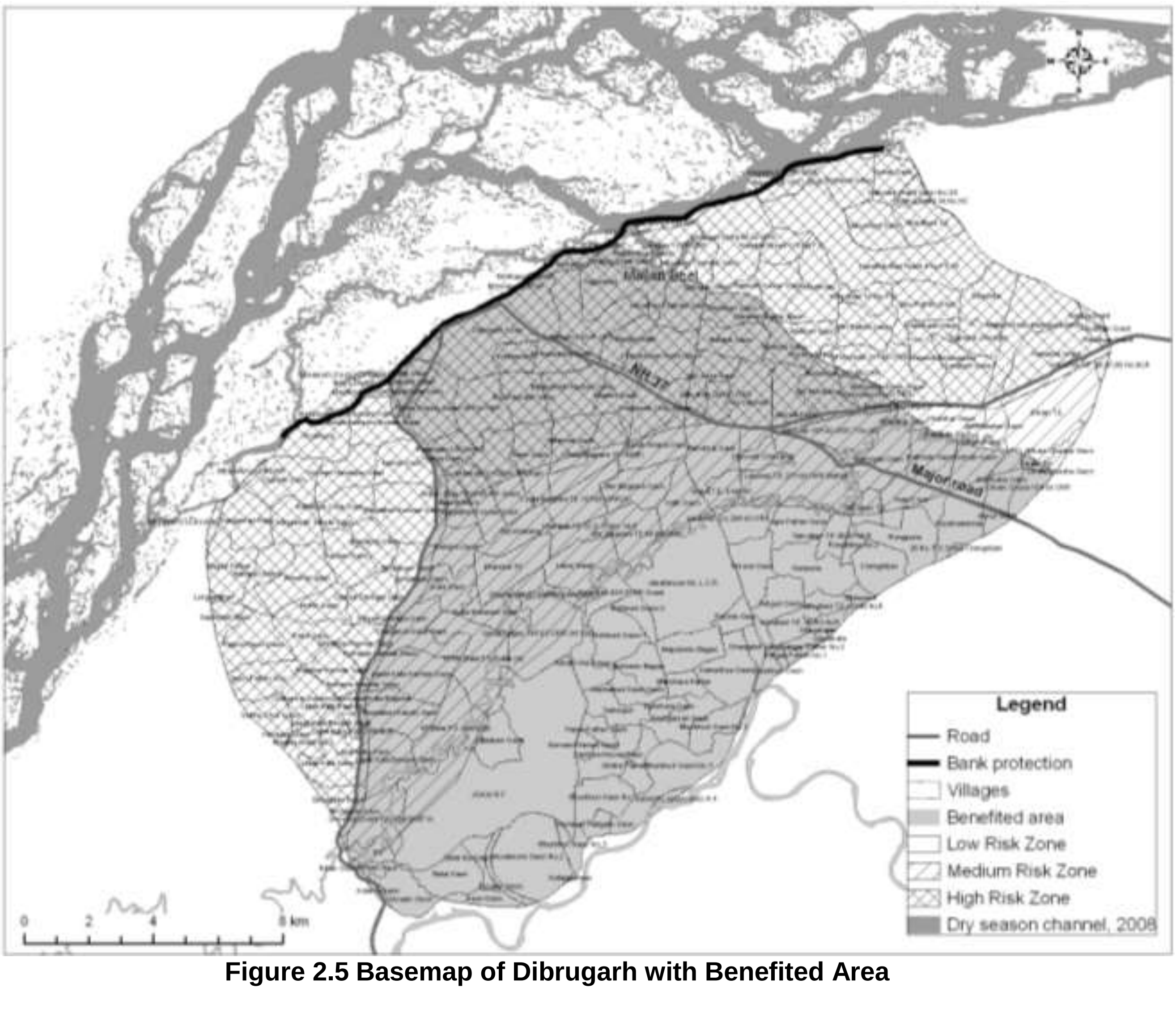


Figure 2.5 Basemap of Dibrugarh with Benefited Area

2.6. Regulatory Requirements

2.6.1. ADB's Environmental Categorization

52. The project was initially considered as environmental category A by ADB. With the structural works focusing on the sustaining the functions of the existing flood embankment systems through renovation of deteriorated embankments, provision of innter secondary embankment and sluice gates, and provision of riverbank protection works, the present EIA indicates that the subproject does not have significant adverse environmental impacts that are sensitive, diverse, or unprecedented, and affect an area broader than the sites or facilities subject to physical works.

2.6.2. Regulatory Requirements of the Government of India and Assam State

53. The Government of India has framed various laws and regulation for protection and conservation of natural environment. These legislations with applicability to this project are summarised below in Table 2.3 and approval and monitoring framework is depicted Figure 2.7. Only the Air and Water Acts are applicable to the IFRERM-Assam Dibrugarh subproject.

Table 2.2 Applicable Key Environmental Legislation at a Glance

Legislation	Key Requirement	Applicability	Remark	Granting Agency	Reporting Requirement	Monitoring Agency
Air (prevention and control of pollution) Act, 1972 and rules there under	An Act to prevent and control of Air Pollution	Applicable	Applicable during construction stage for the operation of air polluting units like Hot Mix Plant	SPCB	Normally compliance monitoring report is to be submitted once in a year or as indicated in the consent letter	SPCB
Water (prevention and control of pollution) Act, 1972 and rules there under	An Act to Prevent and Control of Water Pollution	Applicable	Applicable during construction stage for discharge of waste from construction camps or maintenance of construction equipment	-do-	-do-	-do-
Environmental (Protection) Act, 1986 and rules there under including EIA Notification, 2006.	Requires prior environmental clearance for all River Valley projects for ≥ 25 MW hydroelectric power generation and ≥ 10,000 ha. of culturable command area	Not Applicable	The proposed project includes only activity related to existing river bank and embankment protection. No hydro power generation or new canal project having large culturable command area.	MoEF/ SEIAA	Once in six months	Regional Office of MoEF
Forest (conservation) Act, 1980 and rules there under	Restriction on the dereservation of forests or use of forest land for non-forest purpose	Not Applicable[8]	No diversion of forests land in the whole stretch	MoEF/ State Forest Department	Once in six months	Regional Office of MoEF/ State Forest Department
Wildlife (protection) Act, 2002 and rules there under	No person shall destroy, exploit or remove any wild life including forest produce from a sanctuary/National park or destroy or damage or divert the habitat of any wild animal by any act whatsoever or divert, stop or enhance the flow of water into or outside the sanctuary, except under and in accordance with a permit granted by the Chief Wild Life Warden	Not Applicable	No wild life sanctuary/ National Park exist in the project area.	Chief Wildlife Warden	As per the consent letter	Concerned protected area office/ Chief Wildlife Warden

[8] The land revnue records need to be verified again to ascertain if any forest land is require to be diverted. If yes then this ACT shall be applicable and necessary clearance for forest land diversion will have to be obtained.

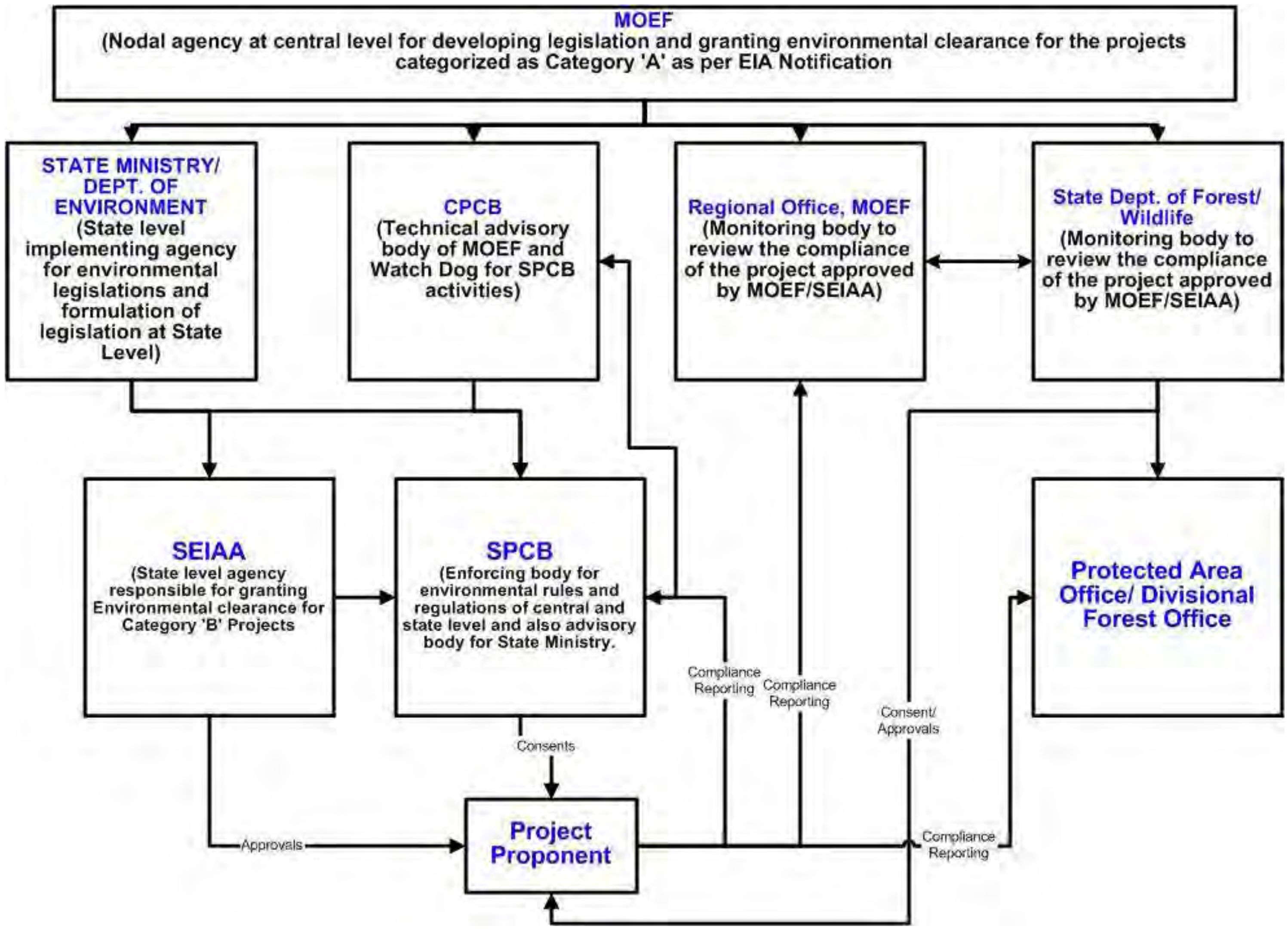


Figure 2.6 Legislative Interface between various Central and State Authorities

3. DESCRIPTION OF THE ENVIRONMENT

3.1. Introduction

54. It is necessary for the environmental assessment studies to establish baseline for valued environmental attributes, which are likely to be affected because of the developmental activities. Hence, it is imperative to study the existing environmental conditions not only to establish the pre-project physical, biological and socio-economic conditions, but also to predict associated environmental impacts caused during the construction and operation phases of the project.

55. In the present study, particular emphasis has been given to data collection on the physical, biological (terrestrial as well as aquatic) and socio-economic environment of the study area (i.e. 10 km area around the embankment). These are considered to be of prime importance *vis-à-vis* the nature and location of the proposed sub-project of development of Dibrugarh reach.

3.2. Description of Physical Environment

3.2.1. Climate

56. The area enjoys sub-tropical monsoon climate with warm and humid summers and mild winters. Average annual rainfall in Dibrugarh City is 276 cm with a total number of 193 rainy days. With the onset of monsoon in early June heavy rainfall occurs. Occurrence of heavy thunderstorm is common during this period. The maximum temperature recorded in the city ranges from 33°C to 37°C.

57. The Brahmaputra Valley in Assam forms an integral part of the subtropical monsoon regime of Eastern Asia receiving a mean annual rainfall of 230 cm with a variability of 15-20%. Distribution of rainfall over River Basins in Assam shows marked spatial variations, e.g. from as low as 175 cm in the Kopili basin located in the central part of the valley to as much as 410 cm in Jiadhol basin close to the Matmora reach in upper Assam. The isohytel map of the Brahmaputra valley and adjoining highlands (based on IMD data) is shown in the Figure 3.1:

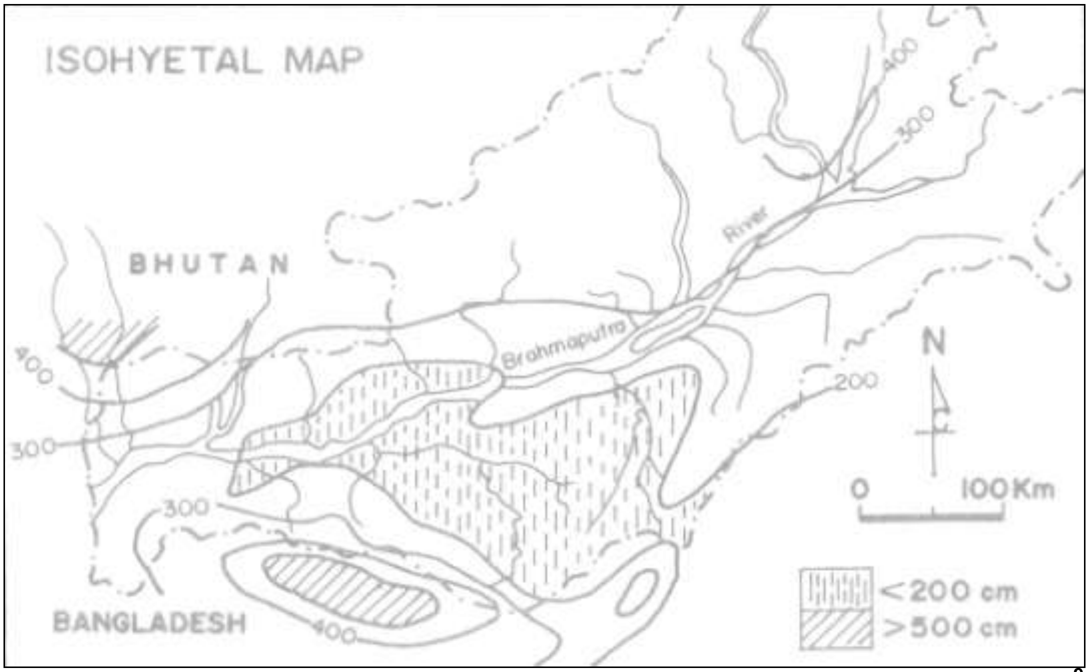


Figure 3.1 Isohytel Map of the Brahmaputra Valley and Adjoinging Highlands[9]

58. During the period 1902-2000, 1954 was the wettest year with an excess rainfall that was 21.8% of the normal rainfall, while the driest year was 1967 with deficient rain 30.6% of the normal.[10] The rainfall pattern of distribution of mean monthly rainfall for the year 2007 is presented in Figure 3.2. It shows that the highest mean rainfall of 534 mm is recorded in the month of July, while the minimum of 10 mm in the month of December. During the monsoon season (i.e. in the months of June, July, August and September) more than 66% of the total annual rainfall occurs.

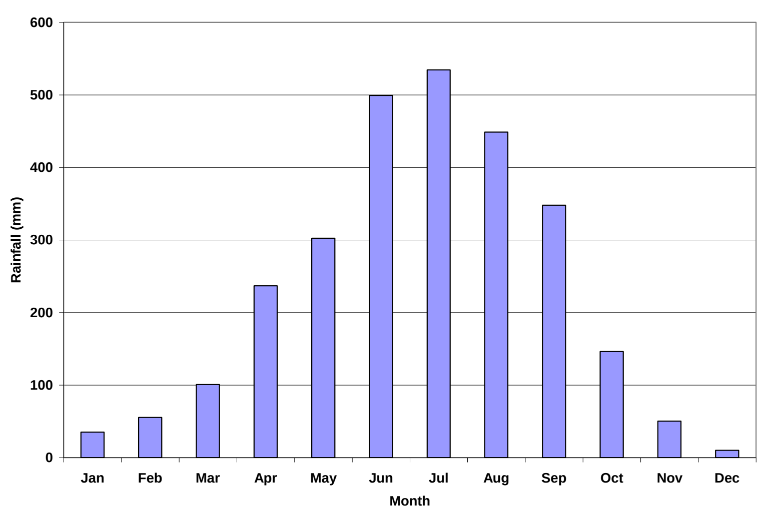


Figure 3.2 Mean Monthly Rainfall in Year 2007 at Dibrugarh

[9] Goswami, D.C. 1998. Fluvial regime and flood hydrology of the Brahmaputra River, Assam. *Memoir Geological Society of India*, No.41: 53-75.

[10] Das, P. J. and Goswami, D. C. 2003. Long term variability of rainfall over Northeast India, Indian Journal of Landscapte Systems and Ecological Studies, Vol. 26, No.1, pp. 1-20

59. Powerful atmospheric systems called cloudbursts that trigger intense rainfall in limited areas causing flash floods of great fury and destruction are being experienced in greater frequency along the foot hill region of and in the immediate downstream areas in the Brahmaputra plains. The situation aggrevates further if such extreme climatic events trigger landslide and slope failure in the upper watersheds or temporarily block river courses creating dams that subsequently break sending surging flood waves downstream. During the 1950 Assam earthquake a massive landslide in Arunachal Himalayas blocked the Subansiri river – a major tributary of the Brahmaputra for days together creating a dam which was eventually released in a deluging flood that greatly devasted the downstream areas in Dhemaji and Lakhimpur districts of Assam. On 10th June 2000, a massive flood occurred in Arunachal Pradesh reportedly as a result of a sudden failure of a landslide induced dam in the neighbouring uplands of Tibet. Cloudburst and landslide related flash floods occurred in 2004 in the Manas and Beki rivers of Assam due to failure of a landslide dam upstream of Kurichu hydel project in Bhutan that caused highly destructive flood and channel avulsion. On October 7 of the same year i.e. 2004, a flash flood in Jinari river of Assam was triggered by a cloudburst over Meghalaya that caused great havoc in the downstream areas in Assam.

3.2.2. Physiography and Topography

60. The physiography of the Dibrugarh Reach (in and around the 40 km long Oakland-Bogibeel Reach) of the Brahmaputra along the south bank comprises of flood plain, beels, swamps, sandbars (chars) and occasional highlands.

61. The physiography of Assam consists of (i) Foothill Zone; (ii) Middle Plain of North Bank; (iii) Active Flood Plain; (iv) Middle Plain of South Bank; (v) Sub-mountain Zone; and (vi) Hills. The physiographic divisions of Assam are shown in Figure 3.3.

62. The Dibrugarh Reach extends some 40 km along the southern embankment of the Brahmaputra River between the new road and rail bridge at Bogibeel (Latitude 94°37' E), which marks the downstream limit of the reach, and the Oaklands Tea Garden (Latitude 95°04' E), which marks the upstream end of the reach. The District of Dibrugarh comprises three major physiographic zones: a Southern Foothills Zone, which consists of the Naga foothills; an Active Floodplain Zone, which lies adjacent to the Brahmaputra and contains many 'charlands'; and a Middle Plain, which covers the intermediate area and contains innumerable beels and swampy areas. Topographically, the District of Dibrugarh slopes gently from east to west, from an elevation of around 200 m in south-eastern corner of the district to some 99 m at the mouth of the Buri-Dehing River. The Dibrugarh Reach, which consists of a mix of active floodplain and middle plain zones, follows this topography, with elevations falling from about 115 m across the Oaklands Tea Estate to about 100 m around the Bogibeel Bridge site (Figure 3.4).

63. The immediate hinterland of the Dibrugarh Reach consists largely middle plain zone and is characterized by beels, wetlands and poor drainage. The Maijan Beel to the immediate west of Oaklands Tea Garden is part of a residual flood runner of the Dibru River. Various anabranches, distributaries and flood runners of the Buri-Dehing River criss-cross the area behind and to the southwest of Dibrugarh Town. One of these channels, the Buridehingmukh River, enters the Brahmaputra just to the west of the western end of the DTP Dyke.

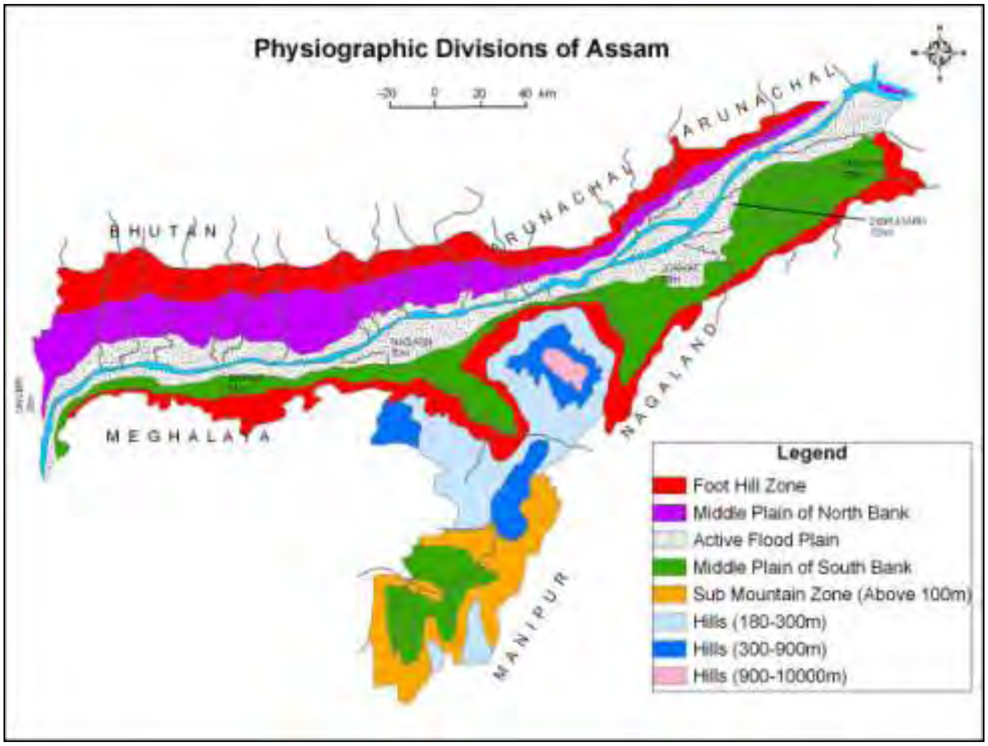


Figure 3.3 Physiographic Divisions in Assam

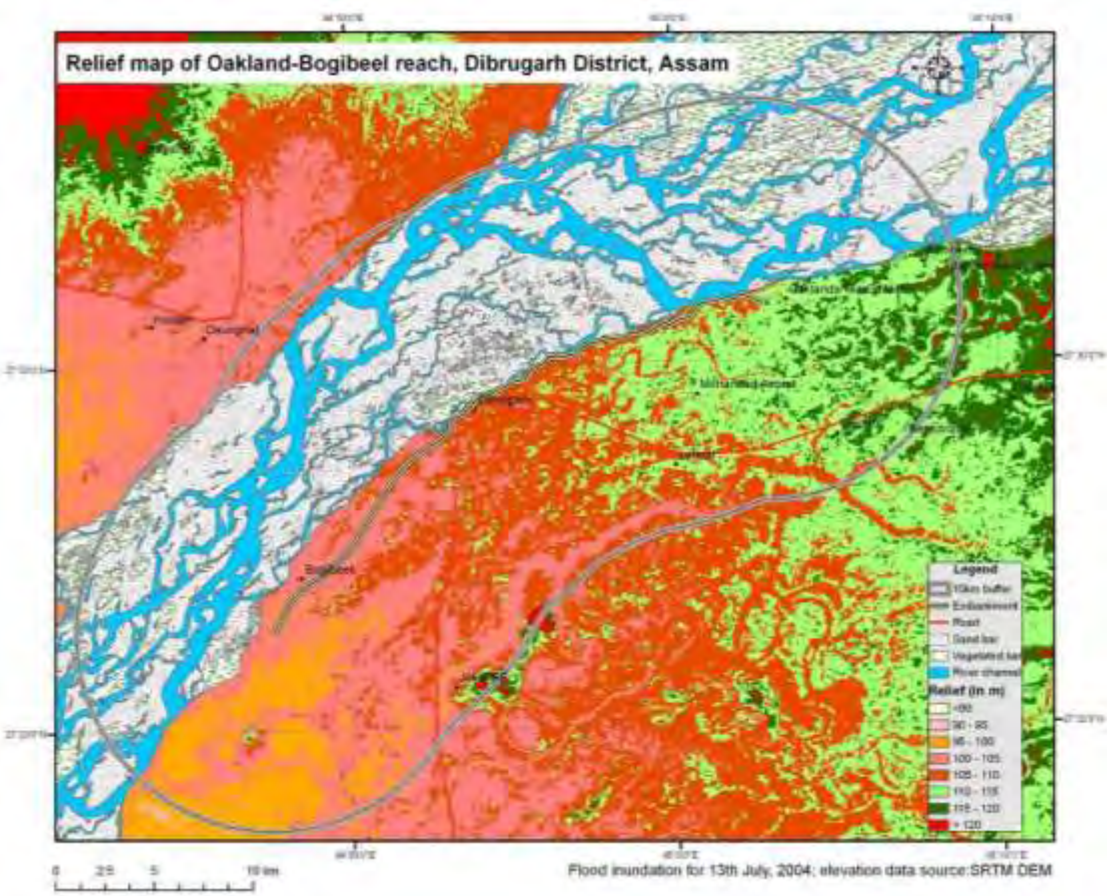


Figure 3.4 Dibrugarh Reach - Topography

3.2.3. Flooding Behaviour

64. Flooding behaviour at the sub-project site is relatively straightforward. The site is exposed to mainsteam flooding from the Brahmaputra River, tributary flooding from both Maijan Beel (to the north of Dibrugarh Town) and the Buridehingmukh River (to the south of Dibrugarh), and local flooding from heavy rains. These three types of flooding behaviour, which can occur separately or in conjunction, can interact to exacerbate flooding impacts. Obviously, high water levels in the Brahmaputra serve to increase the level and duration of tributary flooding in Maijan Beel and the Buridehingmukh River. It is noted that the outlet sluice on Maijan Beel is of small capacity, which raises the level and extends the duration of tributary flooding along this waterway. It is also noted that local flooding is an issue at Dibrugarh Town: the town drainage is poor, and a major south-westerly flowing drain was constructed. This drain, which runs behind and parallel to the Brahmaputra River, delivers runoff to the Buridehingmukh River. The drain has fallen into disrepair and WRD plan to clean, repair and increase the capacity of the drain.

65. There were three major flood episodes along the Brahmaputra in 2004 – in April, July and October -causing widespread havoc across Assam, including Dibrugarh District and Town.

- The pre-monsoon rainfalls of March and April were unseasonally heavy, filling low-lying areas and wetlands, causing the first spate of flooding in April.
- Intensive rainfalls in June and July caused the second spate of major flooding around mid-July: 26 of the 27 districts of Assam were affected. At Dibrugarh, the Brahmaputra was flowing at a level some 2 m above danger level and over 2m above ground level in the old town. The DTP, Oaklands and Bogibeel embankments suffered breaches (details unknown); the dykes protecting Mohenbari Airport and the nearby army cantonment developed substantial leaks, threatening these facilities.
- Incessant rains in early October triggered the third spate of major flooding down the Brahmaputra. Fourteen districts of Assam were affected, including Dibrugarh District, where some 44,000 ha of land and 100 villages were flooded.

66. It was not possible to obtain details of actual flooding behaviour in the Town of Dibrugarh, but based on the above reports, it can be surmised that the major threat in 2004 was mainstream flooding from the Brahmaputra and that town flooding was presumably exacerbated by poor drainage and the inadequate sluice outlet on Maijan Beel.

67. Major flooding again occurred down the Brahmaputra in 2008. The floods arrived in three waves over the period July-September. Floodwaters from the previous wave were unable to drain away before the next wave of flooding occurred, thereby exacerbating impacts. In all, 20 of the 27 districts of Assam were affected by floods, the lower and central districts of Kamrup, Morigoan, Dhubri, Jorhat, Lakhimpur and Dhemaji being the worst affected. Dibrugarh District also suffered from flooding: from major tributary flooding along the Buri-Dehing River11 and from mainstream flooding from the Brahmaputra. Again, details of flooding around Dibrugarh Town are scant. In early September, the Brahmaputra at Dibrugarh was flowing some 1.5 m above danger level and was approaching its highest previous flood level. Part of the municipal area of Dibrugarh was knee-deep in local floodwaters (rainfall); the Brahmaputra threatening the embankments. The Dibrugarh embankments are in poor repair, as evidenced by many 'leaks' (attributed to rodent burrows) that were successfully plugged with bags of silt. It

[11] It is not known whether the embankments along the Buri-Dehing River held. If they failed, 100 villages were under threat.

is apparent that ensuring the Dibrugarh embankments (and indeed embankments in general across Assam) can provide the expected levels of protection are a year-by-year challenge.

3.2.4. Water Environment

68. The Dibrugarh Reach represents one of the most dynamic reaches of the river Brahmaputra, especially in the aftermath of the great Assam Earthquake of 1950. However, due to timely and appropriate remedial measures taken up by the then Government and initiative taken by Prime Minister Jawaharlal Nehru the urban centre was saved from totally being wiped out although it had already lost a considerable part to the river's erosion.

3.2.4.1 Surface Water

69. In Dibrugarh reach, till the great earthquake of 1950, the northeastern corner of the reach was drained by the Dibru River, a tributary of the Brahmaputra with its confluence about 18 km east of the Dibrugarh city. However, due to the raising of the river bed through aggradation as a result of the earthquake, the Dibru River got merged with the Brahmaputra River. At present Maijan channel, a tributary of the former Dibru River, meets the Brahmaputra through a small opening and becomes a great cause of concern.

70. The Burhi Dihing is a major tributary of the Brahmaputra that joins this stretch at its extreme western end about 16 km.downstream from the Bogibeel Bridge. The course of the river shows intense meandering in the valley. It carries an average annual discharge of 1,41,539 m^3/sand a suspended load of 210 ha m with a sediment yield of 1,129 tons/km^2/year. The location of wetlands and other water bodies along with landuse of the Dibrugarh Reach in a 10 km buffer zone around the embankment is shown in Figure 3.15.

71. Water quality monitoring and analysis in regard to physico-chemical as well as biological parameters was carried out on samples collected from two locations in the project area. The locations of the sampling points are shown in Figure 3.5. The analysis results are presented in Table 3.1 and these are compared with the water quality criteria of designated best use given by Central Pollution Control Board (CPCB). (Refer Appendix 3.1).

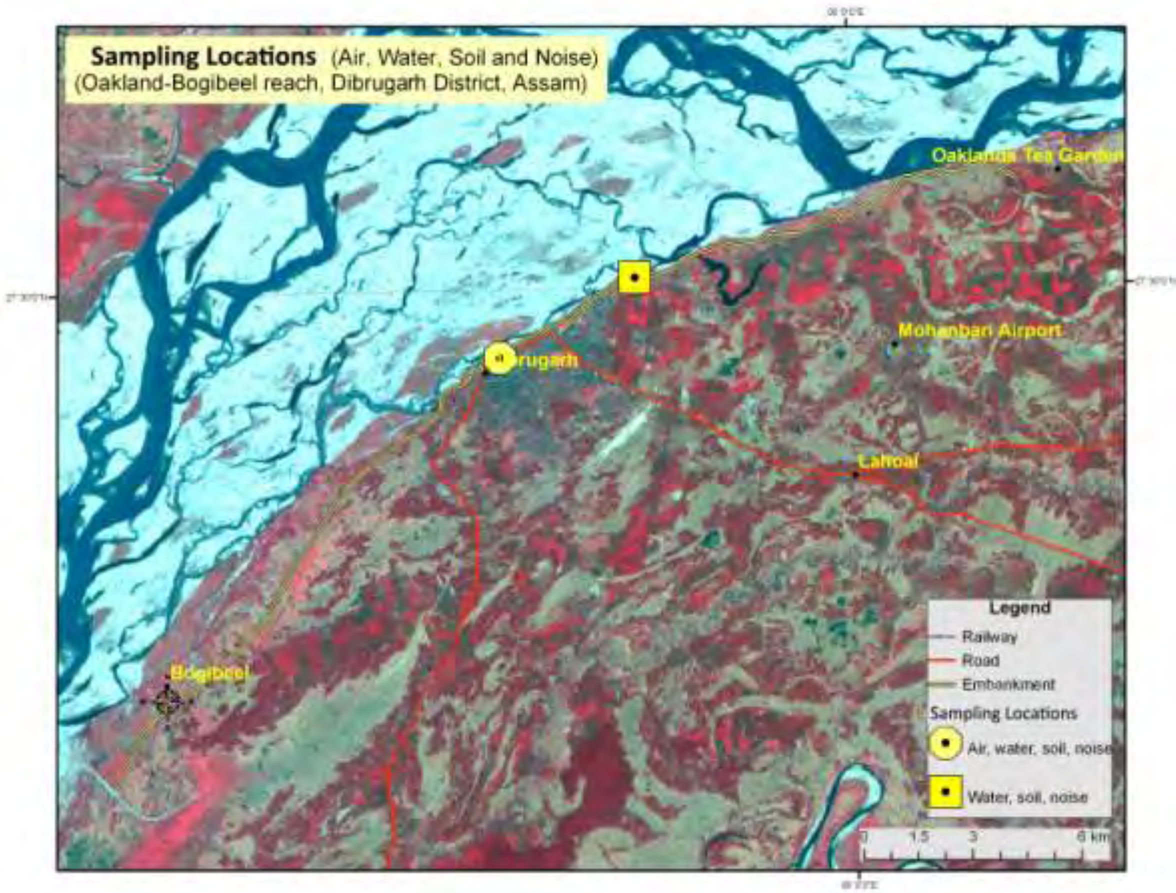


Figure 3.5 Sampling Locations of Water, Soil, Air and Noise

Table 3.1 Water Quality at Selected Locations in Dibrugarh Reach

Parameter	Unit	Pach Ali	Kahai Spur
Colour	Hazen	Colourless	Colourless
Odour	-	Nil	Nil
Temperature	(ºC)	18	20
pH	-	5.8	7.5
Electrical Conductivity	(mS/cm)	0.8	3.4
TSS	mg/L	189	172
TDS	mg/L	15.7	13.6
Total Hardness	mg/L	42	64
DO	mg/L	8.9	6.5
BOD	mg/L	4.6	4.2
COD	mg/L	3.3	3.1
Chloride	mg/L	26	34
Sulphate	mg/L	4.7	7.4
Nitrate	mg/L	4.3	3.9
Phosphorus	mg/L	BDL	BDL

Parameter	Unit	Pach Ali	Kahai Spur
Calcium	mg/L	14.4	12
Magnesium	mg/L	27.6	52
Ammonical Nitrogen	mg/L	4.5	3.8
Total nitrogen	mg/L	6.8	5.9
Arsenic	Ppb	0.003	0.002
Iron	Ppm	0.9	0.87
Manganese	mg/L	BDL	BDL
Lead	mg/L	BDL	BDL
Floride	mg/L	1.07	1.4
Total Coliform	Coliform/100mL	12	9
Fecal Coliform	Coliform/100mL	2	1

(Note: BDL – Below Detection Limit)
(Source: Field monitoring and analysis done by Department of Environment Science, Gauhati University)

72. The comparison of the surface water samples analyzed against the water quality criteria for designated best use shows that the water quality of the project area meets the criteria of Class ‘C’ “Drinking Water Source After Conventional Treatment.”

3.2.4.2 Hydrological and Morphological Aspects

73. The hydrologic and morphological regime of the Brahmaputra in the Dibrugarh section is examined on the basis of satellite imageries and recorded river observations. It is focused primarily on the recent years extending for the last twenty years that explains the present configurations better and indicates trends for the future.

Table 3.2 Water and Sediment Yields of Selected Tributaries of the River Brahmaputra, Assam

River	Drainage area (km^2)	Water yield ($m^3 s^{-1} km^{-2}$)	Sediment yield (tons $km^{-2} yr^{-1}$)
Brahmputra at			
❖ Tsela d’ Zang (china)	191222	0.0105	100
❖ Pasighat (India)	244700	0.0231	340
❖ Pandu (India)	500000	0.0306	804
❖ Bahadurabad (Bangladesh)	580000	0.0331	1128
Dibang	12120	0.1066	3765
Lohit	22077	0.0709	1960
Subansiri	27400	0.0756	959
Jia Bharali	11300	0.0858	4721
Puthimmari	1787	0.0403	2887
Pagladia	383	0.1087	1883
Manas	36300	0.0232	1581
Kulsi	750	0.0797	135
Buridhing	4923	0.0788	1129
Desang	3950	0.0382	622

River	Drainage area (km^2)	Water yield ($m^3 s^{-1} km^{-2}$)	Sediment yield (tons km^{-2} yr^{-1})
Dhansiri	10240	0.0184	379
Kopili	13556	0.0182	230

(Source: After Goswami, 1985) [12]

74. The flood inundation scenario in the Dibrugarh Reach based on analysis of satellite data is revealed in Figure 3.6. It shows the area affected during the flood of year 2004, which is considered to be among the most severe ones to occur in this region. The area covered by inundation was 6231 ha, which accounts for 6.7% of the geographical area in 10 km buffer around the embankment.

Table 3.3 Pattern of Flooding in 10 km Buffer Zone of Dibrugarh Reach

Particular	Area (ha)	Area (%)
Total Flooded Area	8,698	9.2
Total Area in 10 km Buffer	**94,900**	**100**

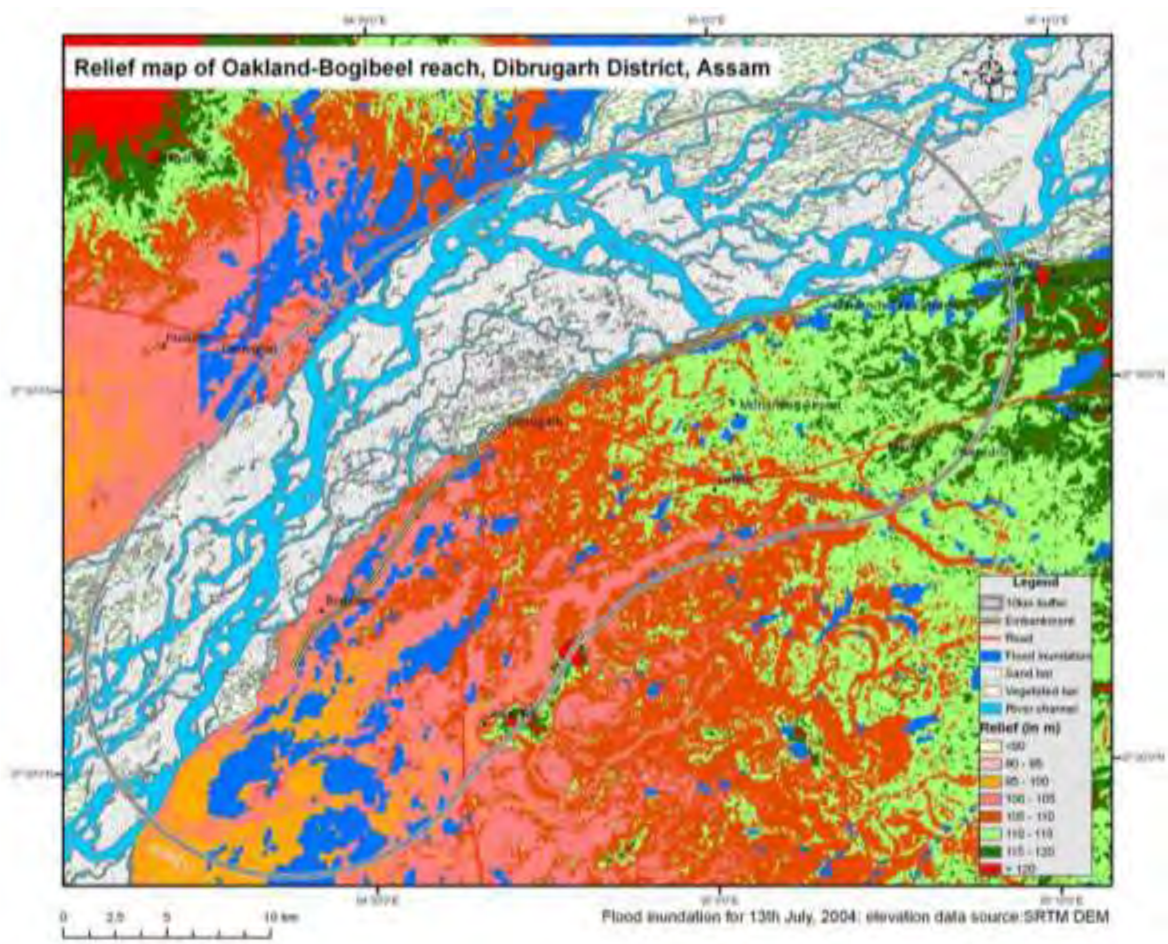


Figure 3.6 Flood Inundation Map of Diburgarh Reach

[12] Goswami, D.C.1985. Brahmaputra River, Assam, India: Physiography, basin denudation and channel aggradation. *Water Resources Research, Amer. Geophys. Union*, 21: 959-978.

75. The morphology of the Brahmaputra River is characterized by intense braiding and bar formation and extremely dynamic bankline and bed configuration. The morphology and behavior of the river undergoes drastic changes in response to variation in the flow regime and pattern of sediment transport and deposition in the river following the seasonal rhythm of the monsoon.

76. The Brahmaputra is a classic example of a braided river – a river in which the channel exhibits successive bifurcation and rejoining of flow around sand bars and islands. In case of the Brahmaputra in its Assam reach, a combination of multiple factors, such as excessive sediment load, large and variable flow, easily erodible bank materials, aggradation of the channel have been identified has the possible underlying factors[13]. Further, the braiding mechanism is related to the presence of narrow sections (nodes) where the banks are stable due to the existence of resistant rocks, like the one near Guwahati, in the immediate downstream of which the channel fans out developing an intricately braided channel. In the case of Dibrugarh reach, no such structural node points are present.

77. Another striking feature of the river's morphology is the continuous shift of the thalweg (deep channel) from one location to another within the banklines of the river. Bank materials of the Brahmaputra consist mainly of varying proportions of fine sand and silt with only occasional presence of clay. There is a relatively fine grained topstatum and a coarser substratum. Bank failures are rampant in numerous locations like the upstream part of Dibrugarh reach. These failures largely seem to be a function of hydraulic character of the flow and engineering properties of bank materials. Shear failures in the upper bank materials appear to be by far the most widespread mode of bank failure in the river. These are caused either by undercutting of the upper bank materials by channels during the high floods producing an overhanging cantilevered block that eventually fails or by oversteepening of bank materials due to migration of the thalweg closer to the bank during the falling stages.

78. The bed regime of the Brahmaputra is characterized by drastic changes in bottom configuration and occurrence of bedforms of greatly varying sizes ranging from small size ripples of few centimeters wavelength to giant size dunes and waves of dozens of meters. The dynamic pattern of the channel configuration and movement of the Brahmaputra in the Dibrugarh reach is demonstrated for different years based on the IRS satellite images for 1973, 1990, 2000, 2007 and 2008 (Figure 3.7). The movement of the thalweg (deep channel) towards the south bank and its present position hugging the backline where existing embankments and spurs are under serious threat is well evidenced in the successive images. Figure 3.8 shows the pattern of erosion and accretion of the bank during the period 1967 to 2008 based on analysis of satellite as well as conventional data using GIS. The rates of erosion and accretion estimated from this analysis between 1967 - 2008 are 3616.42 ha, and 802.87 ha, respectively, giving a net loss of around 2813.55 ha of land.

[13] Goswami, D.C. 1998. Fluvial regime and flood hydrology of the Brahmaputra River, Assam. *Memoir Geological Society of India*, No.41: 53-75.

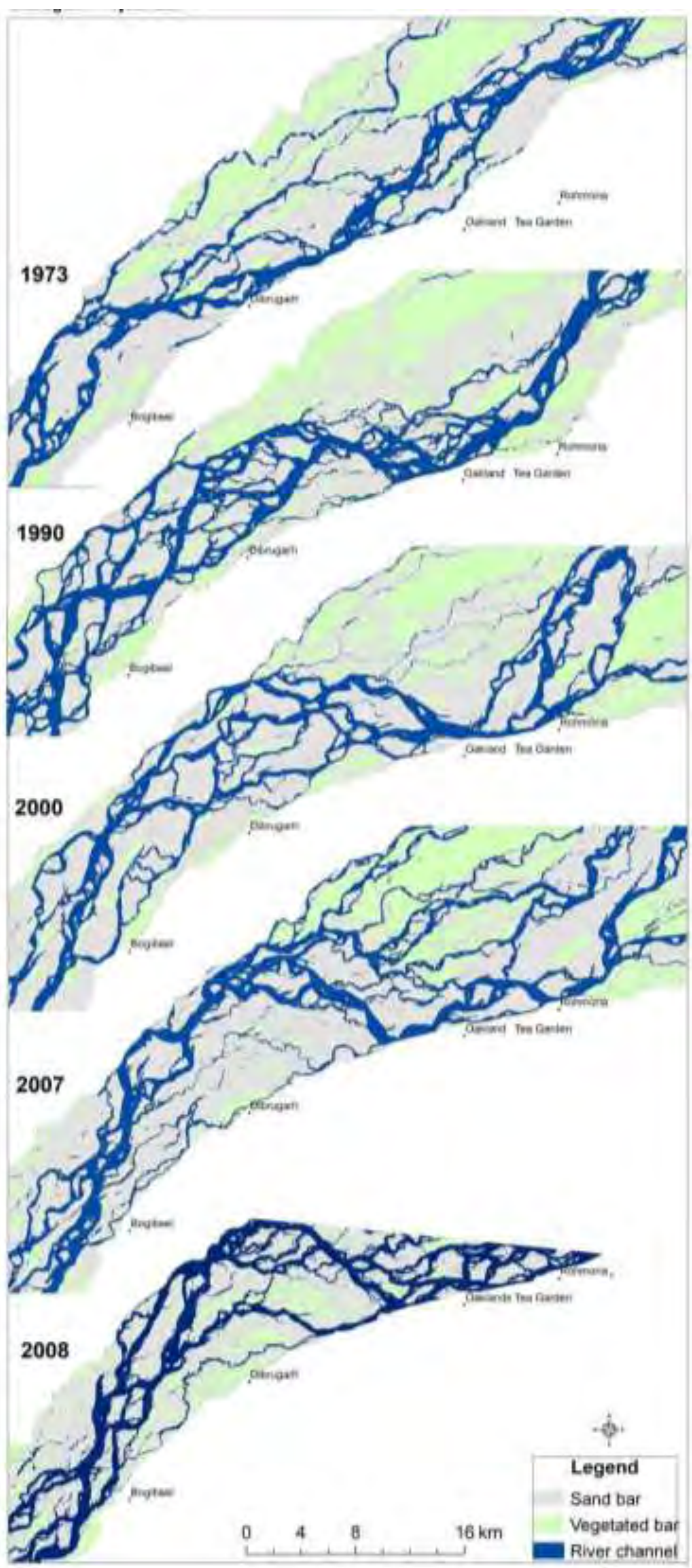


Figure 3.7 Channel Configuration of River Brahmaputra in Dibrugarh Reach

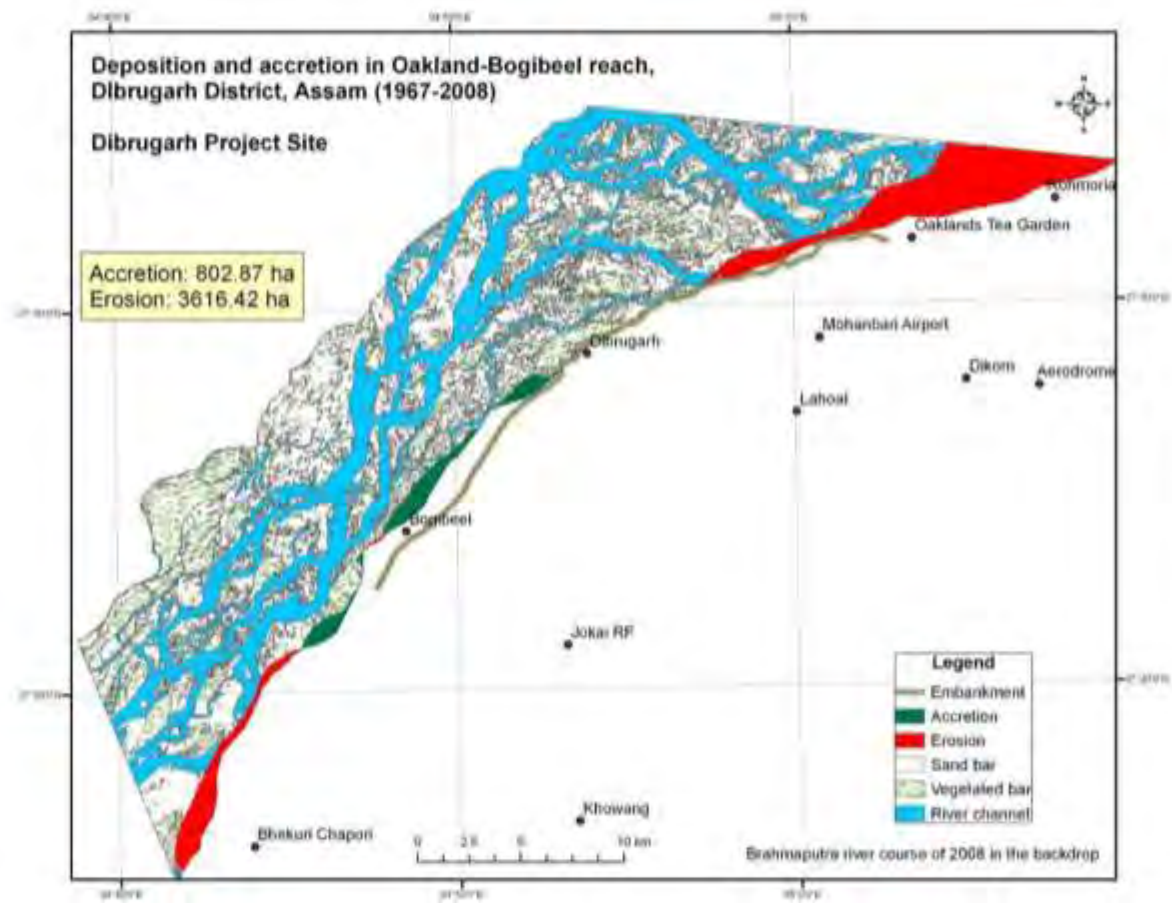


Figure 3.8 Pattern of Erosion and Accretion of the Brahmaputra Bank in the Dibrugarh Reach (1967 – 2008)

79. The pattern of bankline migration in the reach during different time periods is shown in Figure 3.9. There has been persistent regression of the backline in most of the locations where cross sections are taken although at varying rates (Table 3.4). The pattern of shifting of the bankline during the present decade as depicted on the map between 2000- 2007 shows regression in all the sections except a major amount of progression (forward shifting) in one cross-section. Maximum bankline shift of about 7 km was observed during the period of 1973 to 1990.

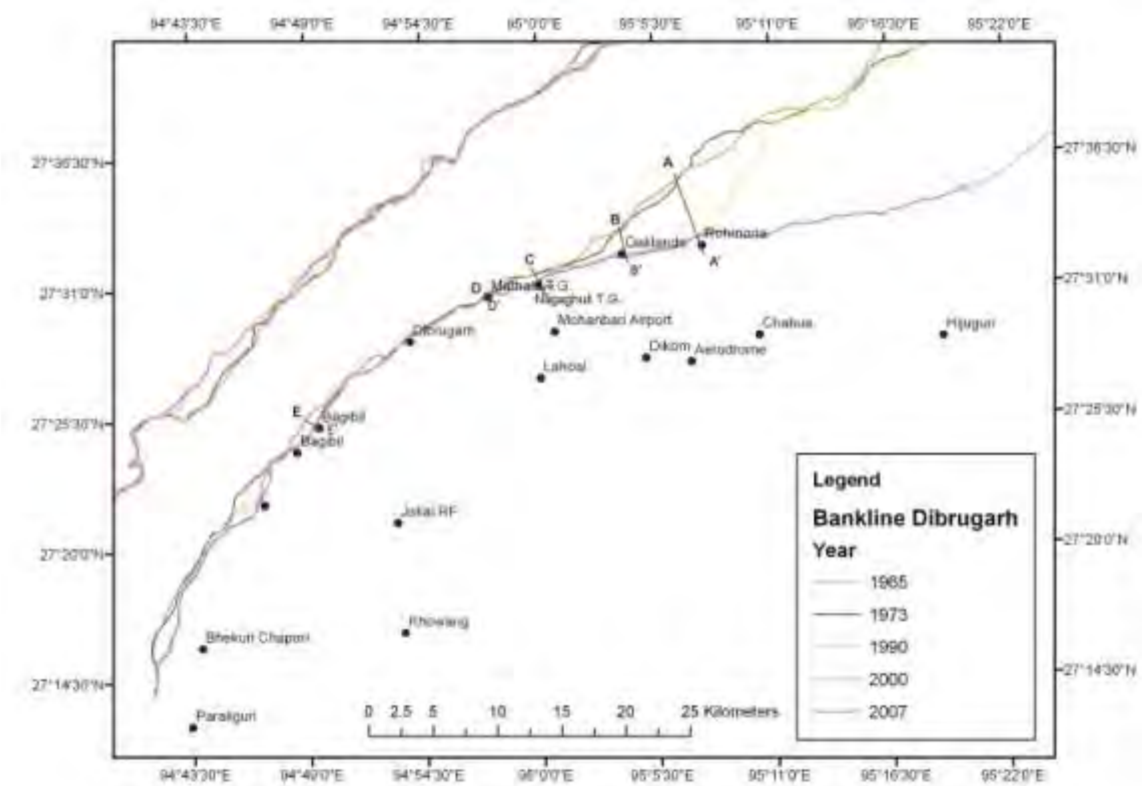


Figure 3.9 Bankline Migration (in m) of the Brahmaputra River in the Dibrugarh Reach at Selected Cross-sections during Different Time Periods

Table 3.4 Rates of Bankline Migration (in m) at Selected Cross-sections in the Dibrugarh Reach during Different Time Periods

Cross-Section	Period			
	1965 – 1973	**1973 – 1990**	**1990 – 2000**	**2000 – 2007**
AA'	-100	-4516	-60	-120
BB'	213	-1612	-266	-392
CC'	-25	-706	73	-12
DD'	-33	-157	163	-176
EE'	-36	-17	-40	898
Total	**19**	**-7008**	**-130**	**198**

3.2.4.3 Ground Water

80. Ground water availability is quite high in this region especially in the active floodplain zone. The availability of ground water in the district is estimated at 0.104 M.ha.m, while the stage of its development is 23.25 %.[14] Analysis of ground water at a station in Dibrugarh town close to the river embankment is presented in Table 3.5. It shows that quality of the water is good since all the test parameters are within acceptable limits.

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[14] Central Ground Water Board, 2005

Table 3.5 Ground Water Quality in Dibrugarh Town

S. No.	Parameters	Unit	IS 10500:1991 (Drinking Water Standard)		Dibrugarh Town
			Desirable	Permissible	
1	pH	-	6.5-8.5	6.5-8.5	6.7
2	Conductivity	(µmho/cm)	-	-	286
3	Hardness as $CaCO_3$	(mg/L)	300	600	118
4	Calcium	(mg/L)	-	-	78
5	Magnesium	(mg/L)	-	-	40
6	NO_3-N	(mg/L)	45	100	0.09
7	Fluoride	(mg/L)	1.0	1.5	0.66
8	Arsenic	(mg/L)	0.05	0.05	BDL
9	Total Iron	(mg/L)	0.3	1.0	1.24
10	Lead	(mg/L)	0.05	0.05	BDL
11	Copper	(mg/L)	0.05	1.5	BDL
12	Zinc	(mg/L)	5	15	BDL

(Source: State Pollution Control Board, Assam)

81. The analysis result shows that the groundwater quality is within permissible limits provided in the drinking water quality standards under IS 10500:1991 and meet all the desirable requirements. However, iron was found in higher concentration, exceeding the permissible standards.

3.2.5. Geology

82. The geology of the area adjacent to the Dibrugarh Reach is almost entirely made up of recent alluvial deposits called new alluvium comprising clay, sand, silt and shingle. The alluvial soils forming the floodplain extend down to a depth of 200 to 300 m.

83. The Brahmaputra valley is formed during the Pleistocene and recent times dating back to approximately 2 million years from sediments derived from the Himalayas in the north and the Assam plateau in the south and brought down by the Brahmaputra River and its tributaries. It is considered to be a tectono-sedimentary basin, 720 km long and 80-90 km wide, underlain by recent alluvium approximately 200-300 m thick consisting of clay, sand and pebble.[15] The basin is underlain for the most part by very young and unweathered sedimentary formations with the result that the river carries mainly fine sand and silt with very little clay. A dominant feature of the riverine landscape of the Brahmaputra is the large number of sandbars of varying shapes and sizes locally known as Chars that develop on the sandy bed of the braided channel. Although mostly transitory in nature, some of these chars are more or less permanent with a veneer of fertile soil on the top that support vegetation, crops and settlements.

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[15] GSI. 1977. *Contributions of geomorphology and geohydrology of the Brahmaputra Valley*. Miscellaneous Pub. 32.

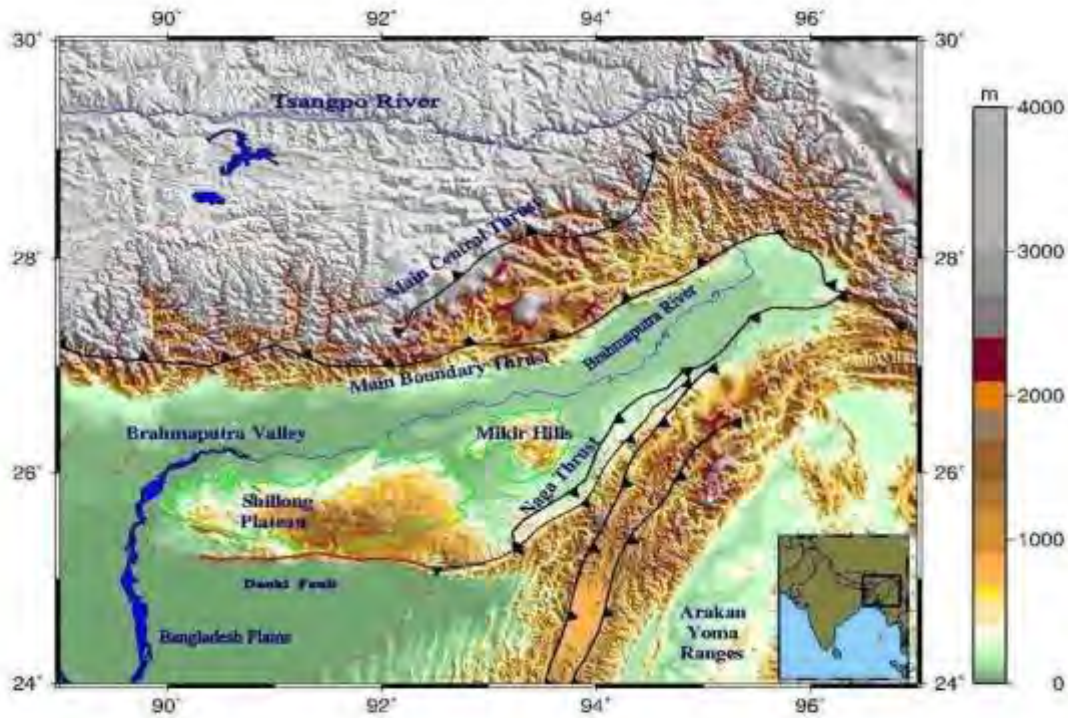

Figure 3.10 Geotectonic Map of Brahmaputra River Valley and its adjoining Highlands

3.2.6. Seismology

84. Due to their strategic location in regard to colliding Eurasia (Chinese), Indian and Burmese tectonic plate boundaries, the Brahmaputra valley and its adjoining hill ranges are seismically very unstable. The earthquakes have caused extensive landslips and rockfalls on the hill slopes, subsidence and fissuring of ground in the valley, and changes in the course and configuration of several tributary rivers as well as the mainstream. The geo-tectonic map of the Brahmaputra valley and its adjoining highlands is presented in Figure 3.10.

85. There appears to be phases of rapid aggradation of the Brahmaputra River associated with earthquakes, mainly as a result of deposition of sediments received from landslides, followed by relatively slower removal of accumulated debris over longer time periods. Active seismicity of the NE region has a very significant impact on the hydrologic regime and morphology of the Brahmaputra River including its host of tributaries and other water bodies (e.g. wetlands) strewn over the floodplains. Occurrence of these episodic events led to intensification of flood hazards, especially in the aftermath of the two great earthquakes of 1897 and 1950.[16]

86. As per the seismic zoning map of India, the entire project area falls in Zone V (very severe seismic intensity zone). The distribution of major earthquakes (above Richter magnitude 7.0) in the NE region since the 1897 Shillong earthquake is shown in Figure 3.13. The seismicity map of Northeast India with respect to the magnitude of earthquakes is shown in Figure 3.11. The Dibrugarh reach lying in the upper course of the Brahmaputra River closer to the eastern Himalayan region of high seismic vulnerability has been significantly affected by the

[16] Goswami, D. C. and Das, P. J., 2002: Hydrological Impact of Earthquakes on the Brahmaputra River Regime in Assam: A case study in exploring some evidences, Proc. 18th National Convention of Civil Engineers, Nov. 9-10, 2002, pp. 40 -48.

earthquakes of 1950, which was epicentered at a place called Rimoron, the tri-junction of India, Myanmar (Burma) and China. Besides the large amounts of sediments generated by the landslides in the lower Himalayan slopes, the earthquake was also reported to have caused choking of the river channel with sediments released from squeezing of the soft level areas.

Table 3.6 Major Earthquakes in Northeastern India and Adjoining Regions since 1897

Date	Epicenteral Area	Lat (°N)	Long. (°E)	Magnitude
12-06-1897	Shilong, Meghalaya	26°00'	91°00’	8.7
31-08-1906	India-Burma Border	27°00’	97°00’	7.0
12-12-1908	Kachim,Burma	26°30’	97°00’	7.0
09-09-1923	Jankaria,Meghalaya	25°12’	91°00’	7.1
02-07-1930	Dhubri,Assam	25°30’	90°00’	7.1
27-01-1931	Kachin,Burma	25°36	96°48’	7.6
04-08-1932	India-Burma Border	26°00’	95°30’	7.0
23-10-1943	Hojai,Assam	26°00’	93°00’	7.2
29-07-1947	Tammu,Arunachal Pradesh	28°30’	94°00’	7.8
15-08-1950	India-Burma-China Border	28°50’	96°30’	8.7
06-08-1988	Manipur-Burma-Border	25°14’	95°12’	7.2

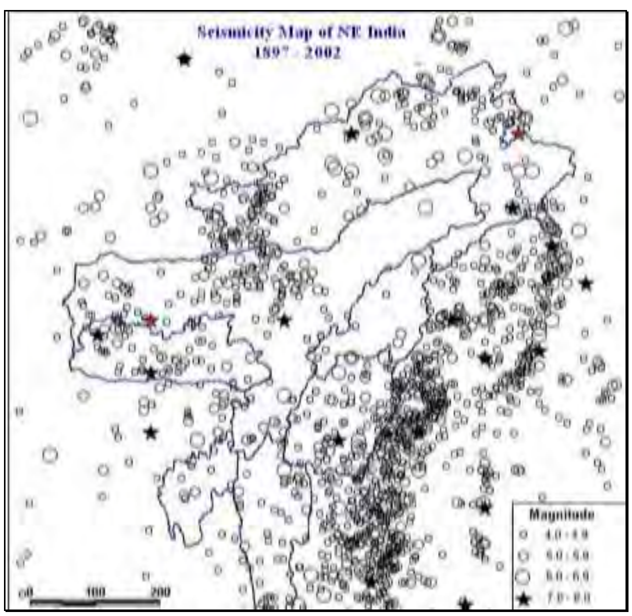

Figure 3.11 Seismicity Map of Northeast India (1897 – 2002)

87. The earthquakes of 1950, for example, raised the bed level of the Brahmaputra at Dibrugarh by at best three meters leading to increased flood and erosion hazard potential of the river (Figure 3.12). Similarly, as reported by Oldham (1899), the great Shillong earthquake of 1897 had several impacts on the hydrology of the river causing severe floods after the earthquake leading to aggradation of the river bed.[17] The bed level of the river was reported to

[17] Oldham, D. 1899**.** *The Great Earthquake of 1897*. Geological Survey of India Memoire 29.

have gone up by more than three meters due to which several tributaries had been blocked leading thereby to inundation of adjoining areas. Subsidence of the ground near the Brahmaputra River created a number of depressed areas now occupied by swamps.

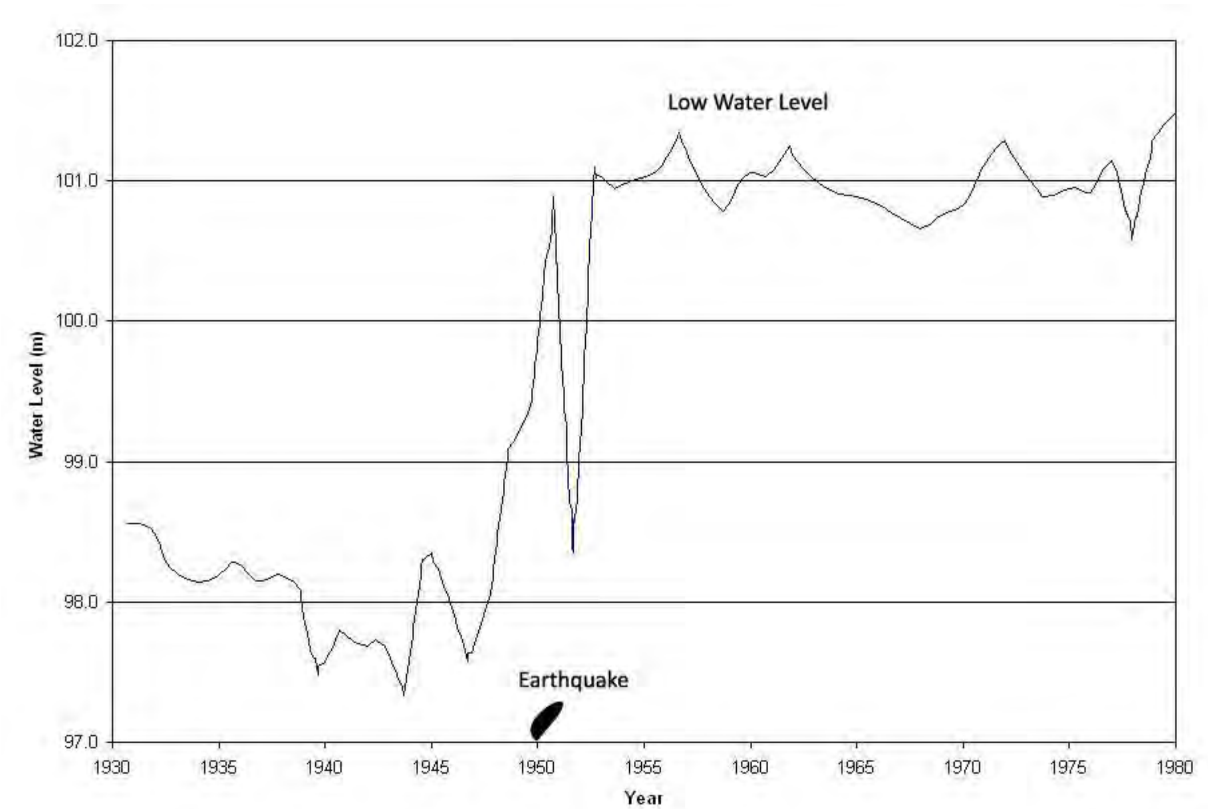

Figure 3.12 Effect of 1950 Earthquake on the Bed-level of the Brahmaputra at Dibrugarh

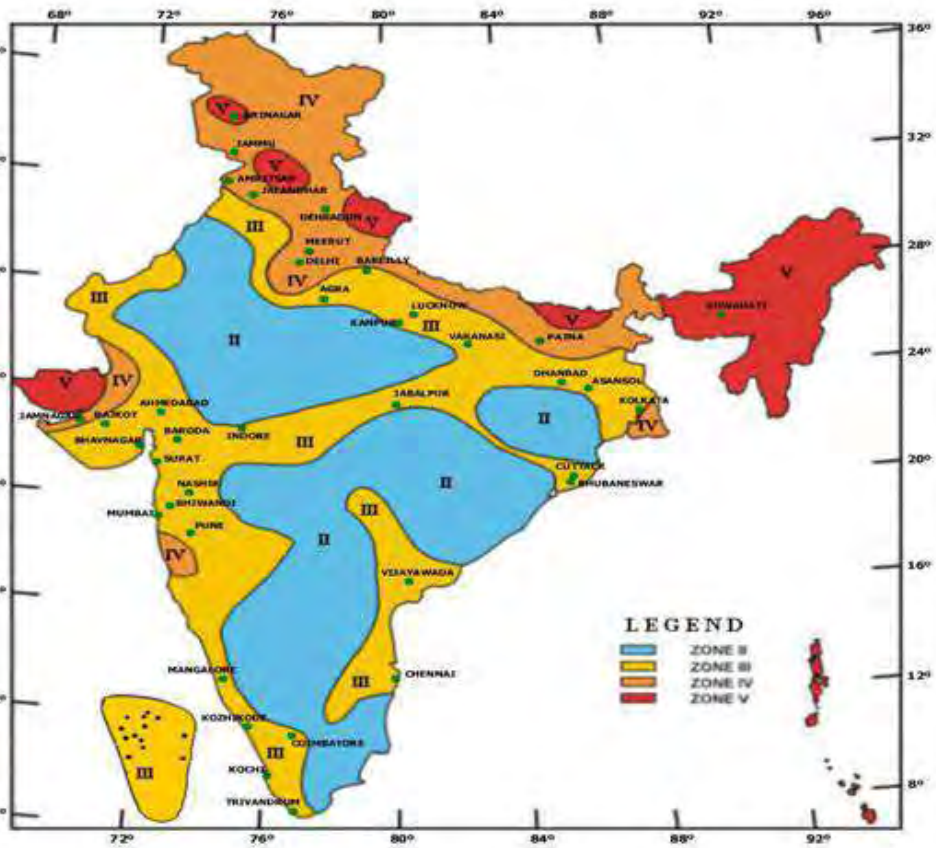

Figure 3.13 Seismic Zoning Map of India

3.2.7. Soil

88. The Dibrugarh Reach is made up of new alluvium that varies from clay to sandy loam in texture and less acidic in reaction with pH varying from 5.5 to 9.0. In the relatively higher parts of the valley, older alluvium soils are found as low terrace deposits. These soils have alternating beds of pebbles, gravels or boulders with loose sand and clays. The old alluvium soils are relatively more acidic with pH ranging from 4.2 to 5.5. The distribution of soil types in Assam is shown in Figure 3.14.

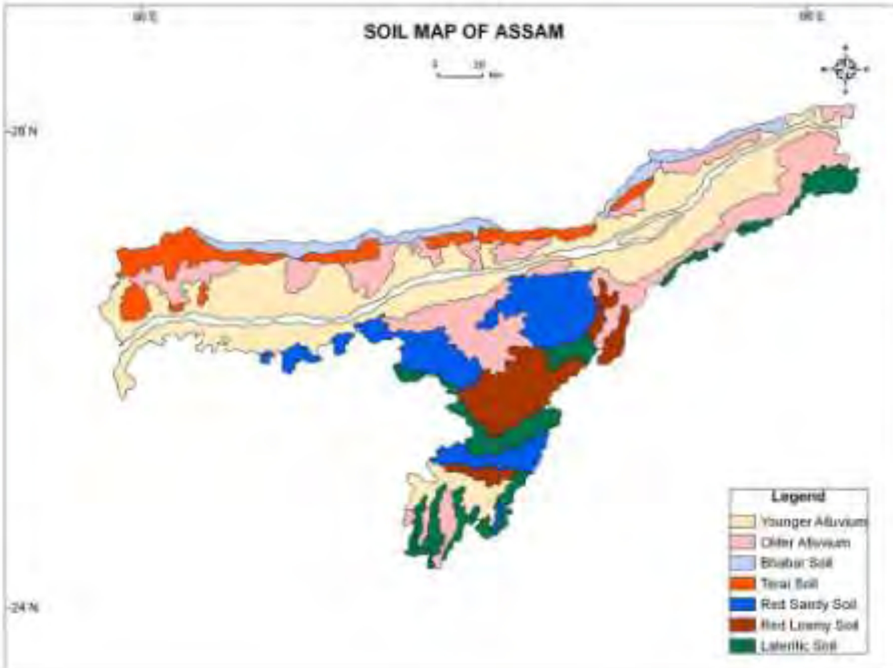

Figure 3.14 Soil Types in Assam

89. To examine the soil quality of the area adjacent to the river banks sampling and analysis of soil was carried out in two locations as shown in Figure 3.5. The results of the analysis are presented in Table 3.7. The soil quality in the Dibrugarh reach shows medium organic carbon, low available nitrogen, low available phosphorous, and medium available potassium.

Table 3.7 Analysis Results of Soil Samples in Dibrugarh Reach

Parameters	Unit	Pach Ali	Kahai Spur
Organic Carbon	ppm	0.48	0.52
Organic Matter	ppm	2.74	1.67
Available Nitrogen	ppm	23.41	21.27
Available Phosphorus	ppm	0.02	0.003
Iron	ppm	0.053	0.029
Copper	ppm	0.014	0.004
Manganese	ppm	BDL	BDL
Lead	ppm	BDL	BDL
Chromium	ppm	BDL	BDL
Zinc	ppm	0.004	0.025
Mercury	ppm	BDL	BDL
Arsenic	ppm	0.001	0.001
Potassium	ppm	49	73
CEC		0.78	0.75
Textural Classes		Sandy	Clay
Clay	%	10	43
Silt	%	15	29
Sand	%	75	28
Bulk Density	g/cc	4.0939	4.125
Water Holding Capacity	%	29.72	32.36

Parameters	Unit	Pach Ali	Kahai Spur
Pore Space	%	38.72	37.54
Specific Gravity	%	1.14	1.3
Electrical Conductivity	(dS/m)	2	3.4

(Source: Sampling and Analysis done by the Dept. of Env. Science, Gauhati University)

3.2.8. Land Use

90. The current landuse pattern in the area is examined in three different scale and space dimensions keeping in view the nature and intensity of the potential impact of the different project elements. On a broader scale, a 10 km buffer around the embankment is chosen and the landuse pattern within the zone is delineated from satellite images using GIS. The landuse map of the 10 km buffer zone is presented in Figure 3.15 and the area covered by different categories of landuse are given in Table 3.8:

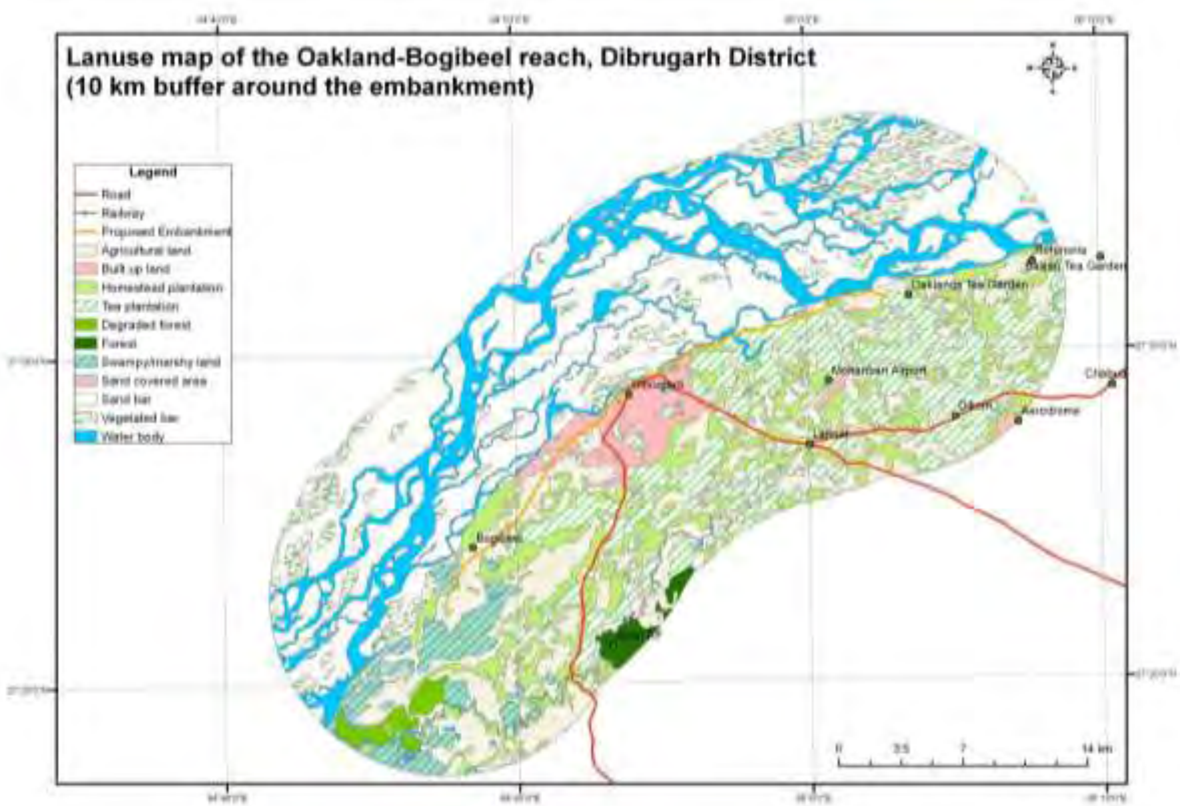

Figure 3.15 Landuse Map of the 10 km Buffer Zone on either side of the Dibrugarh Reach along the South Bank of the River Brahmaputra

Table 3.8 Landuse in the Study Area (10 km buffer around embankment)

Category	Area (ha)	Area (%)
Agricultural land	17141.2	18.3
Built up land	2825.6	3.0
Degraded forest	916.2	1.0
Forest	699.0	0.7
Homestead plantation	10460.1	11.2

Category	Area (ha)	Area (%)
River channel	12619.3	13.5
Sand bar	28345.3	30.3
Sand covered area	7.2	0.0
Swampy/marshy land	3354.5	3.6
Tea plantation	11659.3	12.5
Vegetated bar	5373.3	5.7
Wetlands and other waterbodies	175.2	0.2
Total	**93576.2**	**100**

(Source: IRS-P6 data for Year 2008)

91. Out of the total study area of 93,576.2 ha, sand bars occupy 28,345.3 ha accounting for 30.3%, followed by agricultural land 18.3%, river channels 13.5%, tea plantation 12.5%, and homestead plantations 11.2%. Wetlands and other water bodies occupy only 175.2 ha (0.2%) area in the buffer zone of 10 km around the embankment.

92. Landuse pattern is also examined in a 50 m direct impact zone on either side of the embankment using satellite remote sensing and GIS. The dimension of the direct impact zone is decided based on field observations as well as discussions with technical and administrative officials of the Government. The 50 m direct impact zone for the entire reach is shown in Figure 3.16. The landuse data for the direct impact zone is presented in Table 3.9. It indicates that the agricultural land occupy highest portion of the area (42.8%) followed by built-up land (23.4%), tea plantation (14.2%), homestead plantation (8.6%), etc.

93. The landuse pattern in the zone lying between the bank and the embankment was also mapped using satellite data and GIS. The result of this analysis is shown in Figure 3.17. It shows that agricultural land dominates the landuse accounting for more than 38.5% of the total area followed by homestead plantations (27.1%) and built-up land (22.8%). These areas are mostly found in the western part of the reach.

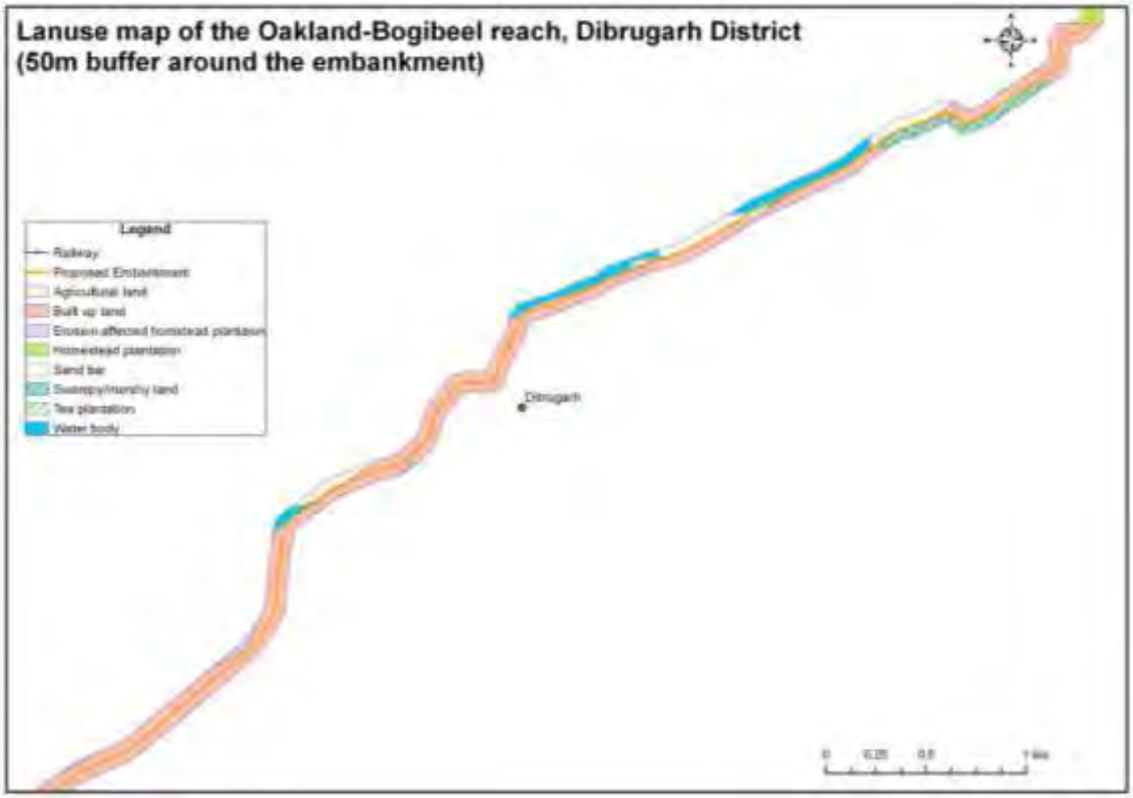

Figure 3.16 Landuse Map of the 50 m Buffer Zone on either side of the Dibrugarh Reach along the South Bank of the River Brahmaputra

Table 3.9 Landuse of Dibrugarh Reach (50 m buffer around embankment)

Category	Area (ha)	Area (%)
Agricultural land	141.9	42.8
Built up land	77.5	23.4
Homestead plantation	28.4	8.6
River channel	11.9	3.6
Sand bar	11.5	3.5
Swampy/marshy land	13.0	3.9
Tea plantation	46.9	14.2
Total	**331.1**	**100**

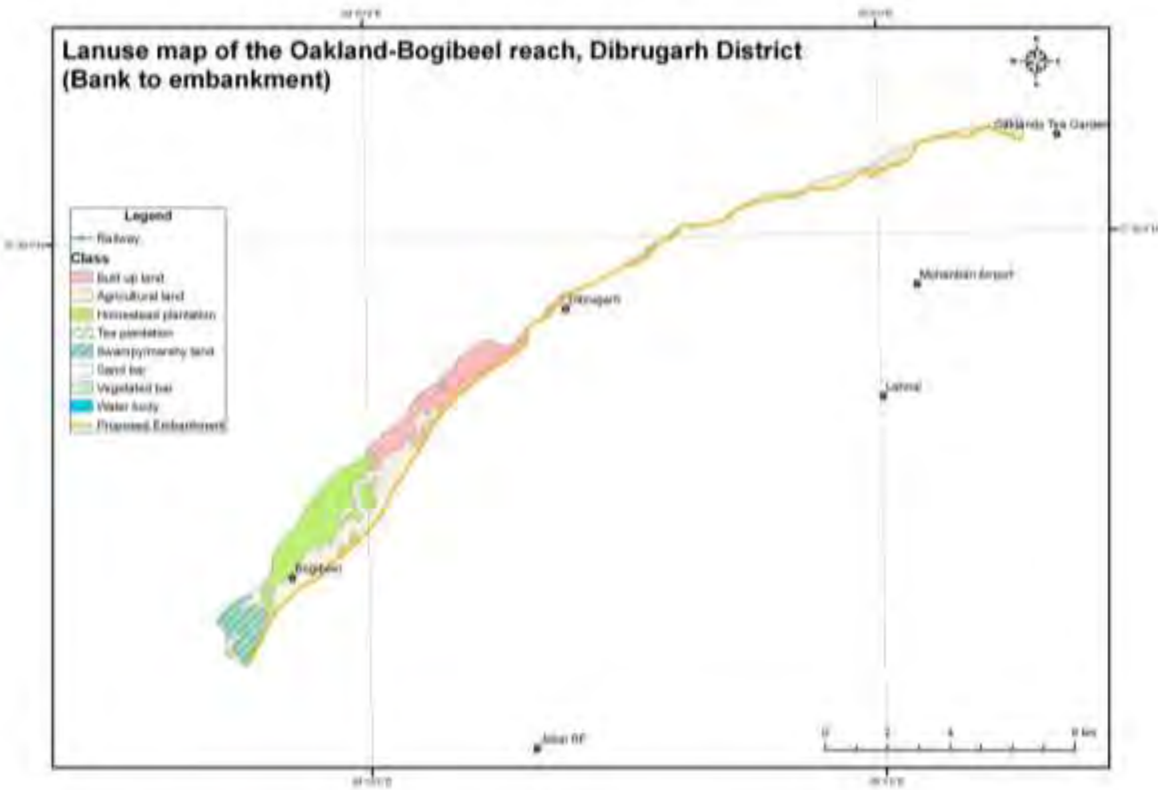

Figure 3.17 Landuse Map of Dibrugarh Reach (bank to embankment)

Table 3.10 Landuse of Dibrugarh Reach (Bank to Embankment)

Category	Area (ha)	Area (%)
Agricultural land	756.5	38.5
Built up land	447.3	22.8
Homestead plantation	532.2	27.1
Swampy/marshy land	184.9	9.4
Tea plantation	43.9	2.2
Total	**1964.8**	**100**

3.2.9. Air Environment

94. Except the stretch falling within the Dibrugarh Town area, the rest of the Dibrugarh Reach comes under rural setting or tea plantations. Air quality was monitored at a location very close to the high activity zone of the urban centre. The results of ambient air quality monitoring in the reach are presented in Table 3.11. The ambient air quality results have also been compared with the National Ambient Air Quality Standards (NAAQS) for Residential and Rural Areas in India.

Table 3.11 Air Quality in Dibrugarh Reach

S. No.	Parameter	Unit	NAAQS for Residential and Rural Areas	Pach Ali
1.	Suspended Particulate Matter (SPM)	µg/m^3	200	76
2.	Respirable Suspended Particulate Matter (RSPM)	µg/m^3	100	57
3.	Oxides of Nitrogen (NOx)	µg/m^3	80	23.8
4.	Sulphur Dioxide (SO2)	µg/m^3	80	3.3
5.	Lead (Pb)	µg/m^3	1.0	0.07
6.	Carbon Monoxide (CO)	µg/m^3	2000	190
7.	Hydrocarbons (HC)	µg/m^3	-	690

(Source: Monitoring done by Dept. of Env. Science, Gauhati University)

95. It is evident from the comparison that all the air quality parameters are found well within the permissible limits as per the NAAQS for residential and rural areas. The National Ambient Air Quality Standards in India are shown as Appendix 3.2.

3.2.10. Noise Environment

96. Noise quality was monitored at the project site close to the high activity zones of the urban centre. The ambient noise levels during day and nighttime have been presented in Table 3.12. The ambient noise levels have also been compared with Ambient Air Quality Standards in respect of Noise for residential areas. The National Ambient Air Quality Standards in respect of noise are shown as Appendix 3.3.

Table 3.12 Noise Quality in Dibrugarh Reach

Location	AAQS in respect of Noise for Residential Area		Day Time [dB(A)]			Night Time [dB(A)]		
	$L_{eq(day)}$	$L_{eq(night)}$	L_{max}	L_{min}	$L_{eq(day)}$	L_{max}	L_{min}	$L_{eq(night)}$
Pach Ali	55	45	75	51	57	67	38	45
Kahai Spur			63	47	52	58	37	42

(Source: Monitoring done by Dept. of Env. Science, Gauhati University)

3.3. Terrestrial Ecology

3.3.1. Methodology of Baseline Data Collection

97. To collect the baseline data from Brahmaputra Dyke in Dibrugarh, the area from Mohona Ghat to Oakland area was surveyed (total length of 40 km). The tree species available inside and outside the embankment has been counted. The identification of tree species was made based on available Books Plant Taxonomy.[18] Samplings were taken after each Ch. 1.0 km and the data has been gathered within 100 m width of either side of the embankment. If the DBH of the tree species ranges between =<0.45 meters, then it was categorized as tree, whereas, it was categorized as sapling if >=0.45 meters. Saplings were not recorded for analysis. Animal species data were collected in study sites through direct sighting methods, indirect evidences

[18] Kanjilal, U. N. and Bor, N. L. (1940). Flora of Assam Volume I-V, Government of Assam, Shillong.

and as well as the information of local inhabitants (through displaying the animal's colour plates). GPS locations of all the sampling sites were taken and the important area has carefully been marked and GPS locations were taken to draw conclusions of the study (Appendix 3.4). Identification of Mammalian, Avian and Reptilian species were made as per the available Books and published materials.[19,20,21,22] Analysis was done following standard methods.[23,24]

3.3.2. Identification of Terrestrial Flora

98. It is significant to note that the land area inside the embankment that frequently interact with Brahmaputra flood water leads to tremendous harmful impacts on the ecosystem. However, outside the embankment, there has been comparatively less impact of floodwater on land surface since long time.

99. The vegetation compositions of the terrestrial zones comprise of Pakori-*Ficus rumphii*, Acacia-*Acacia auriculiformes*, Sagina-*Moringa oleifera*, Amlakhi-*Phylanthus ambilica*, Bhimkol-*Musa balbasiana*, Atlas-*Annona squatamosa*, Owtenga-*Dillenia indica*, Jatibanh-*Bambusa tulda*, Aam-*Mengifera indica*, Kadam-*Anthrocephalus cadamba*, Ahot-*Ficus religiosa*, Bot Goch-*F. bengalensis*, Indian Rubber-*Ficus elastica*, Simul-*Bombax ceiba*, Gamari-*Gmelina arboria*, Narikol-*Cocos nucifera*, Jolphai-*Elaeocarpus fleribundus*, Segun-*Tectona grandis*, Ghoranim-*Melia azedarach*, Deodaru-*Polialthia longifolia*, Satiana-*Alstnia scolaris*, Amita-*Carica papaya*, Kathal-*Artocarpus heterophyllus*, Bogori-*Zizyphus jujuba*, Siris-*Albizia lebek*, Ranga Kanchan-*Bauhinia purpurea*, Krishnasura-*Delonix regia*, Karash-*Pungamia pinnata*, *Areca catechu*, Bijuli Banh-*Bambusa pallida* and Tambul- *Areca catechu etc.* The other important terrestrial plants included viz., Jati bet- *Calamus erectus,* Dubari Ban- *Cynodon dactylon,* Locosa Ghanh-*Hemarthia compressa,* Birina- *Vetiveria zizanoides,* Khagori- *Phragmites karka,* Ulukher-*Imperata cylindrica,* Hankher- *Pollinia ciliata,* Kahua- *Saccharum sponteneum and* Borota Kher-*Saccharum elephantinus etc*.

100. The main climbers comprises the species of *Stephania harnondifolia* (Tubuki Lata), *Zanthoxylum hamiltonianum* (Tej-muri), *Illegeria khasiana* (Kerkeri Lata), *Dioscorea hamilttoni* (Bonoria Alu), *Smilax macrophylla* (Tikoni Boral), *C. gracilis* (Wahing Bet), *C. latifolius* (Motha bet), *Pinaga gracitis* (Raidang Bet), *Pothos cathcartii* (Hati-poita) and *P. scandens* (Kawri Lata) etc. The details of tree species identified along the embankment have been presented in Appendix 3.5. The community dominance index of tree species in various study zones of Dibrugarh reach have been presented in Appendix 3.6.

3.3.3. Ecology of Terrestrial Zones

101. Inside and outside of the Brahmaputra dyke in Dibrugarh reach has been occupied by secondary vegetation and characterized by *Bombax ceiba, Trtramelos nudiflora, Cordia dichotoma*, *Erythrina indica, Ficus rumphii and Zizyphus jujuba etc*. The area was gradually

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[19] Menon, B. (2003). A Field Gudie to Indian Mammals, D. K. Publication, Delhi, pp. 201.

[20] Ali, S. and Riplley, S. D. (1987). Handbook of Birds of India and Pakistan, 2nd edition, Delhi: Oxford University Press, Oxford, pp. 700.

[21] Whitaker, R. and Captain, A. (2004). Snakes of India, The Field Guide. Draco Bookds, P.O. Box – 21, Chengalpattu 603001, Tamil Nadu, India, pp. 480.

[22] Chaudhary, A. U. (1997). Checklist of Mamals of Assam, 2nd revised edition, Gibbon Books, Guwahati, pp. 102

[23] Magurran, A. E. (1988). Ecological Diversity and its Measurement, London: Chapman and Hall, pp. 179

[24] Dytham, C. (1999). Choosing and Using Statistics, A Biologist's Guide, Blackwell Science Ltd. Osney Mead, Oxford OX2 OEL, pp. 218

colonized by these plants owing to frequent interactions with Brahmaputra floodwater, sand deposition, and frequent construction/repairing of the embankment during flood season. As a result of regular flooding, once fertile land has been converted into barren land along the stretches of embankment. The area within Maijan site near Tea Estate (coordination: 27°30′58″N - 94°59′20″E), Naga Ghuli area (coordination: 27°31′16″N - 95°00′18″E), near Last Spur (coordination: 27°31′50″N - 95°02′14″E), and near earth spur has been eroded heavily and critically threatened of being washed-out in the immediate future. Most of the land area inside the embankment has been sandcasted.

102. All tea gardens were situated along the dyke, covering almost half-length of the existing embankment. Along the dyke are also the majority of settlers – mostly tea laborers. The only natural wetland found near the embankment site is the Maijan beel, which is the lifeline of the local fishermen. This beel is located about 500 m apart from the existing embankment site, but no feeding channel was observed from Brahmaputra to this beel.

103. According the local elderly people, both the sides of the embankment used to have full of vegetation with valuable trees and fertile agricultural land, but due to regular floods of River Brahmaputra, the area have been either engulfed or washed out along with vegetation therein. Now the entire area has turned into wasteland..

3.3.4. Identification of Terrestrial and Aquatic Wildlife Fauna

3.3.4.1 Birds

104. Altogether 156 species of avian fauna belonging to 36 families were recorded in Dibrugarh Reach, of which 114 species were residential and 42 were migratory birds (Appendix 3.7). Among migratory birds, nearly all were ducks, gees, and waders were recorded at the river Brahmaputra. More species were not found here owing to seasonality of most of them, but the species have similarities with neighboring Dibru-Saikhowa BR.[25]

3.3.4.2 Mammals

105. There were altogether 16 mammalian species recorded in Dibrugarh reach that belongs to 9 families and 16 genuses, of which two species (Leopard and River Dolphin) were categorized as Schedule-I under Wildlife Protection Act 1972. The comprehensive list of mammals in Dibrugarh Reach is presented in Appendix 3.8. Most of the species were recorded in the habitat near tea garden and residential campus. The species River Dolphin was recorded in the deep channels of river Brahmaputra and Otter was recorded in adjacent habitat of Maijan beel.

3.3.4.3 Amphibian Fauna

106. There were altogether 8 amphibian species recorded in Dibrugarh Reach that belongs to 5 genuses, but no Schedule – I species under Indian Wild Life Protection Act, 1972 was found. The comprehensive list of amphibian fauna in Dibrugarh reach is presented in Appendix 3.9.

[25] Choudhury, A. U. (1998). Mammals, Birds, and Reptiles of Dibru-Saikhowa Sanctuary, Assam, India. Oryx 32(3) pp. 192-200.

3.3.4.4 Reptiles

107. Altogether 24 reptilian species were recorded belongs to 8 families in Dibrugarh reach during the survey. The comprehensive list of reptilian fauna in Dibrugarh reach is presented in Appendix 3.10.

3.3.5. Faunal Behaviour Pattern

108. The river Dolphins come close to the dyke during monsoon flood when water depth increase, but during survey period, very less sightings were made beyond Mohanaghat and Oakland Ch. 0.0 point. According to local inhabitants, the Dolphins were frequently seen along the dyke and Dhansirimukh during monsoon flood. The Chelonian species (turtles) has been noted to reach the sandbar to lay eggs sometimes coming close to the dyke in Nagaghuli, Maijan and Kohi Spurs, Maijan beel, Maijan Barsaikia, and the last spur.

3.3.6. Land River Interface

109. There were two land-river interfaces found along the dyke, the Maijan Beel and Burhidihing Mouth. No other connection of wetland was observed with the River Brahmaputra along the dyke. These two interfaces are very important for the entire area for annual biodiversity re-colonization and feeding channels.

3.3.7. Migratory Route of Terrestrial Fauna

110. There was no migratory route of terrestrial faunas reported throughout the embankment in Dibrugarh Reach possibly due to the absence of nearby forest reserve. What was noted during the study was the movement of amphibian and reptilian fauna to and from river Brahmaputra, however no map was prepared due to lack of detailed information.

3.3.8. Dolphin and Its Behaviour Pattern

111. Dolphins generally feed on fish at deep-water channels, where density is very high, sometimes coming very near the dyke particularly during monsoon season. Dolphins are very accustomed to machine boats because they can easily capture the prey species near moving boats. When water depth recedes, they move to the deeper channels.

3.3.9. Areas of Eco-sensitivity/ Protected Area

112. No eco-sensitive and protected areas were found in the Dibrugarh Reach and in the buffer zone of embankment. Also, no wildlife habitat/ reserve forest areas/ sanctuaries were found in this reach. Only tea gardens were found near the Brahmaputra Dyke.

3.3.10. Vegetation Profile

113. From the vegetation point of view, the area is not very productive, except for the tea gardens. Most of the vegetation indicated secondary growth. The horticultural plants are mostly available in residential compounds and riverside. The survey of vegetation profile revealed that area harbors 33 species of plants were in the dyke area, of which, the Satiana-*Alstnia scolaris* and Bogori-*Zizyphus jujuba* species are the dominant plant (Tea species were not included in the survey). (See Appendix 3.5 and Appendix 3.6).

114. Analysis of Community Dominance Index in the dyke area suggested that it is very high in Kaliaghat/ Phulbagan inside, Mohanaghat area, Tinikunia, and Oakland Tea Estate area indicating very limited species diversity (when species diversity is high community dominance index is reduced). In Maijan Thakurbari (inside the embankment) only *Bombax ceiba*, *Alstonia scolaris* are found and in contrast there was no tree species in Maijan Thakurbari (also inside the embankment). In the Oakland Tea Estate (inside the embankment) only *Alstonia scolaris* plant was found.

3.3.11. Economically Important Plants

115. Apart from tea plants, there were two medicinal plants (total number 1,480 individuals), 8 economically important plant species (total number individuals 15,640), 4 fuel wood (total number individuals 9,545) and 2 timber tree species were (Total number individuals 7820) recorded in Dibrugarh Reach. The comprehensive list of economically important plant species is presented in Table 3.13:

Table 3.13 Medicinal, Timber, Fuel Wood Plants in Dibrugarh Reach

Tree Species	Importance			Total Numbers
	Medicinal (M) /Economically Important (E)	Fuel wood	Timber	
Sagina-*Moringa oleifera*	E			2415
Amlakhi-*Phylanthus ambilica*	M			115
Jatibanh-*Bambusa tulda*		√		460
Aam-*Mengifera indica*	E			2530
Kadam-*Anthrocephalus cadamba*		√		2875
Gamari-*Gmelina arboria*			√	5290
Narikol-*Cocos nucifera*	E			1495
Jolphai-*Elaeocarpus fleribundus*	E			460
Segun-*Tectona grandis*			√	2530
Ghoranim-*Melia azedarach*	M			1380
Kathal-*Artocarpus heterophyllus*	E			2185
Siris-*Albizia lebek*		√		5980
Areca catechu	E			5750
Bijuli Banh-*Bambusa pallida*	E	√		230
Acacia-*Acacia auriculiformes*	E			575
Total				**34270**

3.3.12. Identification of Endemic/ Threatened and Endangered Species

116. There was no endemic wildlife species found in the study area, but few species of endangered species were recorded during survey. Study recorded 2 endangered mammalian fauna (Table 3.14), 5 reptilian species (Table 3.15) and 10 endangered avian faunas (Table 3.16) in Dibrugarh reach.

Table 3.14 Endangered Mammalian Fauna in Dibrugarh Embankment Site

S. No.	English Name	Order/Family/Scientific Name	Status of IWPA
1.	Leopard	***Order: Carnivora: Family: Canidae:*** *Panthera pardus*	Schedule-I
2.	River Dolphin	***Order: Primate: Family:*** *Planista gengeticus*	Schedule-I

Table 3.15 Endangered Reptilian Fauna in Dibrugarh Reach

S. No.	Common Name	Scientific Name	Status of IWPA
1	Indian Roofed Terrapin	*Kachuga tecta* (Gray)	Schedule-I
2	Spotted Black Terrapin	*Geoclemys hamiltoni* (Gray)	Schedule-I
3	Indian Mud Turtle	*Lissemys punctata* Lacepede	Schedule-I
4	Peacock Soft-shell	*Trionix hurum* (Gray)	Schedule-I
5	Ganges Soft-shell Turtle	*Trionix gangeticus*	Schedule-I

Table 3.16 Endangered/ Globally Threatened Avian Fauna in Dibrugarh Reach

S. No.	English Name	Family/Scientific Name	Status	Status of IWPA/GS
1.	Spot-billed Pelican	*Pelecanus philippensis*	R	Schedule-I/GT
2.	Lesser Adjutant Stork	*Leptoptilos javanicus*	*R*	GT
3.	Greater Adjutant	L. dubius	*R*	Schedule-I/GT
4.	Bar-Headed Goose	*Anatidae* *Anser indicus*	*M*	Schedule-I/GT
5.	Grey-Lag geese	*Anser anser*	*M*	GT
6.	Osprey	*Accipitridae* *Pandion haliatus*	*R*	Schedule-I/GT
7.	Red-headed Vulture	*Sarcogyps calvus*	*R*	GT
8.	Shikra	*Accipiter badius*	*M*	Schedule-I/GT
9.	Lesser Kestrel	*Falco naumanni*	*M*	Schedule-I/GT
10.	Blossom-headed Parakeet	*Psittacula roseate*	*R*	GT

3.3.13. Wetlands

117. There are only two wetlands found near project site namely, Maijan perennial beel and Nagaghuli temporary wetland. According to local fishermen, the Maijan beel has tremendous potential to support various aquatic fauna including indigenous fish species. The Nagaghuli temporary wetland is also important for various fish fauna, because during monsoon season, the fish species have colonized here and the people catch it, when water level comes down at a suitable depth. No other wetlands were found nearby project site except natural rivers.

3.3.14. Peoples Dependence on Flora and Fauna

118. The people who reside near Brahmaputra Dyke in Dibrugarh are tea labourer, fishermen, cultivator, and businessmen. They are economically very poor. So, most of them

primarily depend on the harvesting natural resources. Majority of the people rely on fishing at river Brahmaputra and Maijan beel for their livelihood. The Maijan beel is the lifeline of fisherfolks in Dibrugarh Dyke where most of the catches are registered to be sold in the daily market. Limited number of people depend their livelihood on selling fuel woods from neighbouring tea gardens or naturally growing tree species along the dyke.

3.4. Aquatic Biology

119. Dibrugarh Reach is very rich in aquatic fauna starting from the macro-invertebrates to the higher vertebrates including mammals. All the aquatic fauna were collected from 12 different study zones. The variability and number of each species in the study zones are found to vary. There is tremendous scope of diversity of aquatic fauna as these areas are flood prone. The major fisheries of these areas are *Barilius spp, Tor sp, Labeo sp, etc.* Migratory fish like *Hilsa* and *Anguilla bengalensis*, an endangered sp. are also encountered in that projected site.

120. A lean channel of Brahmaputra in Koilaghat area is filled with water during the flood seasons and currently some portions of that channel are covered with benthoses and Minnows. Burrowing fishes, crabs, turtle like *Kachuga sylhetensis, Aspideretes gangeticus* were also seen in the area. Dolphins are reported to be frequently seen by the local villagers and fishers.

3.4.1. Aquatic or Macro-Invertebrates Ecology

121. The aquatic fauna gives a rich diversity in the project area. Under macro-invertebrates such as crabs, molluscs, snails, lizards, amphibians and other aquatic mammals are seen.. Zooplanktons are also recorded which are listed in Appendix 3.13.

122. Presence of Dolphin was also recorded at Dibrugarh site. The high abundance is reported at the confluence of Maijan beel to feed. At Maijan Thakur area (Stone Spur No. - 1) the abundance of fish is high. This is because of a sub channel of river Brahmaputra which forms a suitable breeding ground for the fish. Many fish prefer to breed in the riparian zone of the river.

123. Although the fish species available are almost similar in both sites, their abundance varies. Ompok species, Baralius sp. and Salmostoma sp. are abundantly found at Dibrugarh area.

3.4.2. Fish Species Diversity

124. Altogether 55 species of fish belonging to 20 families has been identified in the study area. Diversity of fishes in different sites gives different results. *Salmostoma, Garra, Gudusia* etc. species are predominant in all project sites. Tor and Mahaseer are found to be more dominant in the flood seasons because it migrates through main channel of the Brahmaputra River. In winter season *Tor* is found to migrate in lesser number. Other fish species like minnows are found to be less diverse at some points. Some species like *Channa, Clarius, Heteropneustes, and Anabas* etc. are predominant in adjoining wetland area in the Maijan Beel. The fish abundance area are shown at Figure 3.18

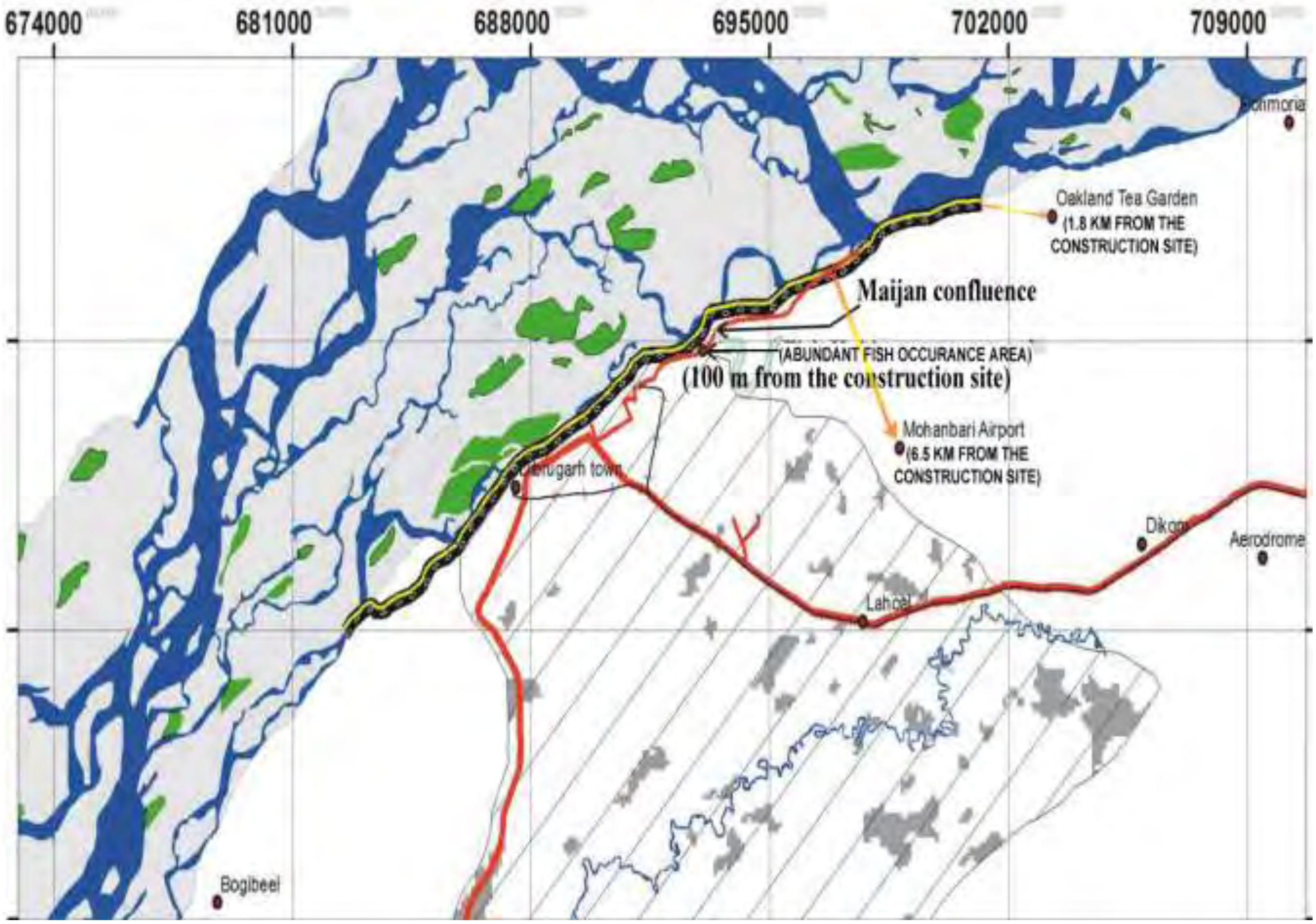


Figure 3.18 Distance of Eco-Sensitive and Fish Abundance area from the Embankment

3.4.3. Faunal behaviour pattern

125. The existing channel of wetland at Tinikonia, Kolaigaon area which is directly connected with the river Brahmaputra has given a rich commercial fishery, supporting large number of fishes and amphibians species which breed during pre-monsoon and monsoon season. The river Dolphins also breed and play in the river water adjacent to all sites. Dolphins come to the connecting channels to feed. Other species like turtles and tortoises prefer to breed only in sandy ground near bank of the river having land-river interface. In Mahanaghat, there are good habitat for the amphibians and the lizards. They prefer to live in the river bank and destruction of the bank will create negative impacts on the species. Some fishes as well as other benthos and turtles are very sensitive to the river erosion, sedimentation and abrupt changes of river ecology.

3.4.4. Migratory Route of Aquatic Fauna

126. The migratory fish species like *Hilsa* and *Anguilla* which have been encountered show anadromus and catadromous migratory behaviour respectively. They migrate through the main channel of the river i.e. through the deeper zones of the river. So migratory route will not have any negative effect owing to the construction of the dyke.

3.4.5. Area of Eco-sensitivity/ Protected Area/ Restricted Area/ Legislative and Others

127. No such eco-sensitivity areas, protected area, restricted area, legislative, and others were found in the project sites. A large number of fish enter through the channel connected with the Brahmaputra. Diversity of fish fauna is high in Maijan Beel. The channel should be permanently open to allow fish and other aquatic animals to breed. The north portion of the beel is suitable breeding ground for Indian major carps, minor carps, live fishes, and minnows and is most essential for breeding ground requiring the channel that connects the beel and Brahmaputra should be maintained.

3.4.6. Identification of Endemic/ Threatened and Endangered Species

128. Only 3 fish species of fish are found under endangered category (Appendix 3.13). Besides fishes, turtles, some amphibians and dolphins are also under Schedule-I endangered species.

3.4.7. Peoples dependence on aquatic fauna

129. Fishery community people are seen in the adjoining areas of Koilaghat, Maizan BorSaikia Gaon, and Nagaghooloi ghat areas. These people are totally dependent on the adjoining areas of Brahmaputra River and Maizan Beel. Intensive fishing activities were seen in the Maigan Beel which is directly connected with the Brahmaputra River.

3.5. Socio-Economic Environment

3.5.1. General Profile and Demography

130. The Dibrugarh District, with 7 development blocks, 1 sub division, and 7 revenue circles is located in the northeastern part of the State. Brahmaputra River is flowing at the northern boundary of the District. The District is comprised of 1,345 villages. The Dibrugarh subproject reach falls under 5 Development Blocks and 134 villages based on land records, namely, Barbarua, Lahowal, Panitola, Tengakhat, and.Khowang. These blocks consist of a total of 134 villages along the reach in the core and buffer zones. The general details of demography of the Dibrugarh reach are given in Table 3.17.

Table 3.17 Dibrurgarh Reach: General Details

Development Block	Area (ha)	Villages	No. of Households	Total Population	Population Density (persons/km^2)
Barbarua	11841	68	10880	57475	485.4
Lahowal	13519	59	14859	75197	556.2
Panitola	439	2	714	3624	825.5
Tengakhat	426	1	243	1379	323.7
Khowang	859	4	351	2062	240
Total	**27084**	**134**	**27047**	**139737**	**516**

Source: Census of India, 2001

131. The population profile of the blocks along the Dibrugarh reach with respect to male, female, schedule castes (male and female), schedule tribe (male and female) have been given in Table 3.18:

Table 3.18 Dibrurgarh Reach: Population Profile

Name of Development Block	Total population			% of total Popn	
	All Categories	Scheduled Caste	Scheduled Tribe	Scheduled Caste	Scheduled Tribe
Barbarua	57475	2988	6810	5	12
Lahowal	75197	3124	985	4	1
Panitola	3624	97	22	3	1
Tengakhat	1379	0	0	0	0
Khowang	2062	260	205	13	10
Totals	**139737**	**6469**	**8022**	**5**	**6**

Source: Census of India 2001

132. The economy of Dibrugarh District relies mainly on tea gardens, rice cultivation, and service sector. In the subproject area of 27, 084 ha, total population was 139,737 with 5%, and 6% population belonging to SC and ST social categories, respectively. The tribal population comprised of several local tribal communities and Mishing community migrated from Dhemaji and Lakhimpur districts. Flooding and riverbank erosion affect severely the tea gardens that generate employment for the two third of the working population in the sub project area. Similarly, the livelihood is based on agriculture for the one third of the population, affect severely due to the flooding and erosion. Though erosion was found to be under control, the flooding every year stalls the economy for at least three to four months.

3.5.2. Education

133. Based on census data 2001, the District has a population literacy rate of 69.96% which is higher than the State average of 63.25%. The higher proportion of literate population is found in Dibrugarh subproject area due to high proportion of population spread in urban settlements with having educational facilities. The education facilities in the project area are distributed mainly in the form of Primary, Middle, Secondary and Senior Secondary schools mainly. Out of 187 villages, 179 villages have any form of educational facility within their boundary. Only 1 college is available in the region for higher education. The details of education facilities in the revenue circles have been presented in Table 3.19.

Table 3.19 Education Facilities in the Dibrugarh Reach

Development Block	Total No. of Villages	Villages having any form of educational facility within boundary	No of Primary schools	No of Middle school	Secondary school	Sr. Secondary School	College
Barbarua	68	62	73	31	8	0	0
Lahowal	59	50	55	12	6	0	1
Panitola	2	2	2	1	0	0	0
Tengakhat	1	1	2	1	1	0	0
Khowang	4	3	5	1	1	0	0
Total	**134**	**118**	**137**	**46**	**16**	**0**	**1**

Source: Census of India 2001

134. The school facilities are available at a distance of about 1 km radius from existing settlements. High schools and college are available at a maximum distance of about 8-10 km. The schools located on elevated platforms in the vicinity of the river bank are used as evacuation camps by flood and erosion affected persons every year. It provides temporary refuge to displaced population at times for more than 2 months. The school buildings also get damaged due to the flood and erosion in the villages along the river bank.

3.5.3. Peoples Dependence on Flora and Fauna

135. As previously mentioned, most of the people residing near the Brahmaputra dyke in Dibrugarh are economically very poor and rely on gathering natural resources for their livelihood. Majority of the people depend their livelihood on fishing at river Brahmaputra and Maijan beel. Limited number of people depends on selling the fuel woods for their livelihood. Fishing communities are present in the adjoining areas of Koilaghat, Maizan Borsaikia Gaon, Nagaghooloi ghat areas depending on the adjoining areas of Brahmaputra River and Maizan Beel fro fishing. The landing of various aquatic fauna in Dibrugarh reach at 12 major landing sites has been shown in Figure 3.19.

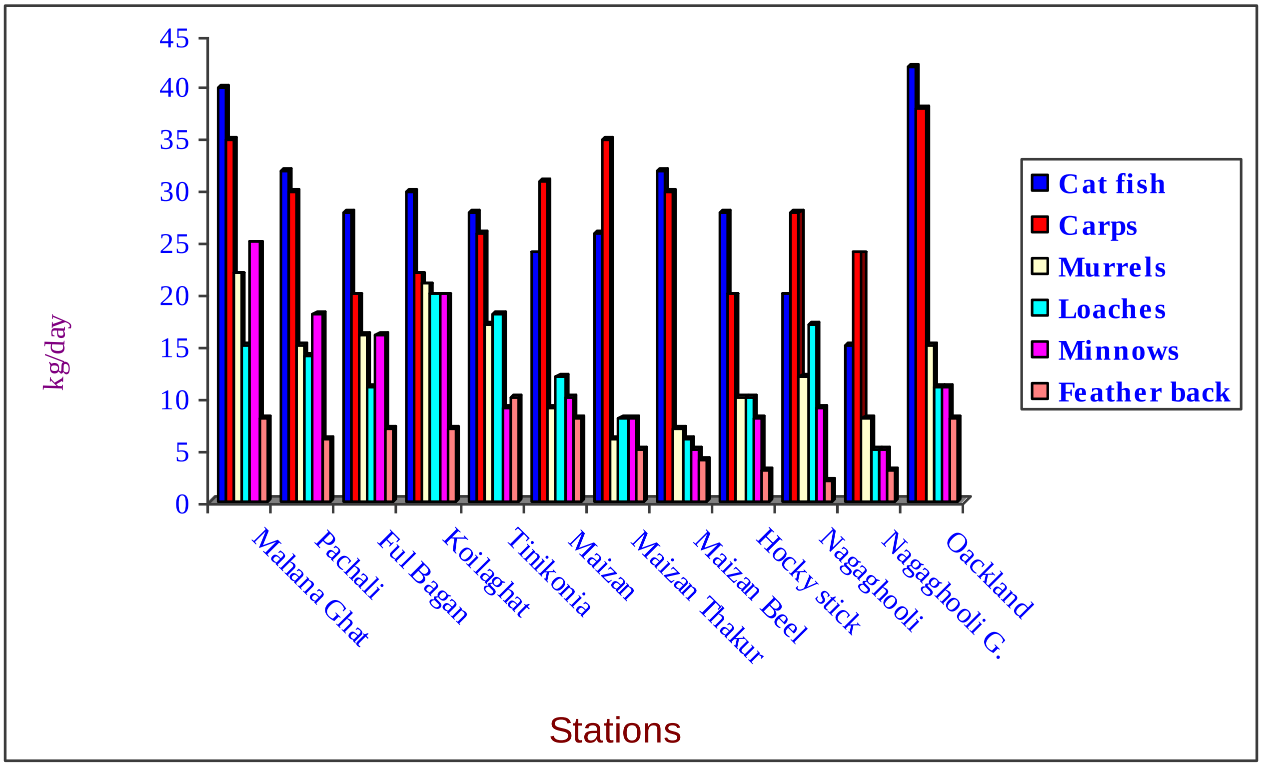


Figure 3.19 Fish Landing at Various Landing Sites along the Dibrugarh Reach

3.5.4. Manufacturing Activities

136. Based on available data, Tea and silk are the main manufacturing activities in the entire area along the Dibrugarh Reach. The tea industry is spread from large areas owned by companies generating employment opportunities. About 55% of the total gardens in state located in Dibrugarh and most of them are found in subproject area. The tea production is also higher in Dibrugarh (1,801 kgs/per ha) compared to state average of 1,672 kg/ha. Small tea growers are rapidly increasing in the area. Farmers who own their land are also shifting from paddy cultivation to tea plantations on a small scaleThe distribution of these industries in various development blocks along the Dibrugarh Reach are given in Table 3.20:

Table 3.20 Dibrugarh Reach: Manufacturing Activity Profile

Block	Tea	Muga Cloth
Barbarua	7	1
Lahowal	3	0
Panitola	1	0
Tengakhat	0	0
Khowang	0	0
Total	**11**	**1**

(Source: Census of India, 2001)

137. Dibrugarh location was strategic in terms of service sector. It is grown up as market for tea, grocery, stationary, and most of the commodities. The market was growing with high pace

catering needs of Lakhimpur, Dhemaji, Sibsagar, Jorhat, Tinsukiya in Assam and adjoining districts of Arunachal Pradesh. Dibrugarh was also known for medical treatments due to existence of Government Medical College.

3.5.5. Commuting Facilities

138. The villages in the 5 Development Blocks are mostly connected through unpaved roads. Only 29 villages having paved road connectivity. During rainy season, most of the raods are unpassable due to muddy or flooded conditions which renders many settlements isolated... The details of the connectivity has been shown in Table 3.21:

Table 3.21 Dibrugarh Reach: Connectivity

Blocks	Total No. of Villages	Approach Paved Road	Approach Mud Road	Approach Footpath	Approach Navigable River	Approach Waterway other than River
Barbarua	68	23	61	11	0	0
Lahowal	59	3	58	2	0	0
Panitola	2	1	2	0	0	0
Tengakhat	1	1	1	0	0	0
Khowang	4	1	4	0	0	0
Total	**134**	**29**	**126**	**13**	**0**	**0**

3.5.6. Power Facilities

139. Power facility in the Dibrugarh Reach area is available in most of the villages. Only 7 villages do not have any electrical connections. Mostly, power is available only for domestic usage. Only in 6 villages, power is also available for agricultural activities. Power interruptions are common in the subproject area affecting most of the village settlements.

Table 3.22 Dibrugarh Reach: Power Facilities

Blocks	Total Number of Villages	Villages having Power Supply	Villages with Power for Domestic Use	Villages with Power for Agricultural Use	Villages with Power for Other Uses
Barbarua	68	62	62	0	1
Lahowal	59	59	59	6	1
Panitola	2	2	2	0	0
Tengakhat	1	1	1	0	0
Khowang	4	3	3	0	0
Total	**134**	**127**	**127**	**6**	**2**

Source: Census of India 2001

3.5.7. Drinking Water Supply

140. Main source of drinking water in the entire Dibrugarh Reach is ground water. Water is available through wells, tubewells, handpumps, and river. The available drinking water facilities throughout the year in the villages are given in Table 3.23:

Table 3.23 Drinking Water Facility

Blocks	Villages	Tap	Well	Tank	Tubewell	Handpump	River
Barbarua	68	2	61	0	61	10	2
Lahowal	59	2	50	1	58	1	0
Panitola	2	0	2	0	2	0	0
Tengakhat	1	1	1	0	1	0	0
Khowang	4	0	3	1	4	0	0
Total	**134**	**5**	**117**	**2**	**126**	**11**	**2**

Source: Census of India 2001

141. During summer season, out of 134 villages, drinking water is available from tapped water, wells and tubewells in 5, 91 and 34 villages, respectively. The distribution of drinking water sources in different blocks is illustrated in Table 3.24:

Table 3.24 Sources of Drinking Water during Summer Season in Matmara Reach

Blocks	Villages	Tap	Well	Tank	Tubewell	Handpump	River
Barbarua	68	2	37	0	25	3	0
Lahowal	59	2	49	0	8	0	0
Panitola	2	0	2	0	0	0	0
Tengakhat	1	1	0	0	0	0	0
Khowang	4	0	3	0	1	0	0
Total	**134**	**5**	**91**	**0**	**34**	**3**	**0**

Source: Census of India 2001

142. The tube wells that were dug by Government are now being mainted by the villagers. The urban water supply is being managed by the Dibrugarh Town Authorities.

143. There is no sanitation and sewerage disposal system exists in the villages. The villagers are following practice of open defecation. In Dibrugarh town, most of the slums are on the vicinity of embankment and have no sanitary facilities provided. They are also following open defecation.

3.5.8. Medical Facilities

144. The medical facility is not satisfactory in most of the villages in the Dibrugarh Reach. The details of the health care facilities are given in Table 3.25:

Table 3.25 Medical Facilities

Blocks	Availability of Medical Facility within Village	Allopathic Hospitals	PHCs	Family Welfare Centre	Public Health Subsidiary Centre
Barbarua	12	6	4	3	3
Lahowal	7	0	0	0	6
Panitola	1	1	0	0	0
Tengakhat	1	0	0	0	1
Khowang	1	0	0	0	1
Total	**22**	**7**	**4**	**3**	**11**

Source: Census of India 2001

3.5.9. Landuse

145. As per the revenue records, the areas under different landuse categories in the villages falling under the core/ buffer zone of Matmara reach are given in Table 3.26:

Table 3.26 Landuse

Block	Forest Land (ha)	Irrigated Land (ha)	Unirrigated Land (ha)	Culturable waste land (ha)	Area not Available for cultivation (ha)	Net Cropped Area (ha)
Barbarua	14	252	7110	1899	2556	7361
Lahowal	0	751	7647	1642	3476	8398
Panitola	0	0	197	128	114	197
Tengakhat	0	0	401	18	7	401
Khowang	0	0	554	140	164	554
Total	**14**	**1003**	**15909**	**3827**	**6317**	**16911**

Source: Census of India 2001

146. As per baseline survey covering 10% of the villages,the succeeding Table presents the proportion of households in each of the land holding category. The landless households accounts for 81.54% of the total population in the reach. This proportion is however changing with the continuous increase of marginal farmers becoming landless due to riverbank erosion. The proportion of households by land holding category in Dibrugarh subproject area indicate that almost all households live on employment opportunities in industry, tea gardens and other service sector, and the livelihood is not mainly dependent on land asset.

Table 3.27 Distribution by Land Holding Category: Dibrugar Reach

Class	Land Holding Category	Category as defined by Government of India	% of households in each category
A	Large Land Holder	Land owned more that 7.01 ha.	0.77
B	Medium Land Holder	Land Owned 4.01 ha to 7.00 ha	1.41
C	Small Land Holder	Land Owned 2.01 to 4.00 ha.	3.47
D	Marginal Land Holder	Up to 2.00 ha	12.81

Class	Land Holding Category	Category as defined by Government of India	% of households in each category
E	Land Less	Household without land holding	81.54

147. The locations of various types of educational, social, religious and other institutions of social importance within the 50 m direct impact corridor around the embankment were obtained using a handheld GPS and the data were subsequently plotted on the satellite image of the tract. The distribution of the institutions is shown in Figure 3.20:

148. The embankments provided substantial benefits to the local communities in terms of protection against loss of crops, assets and displacement. However, there are those affected by land acquisition for flood control embankments who have not received compensation as required by the Assam Land (Requisition and Acquisition) Act of 1964. Compensation remained an outstanding issue for households who lost land due to construction of embankments. In Dibrugarh subproject, 6 LA case are pending from 1975-76 to 1980-81 case are pending from 1972 to 2003, which is now being addressed by WRD in the context of preparing the subproject proposal under the IFRERM Assam.

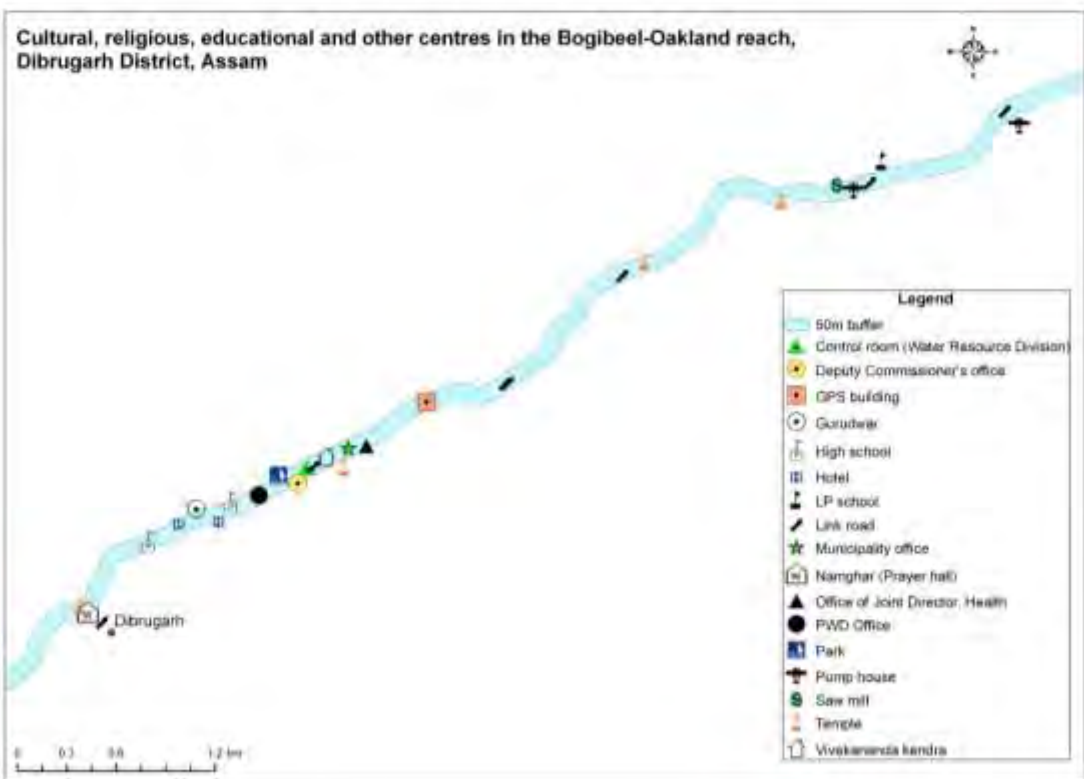


Figure 3.20 Social Establishments in 50 m Impact Corridor

3.5.10. Occupational Pattern

149. The detail of working population is presented in Table 3.28 and distribution is illustrated as bar diagram in Figure 3.21.

Table 3.28 Distribution of Working Population

Category	Male	Female
Main worker	28014	11269
Main Casual Labor	3680	1346
Main Approved Labor	606	404
Main Worker House hold	344	184
Main Other	23384	9335
Main Worker House hold	344	184
Marginal Worker	6931	8996
Marginal Casual Labor	2111	3173
Marginal Approved Labor	1482	1820
Marginal Worker House hold	177	882
Marginal Other	3161	3121
Non Worker	37656	48597

150. The baseline study revealed that in 2008, 45.35% population is employed or under the service of the Government, Private and casual or daily wage earner accounts for 26.76% population, mostly migrant workers from Tisukiya and other places. About 18.33% population is engaged in agriculture and livestock while the. 9.57% population are involved in business and allied activities.

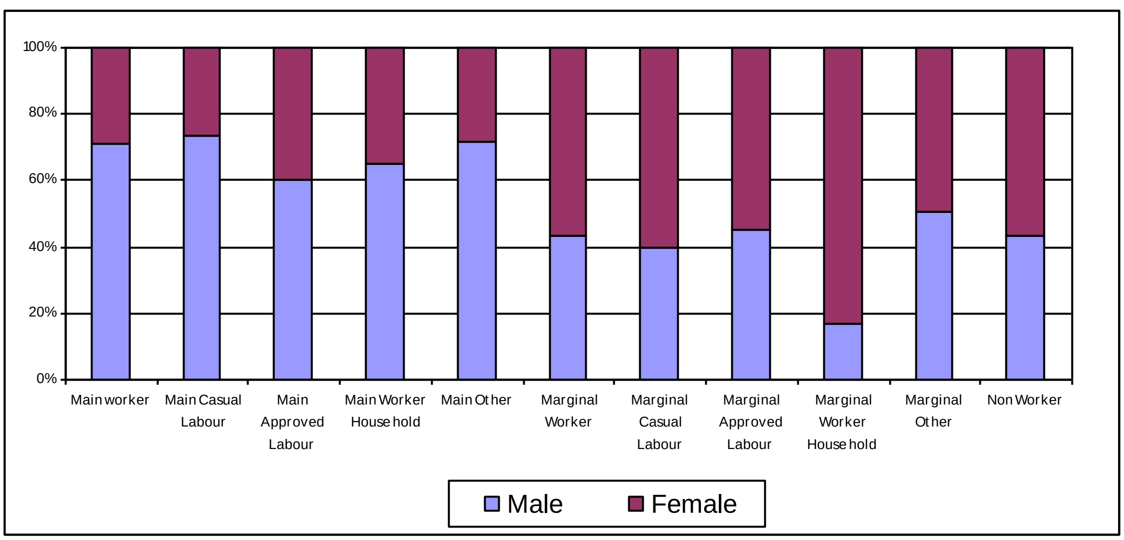


Figure 3.21 Distribution of Working Population

4. ANALYSIS OF ALTERNATIVES

151. The analysis of alternative is an effective tool to examine the number of options (locational and technological) and establishing most environmentally favourable alternative, which may cause minimum environmental loss to the natural and social environment. However, since the Program aims to sustain the functions of the existing flood embankment systems protecting a large number of people and landmass from frequent devastating flooding and riverbank erosion of the Brahmaputra River, the scope for assessing alternatives to the project is limited. As such, the alternative assessment considered "with project" and "do-nothing" (meaning "without project") conditions only. Under the "with project" condition, the structural works include rehabilitation and strengthening of existing DTP and Hiloidhar/ Titadimaru dykes, maintenance of existing spurs, construction of inspection road, and construction of drainage sluices, along with riverbank protection/ pro-siltation measures. Various revetment options like cement slabs, geo-textiles, and sand bags were assessed and the most cost-effective option was chosen (of which environmental impacts are discussed under environmental impact section). The following sections address these issues in detail.

4.1. Alternatives to the Project

152. Since, the proposed project aims to provide protection to large number of people and landmass from frequent devastating flood of the Brahmaputra River, the scope of assessing alternatives to the project is limited to the “with” and “without sub-project” (means do nothing or status quo) options.

4.1.1. 'Without the Project' Option

153. **Physical Environment**. Under this scenario, loss of precious land at the rate of about 103 ha/year will continue due to river bank erosion. Siltation of land due to flood will also happen resulting in reduced productivity or loss of single cropping. No effect is anticipated on ambient air and noise quality. The sedimentation level in wetlands and river bank may continue to increase due to erosion or flood.

154. **Biological Environment**. The present species composition of the vegetation, fisheries and wild life is expected to remain unchanged. In normal conditions (no flood scenario), no change is anticipated in fish productivity of wetlands, pond fisheries, or productivity of agricultural land. However, loss of vegetation or loss of agricultural productivity, loss of pond fisheries productivity would be high during floods.

155. **Socio-Economic Environment**. Without the project, large number of population will remain vulnerable to flood effect (Dibrugarh town is one of them). Even the current rate of erosion to the tune of about 103 ha every year is a big loss of agricultural land and people houses. Flood also causes many linked socio-economic and health problems.

4.1.2. 'With the Project' Option

156. **Physical Environment** In the “with project” scenario, no change is expected in air, soil and water conditions. Air pollution and noise level are likely to increase during construction phase but that will be confined within the close vicinity of construction sites and will be temporary in nature. Bank protection measures will prevent loss of about 37 ha/year of productive land and will prevent increase of sedimentation load to river equal to 103 ha/year of land area.

157. **Biological Environment** There is likelihood of improved fish productivity from wetlands and pond fisheries. No significant impact is expected in terms of increase in sedimentation level or fish productivity during construction stage. With the implementation of mitigation measures the overall impact of the project is likely to be nil or positive on the biological environment except in terms of loss of tree which will be minimised and also regenerate over a period of time due to proposed tree plantation programme.

158. **Socio-Economic Environment** The scenario is also likely to bring stability to the economy of the area. It will facilitate conservation of large area from erosion (~103 ha/year), which means increased agricultural produce. Farmers will be able to have three crops, which otherwise are able to take mostly two crops in a year. Pond fisheries productivity will improve due to reduce siltation load and improved fishery practices. The project will also provide better commuting opportunities to fishermen and people of the area through the paved road on the top of embankment, which means reduced commuting time to reach the markets. The flood protected environment may also promote agro based industries in the area. The post project scenario will enhance overall economy of the area.

4.1.2.1 Conclusion

159. From the above analysis, ‘with project’ benefits are likely to be more than ‘without project’ scenario. Hence, ‘with project’ scenario is preferred.

5. ANTICIPATED ENVIRONMENTAL IMPACTS AND MITIGATION MEASURES

160. Based on the compiled information, attempts have been made to assess the present environmental status of the Dibrugarh Reach and identification of Valued Ecosystem Components (VECs). Preliminary environmental surveys along the Dibrugarh Reach were conducted coupled with detail study of flood patterns, erosion, study of topographic maps, satellite imageries, collection of baseline data for physical, biological and socio-economic environment from primary and secondary sources, etc. During the survey, a number of discussions were held with the stakeholders including those presently living along the various stretches of the Dibrugarh Reach. Some NGOs working in the areas were also consulted. The details of public consultation are furnished in Chapter 8. The ADB's Rapid Environmental Assessment (REA) checklist for irrigation projects[26] (Refer Appendix 2.2:) was used for identifying the valuable ecosystem components in the region.

5.1. Valuable Ecosystem Components

161. The VECs identified in the Dibrugarh Reach are as follows:

- Land:
    - Soil erosion
    - Change in landuse
    - Soil compaction and Soil Contamination
- Hydrology and Morphology
    - Upstream and Down stream Effect
    - Flood Effect
    - Effect on river water levels/flow velocity/discharge intensities
    - Effect on drainage system
    - Silt Disposition and Bed level Changes
    - Effect on Wetland and Beels
- Water Quality :
- Climate
- Air:
    - Change in air quality
- Noise:
    - Change in ambient sound pressure levels
- Terrestrial Ecology:
    - Disturbance to Vegetation
    - Habitat fragmentation and destruction
    - Animal distribution and Migratory routes
    - Endangered species
- Aquatic Ecology

[26] Under ADB Environmental Assessment Guidelines 2003, only following 16 REIA checklists have been defined: (i) Irrigation, (ii) Fisheries, (iii) Forestry, (iv) Hydropower, (v) Thermal Power Plants, (vi) Power Transmission, (vii) Agro Industrial Projects, (viii) Chemical-based Industrial Projects, (ix) Petrochemical Industrial Projects, (x) Urban Development, (xi) Water Supply, (xii) Solid Waste Management, (xiii) Sewage Treatment, (xiv) Airports, (xv) Ports and Harbors, (xvi) Roads and Highways, (xvii) Governance and Finance. Taking into consideration all the REA checklists, "Irrigation REA checklist" was found the most closer to the nature of IFRERM project activities.

- Effect on fish Activity and Productivity
- Effect on spawning and breeding ground
- Effect on pond fisheries

- Socio-economic:
  - Effect on Establishments
  - Effect on Archaeological sites
  - Water Supply and Sanitation
  - Socio economic Impacts
  - Accident and Safety
  - Navigation

5.2. Potential Environmental Impacts

162. Potential environmental impacts associated with the proposed project at Dibrugarh Reach are classified as: (i) impacts during design and construction phase and, ii) impacts during operation phase. Qualitative and quantitative techniques have been applied for direct and indirect impact identification. Impacts are classified as being insignificant, minor, moderate and major. The mitigation measures have been presented along with the impacts required.

5.2.1. Landuse

5.2.1.1 Landuse Change due to Project Activities and Borrow Areas

<u>Design and Construction Phase</u>

163. **Impacts.** The project activity involve rehabilitation and strengthening of the existing embankments (DTP dyke and Titadimaru dyke), construction of inspection road, construction of 2 gated drainage sluices, riverbank anti-erosion measures such as renovation of existing land and stone spurs, bank revetment and/or porcupine works.

164. For construction of river embankment of about 5 m height above the ground level with a top width of 7.5 m and a side slope of 1:2 to 1:3 that is estimated to provide protection against 100 year floods, substantial quantity of earth is required along the Dibrugarh Reach. The demands for earth will be fulfilled by excavating borrow pits in the vicinity of the river embankment or away from the embankment towards country side, if unavoidable and depending on quality of earth material, which has to be of sufficient quality with cohesive elements. The unplanned selection of borrow areas/ no rehabilitation of the borrow areas may cause loss of productive use of the land. The transportation of borrow earth may also cause air pollution, if transported in uncovered trucks.

165. Due to such construction activities along the river bank, the landuse of about 50 m buffer around the embankment is likely to be effected or changed. As per the satellite imagery and GIS interpretations, in the Dibrugarh reach currently about 141.9 ha land (42.8%) of this buffer area is used as agricultural land and about 77.5 ha (23.4%) area is built-up land (Refer Figure 3.16).

166. The access to the embankment construction sites will be mostly through the roads connecting to NH-37. In addition, 2-3 construction camps are likely to be located about 10 – 15 km apart, close to the embankment along the 40 km Dibrugarh Reach. This will also temporarily change the land use of the area.

167. Due to the proposed interventions, most of the agricultural and built-up land around the embankment site and construction camp areas may be affected adversely. Loss of topsoil from agricultural land is also one of the most potential impacts due to project intervention. Besides, compaction of soil along the haulage route may also take place, if proper mitigation measures are not employed.

168. **Mitigation Measures**. Since the impact zone around the embankment covers productive agricultural land and tea plantations, the conversion of land for project purposes shall be minimised to the extent feasible. Adjacent cultivable lands shall not be occupied for storage and/or handling of construction materials. Construction camps shall preferably be located on uncultivated areas. All requisite facilities (drinking water supply, sanitation, domestic solid waste collection and disposal, fuel supply etc.) shall be provided at these camps. The land used for construction camps shall be made reusable/cultivable after closure of construction camp. No construction debris shall be deposited on agricultural land. Loss of land or loss of crops for construction camp area shall be compensated to the landowners in accordance with the RAP.

169. **Borrow Area Location and Rehabilitation:** The borrow pits shall be on river side since borrow pits on the river-side get silted up in the course of time whereas on the country-side remains a permanent disfiguration. Further the borrow pits next to embankment on the countryside can induce seepage to the foundations. In case borrow earth has to be sourced from the country side, the borrow pits should be away from embankment even at the expense of comparatively long hauls. In the scenario that sourcing earth from country side is unavoidable, the preference to be given for the following options:

- Land which farmers want to either convert into a fishpond or lowering the agriculture field level to increase its water retention capacity.
- Exploring the option of using combination of soil and sand in embankment construction i.e. using soil as outer cover and sand as filler in between.
- Exploring technical feasibility of using soil from sandbars existing away from the bank.
- No land acquisition shall be made for borrow areas.

170. Follow the WRD guidelines for locating borrow pits near the embankment. All efforts shall be made to avoid or minimize tree loss due to borrowing. The trucks shall be covered while transporting the earth.

171. While borrowing the earth top soil shall be preserved. The borrow pits shall be rehabilitated after borrowing the earth. The WRD guidelines for rehabilitation of the pits shall be strictly followed. The Indian Road Congress (IRC):10-1961 guideline will govern the selection of borrow pits. In all cases good engineering and construction practices shall be followed. The construction contractor or DPR consultant shall submit the borrow area identification details along with borrow area rehabilitation plan in advance.

172. WRD Guidelines with respect to borrow area location and rehabilitation:

- For high embankments no excavation shall be done within 45 m of the riverside toe of the embankment. From 45 m to 60 m the borrow pits must not be more than 1.8 m deep and from 60 m to 90 m not more than 2.4 m deep and beyond 90 m they can be of any depth.

- If earth is to be taken from land-side of the embankment, no borrow pits shall be excavated within 24 m of the land–side toe of the embankment. The depth of excavation in 24 m to 36 m shall not be more than 0.6 m.
- For low embankments the borrow pits on the river-side and on the land-side shall not be located at less than 24 m from the toe.
- The borrow pits shall be staggered and on undisturbed ground 6 m wide left at regular intervals to prevent the velocity of flow through the river-side borrow pits. The staggering will also help in inducing silting and filling up of these borrow pits.
- On the country-side the water logged areas (bandhis) shall be cut and interconnected to permit ordinary drainage. These shall be connected to the nearest drainage channel so as to carry away the drainage water.
- The borrow areas selected for taking earth shall be cleared of all trees, shrubs, grass and vegetation mounds.
- No borrow pits shall be made on roads, village tracks, graveyards, canals or embankments.

173. The Indian Road Congress (IRC):10-1961 guidelines for selection of borrow pits and amount that can be borrowed.

- Borrow areas shall not be located on cultivable lands. However, if it becomes necessary to borrow earth from temporarily acquired cultivated lands, their depth shall not exceed 45 cm. The topsoil to a depth of 15cm shall be stripped and set aside for its later use for the purpose of turfing on slopes of the embankments. Thereafter, soil may be dug out to a further depth not exceeding 30 cm and used in forming the embankment.
- Borrow pit shall be selected from wasteland;
- Priority shall be given to the borrowing from humps above the general ground level within the road land;
- Priority shall be given to the borrowing by excavating/enlarging existing tanks;
- Borrowing shall be from land acquired temporarily and located at least 500m away from the road;
- Borrowing shall be from mounds resulting from the digging of well and lowering of agricultural fields in vicinity of the road;
- In case of settlements, borrow pits shall not be selected within a distance 800 m from towns or villages. If unavoidable, earth excavation shall not exceed 30cm in depth;
- The haulage distance from site shall not be too far.

Operation[27] Phase

174. **Impacts.** Encroachment on embankment for habitation and cultivation purpose may affect embankment stability. Villagers/ local residents also cut the embankment to create approach to river side for their movement for toileting, cattle grazing, farming etc. Borrow areas if not rehabilitated may have landscape and accidental hazards. Also if the borrow areas are not rehabilitated as per the intended end use of the owner, some social impacts e.g. loss of income may occur.

175. **Mitigation Measures**. Provision shall be made in the embankment design for providing access to the river bank close to the settlement areas. Where possible, platforms will be

[27] Operation phase in this section means post-constructtion use period.

attached to the embankments to provide space for the possible squatter, with regular monitoring and guidance by the executing agency so that encroachers will not affect the integrity of the embankment structure. Provision of nine drainage sluices has already been made in the project design to reduce the possibility of cutting of embankment by the villagers. The construction contractor shall ensure rehabilitation of borrow area before handing over the project..

5.2.1.2 Landuse Change due to construction material sourcing (Quarrying)

Design and Construction Phase

176. **Impacts.** A project of this magnitude would require significant amount of construction material. Illegal quarrying may lead to landuse change, unstable rock formation, air and noise pollution. The aggregate demand for construction of river embankment with paved road on the top in Dibrugarh Reach will be met through approved Bihora quarry located at distance of about 225 km from the reach. The environmental aspects and control of pollution due to quarrying operation of these approved quarries are controlled and monitored by SPCB. Thus, adverse impacts as a result of quarrying operations are not envisaged in the proposed project.

177. **Mitigation Measures**. Aggregates required for construction of embankment and roads shall be procured from quarries approved by State Pollution Control Board. Air and noise emissions from quarry shall be well within the prescribed limits. Setting up of stone crushers, if required, shall be done only after obtaining consent from State Pollution Control Board and taking adequate measures for air pollution control. While finalising the site, proper land use assessment shall be done. The land to be earmarked for dumping construction waste, if any shall be free from any social or R and R issue.

5.2.2. Soil

5.2.2.1 Soil Erosion

Design and Construction Phase

178. **Impacts.** Soil erosion potential of an area depends on its topography, geological structure, rainfall, soil type, and landuse/ land cover. In the Dibrugarh Reach, the topography of the terrain comprises of alluvial floodplain. There is a general lowering of the gradient of the area from southeast to the northwest. From the highlands in the south-eastern side covering foothills of the Barail range with elevation of 200 m, the gradient reduces towards the Burhi-Dihang outfall with an elevation of 99 m. Due to the relatively steeper slopes and friable rocks structure, the soils in the upland areas are easily erodible and during heavy rainfall, the rivers in the valley part of the basin show more of a depositional character due to their greatly reduced slope, transport of higher sediment load from upstream areas and congestion of drainage.

179. **Mitigation Measures.** Following mitigation measures can prevent the soil erosion:

- Construction shall be scheduled such that large areas of soil particularly at borrow areas near the embankment are not laid bare during the monsoon.
- Exposed surface shall be resurfaced and stabilized as soon as possible. This shall also be covered by straw or mulch to avoid soil loss in the intervening period.
- Ground disturbances shall be phased so that it is limited to workable size.
- Stabilizations of soil around approach roads/slopes shall be done by turfing and tree plantation in ROW.

- Other slope stabilization measures like selection of less eroding materials around water bodies/water streams shall be adopted.
- Soil erosion shall be visually checked on potential erosion zones during construction phase. In case soils erosion is found, suitable measures shall be taken to control the same.

Operation Phase

180. **Impacts**. Due to bank erosion, the bank line at various sections through out the reach has shifted up to maximum of 7.0 km from 1973-1990. A total of 3,616.42 ha land was eroded between 1967-2008. The proposed project will have net benefits in terms of soil erosion and preventing progression of land loss which is about 90 ha per year at present in the Dibrugarh Reach. Soil erosion may still occur during the operation phase and early detection and remedial measures shall need to be taken for safety of the embankment and roads.

181. **Mitigation Measures**. Periodic checking shall be carried out to assess the effectiveness of stabilisation measures already taken. A detailed inventory and study to assess the location, reasons of soil erosion along the embankment during third year of the operation phase shall be undertaken. Suitable strengthening measures shall be taken to prevent re-occurrence of soil erosion at existing erosion prone locations and prevent erosion at newer locations. To combat the menace of soil erosion and to ensure its conservation on a sustainable basis, efforts shall be made to develop watershed management plans by Assam Government.

5.2.2.2 Soil Compaction and Contamination

Design and Construction Phase

182. **Impacts**. Soil around construction site, haulage road, construction camp, and workshop, will be compacted due to transportation of man, machine and materials. Since about 42.8% of land in the closed vicinity of river embankment is used for agricultural purposes in Dibrugarh Reach, and construction period is for 6 years, the agricultural yield may be reduced substantially. Soil may also get contaminated around the construction site, machine maintenance area, fuelling station, construction camp, hot mix plant site, and haulage road.

183. **Mitigation Measures**. The movement of construction vehicles, machinery and equipment shall be restricted to the embankment site and pre-defined haulage road. Adequate provision for approach roads capable of handling movement and haulage of heavy vehicles and machineries shall be made to avoid damage to existing village roads, crop lands, and settlement areas. The non-usable, non-saleable, and non-hazardous construction waste shall be dispose of in the properly delineated places. Usable or saleable waste shall not be disposed to landfill.

184. All efforts shall be made to prevent soil contaminations. Following measures shall be taken to prevent the same:

- The construction vehicles shall be fuelled or repaired/serviced at the designated place with proper arrangement of waste collection and disposal. The arrangement shall include, cemented floor with dyke around for fuel storage and filling as well repairing of construction equipments.
- To avoid the soil contamination at the wash down and re-fuelling areas, “oil interceptors” shall be provided.
- The demolition waste if any shall also be used to the extent feasible for construction.

- Oil and grease spill and oil soaked materials shall be sold off to State Pollution Control Board (SPCB)/ MoEF authorized vendors.

<u>Operation Phase</u>

185. **Impact.** During the operation phase, contamination of soil is not likely to happen other than due to accidental spillage from vehicle movement.

186. **Mitigation Measure**. Depending on the nature and magnitude of spill, appropriate land remediation measures shall be employed by the concerned authorities.

5.2.3. Hydrology and Morphology

<u>Design and Construction Phase</u>

187. **Impact.** No impact is expected during this phase. The aspects associated with design and construction of various project components associated with hydrology and morphology have been addressed under land use, soil, flora and fauna, air and noise and water quality section. The impacts associated with the operation stage are presented under various sub-sections below:

5.2.3.1 Effects on River Morphology - Upstream and Downstream Effect

<u>Operation Phase</u>

188. **Impacts.** The impact of the planned flood protection measures along the Brahmaputra is considered negligible, as they focus on strengthening existing embankments. The proposed bank protection measures will confirm and stabilize the present bank line; the pro-siltation measures will have no discernible effect on general bed levels. In summary, the proposed works are expected to have no adverse effects on the dynamic river morphology.

189. The construction of riverbank protection leads to a river response to the implemented work, commonly deepening of the channel alongside the protection work. This is a consequence of flow concentration and/or a reduction of sediment entrainment from eroding bank. It is commonly believed that the Brahmaputra instability is largely associated with excessive sediment transport. The proposed interventions, revetments and anti erosion measures, reduce the sediment. Both measures further reduce turbulences and the impact on the currents as opposed to spurs, which actively deflect the currents, and as a consequence minimize negative effects. The reduced sediment entrainment alongside the protected reach has the tendency of encouraging more pronounced and stable channels without affecting the opposite bank or the upstream area. In order to avoid downstream riverbank erosion the project places the downstream termination with a slight curvature away from the existing bank, which results in passive protection of a certain downstream length. This does not alter the dynamic pattern of constantly changing in-stream channel bars, locally called, chars or chaporis.

190. The project will not build new river training works, namely spurs. In some cases existing spurs will be rehabilitated, not changing their length or orientation, but concentrating on repairing local damages. As the existing spurs are long established, limited rehabilitation under the Project will inflict no change on their impact on the dynamic river and char system.

191. A number of charlands in the Project area are used for seasonal cropping and other uses. It is expected that the current adaptive land use patterns of these charlands will continue into future to ensure their beneficial use. Charland in the immediate vicinity of the project sites does not have permanent settlements.

192. The impact of the pro-siltation measures proposed at Dibrugarh will have no discernible effect on general riverbed levels or flood levels. Over the last 100 years (ie over the period of record), flood levels at Dibrugarh have increased at more-or-less constant rate of 0.33 m per decade because of periodical slugs of extreme sediment load resulting in an overall aggradation of the riverbed. The aggradation is caused by an excess of sediment inflow over sediment outflow. Any impact of the pro-siltation measures on the southern bank will be indiscernible against this ongoing basin-wide sediment behaviour and the expected impact from downstream river training work. Exact effects of the currently constructed Bogibeel Bridge on the aggradation tendency at Dibrugarh are unknown. It can be expected that the constriction downstream of Dibrugarh caused by Bogibeel Bridge will increase this tendency.

193. **Mitigation Measures**. The Project envisages a process of systematic annual analysis and prediction of sedimentation and erosion behaviour, which includes the analysis of the structural response to riverbank protection work. The analytical tools consist of (i) low-water satellite imagery based large-scale morphological analysis of Brahmaputra reaches, supported with (ii) large-scale bathymetric surveys covering the near bank channel pattern starting from several kilometres upstream of locations of interventions and typically ending around 10 km downstream, and (iii) near-bank surveys, providing a detailed picture of the river response and structural performance. In case unexpected downstream effects are observed, the Project concept allows later rectification within the concept of adaptive approach. To this end, the project has substantial contingencies.

5.2.3.2 Flood and Drainage

194. **Impacts.** The proposed structural flood protection works at Dibrugarh, which merely confirm existing flood behaviour and provide better protection from mainstream flooding, will have no discernable effects on flooding behaviour in the Brahmaputra River or its tributaries. The proposed ant-erosion and pro-siltation works will not significantly affect flood behaviour, gross cross-section-wide sediment behaviour of river morphology. The embankment alignment will follow largely its present position, so there is no change in floodplain storage or cross-section conveyance. No discernible change in downstream flood levels will occur. The proposed bank protection measures will stabilize the banks and have no discernable effect on flood behaviour. .

195. It is noted that WRD and the Railways Department are repairing/strengthening the Bogibeel Dyke and that this dyke forms part of the Dibrugarh Sub-project. This provides an opportunity for the Project to work with Railways Department at a technical level and foster institutional cooperation and technical exchange.

196. **Mitigation Measures**. Under the Project, it is proposed to develop and use a numerical hydraulic model to investigate flooding and drainage behaviour, both within and outside the protected areas, associated with mainstream, tributary and local flooding. . This model will be used to ensure that there is adequate freeboard against embankment overtopping and that adequate provision has been made for sluice gates to facilitate drainage from the protected areas. Natural drainage systems shall be left undisturbed to the greatest extent possible; the flooding behaviour of beels and wetlands will be assessed and where possible improved and/or preserved. Adequate provisions shall be made in designing embankments to withstand extreme meteorological and other geophysical events.

5.2.3.3 Changes in Water Levels

197. **Impacts.** The conveyance capacity of the Brahmaputra River at Dibrugarh Town is enormous – the river cross-section is some 8 km wide – and proposed works on the southern bank will have no discernable effect on river water levels. The long-term trend in the increase in water levels caused by accretion of the river at Dibrugarh is a much more significant driver of water level changes. In passing, it is noted that changes in cross-section and the accretion of the river channel need to be monitored at regular intervals to ensure that the bunds continue to deliver the design level of protection against overtopping. An improved embankment network will reduce the risk of sudden devastating flooding and as such provide more predictable and stable water levels on the flood plains especially for areas upstream and downstream of the town (especially from temporary local inundation during the flood season).

198. **Mitigation Measures.** Changes in cross-section will be monitored at regular intervals to detect any changes and initiate corrective measures. The Project concept allows later rectification within the concept of adaptive approach. To this end, the project has substantial contingencies. Under the Project, the numerical hydraulic model of the sub-project area will be used to identify low lying areas with a potential risk of deep inundation when major floods occur. The option of providing raised flood refuge platforms in appropriate locations will be explored.

5.2.3.4 Effect on Flow Velocity/discharge Intensities

199. **Impacts.** The proposed interventions are not expected to have any significant effect on the overall velocity profile of the river as the works are limited to the bank or near shore areas of the river and a combination of largely passive river training and flow regulating measures will be taken up to provide an optimum flow velocity in the section. Recognizing instability and unpredictability of the Brahmaputra River, clearly two different scales need to be distinguished for studying effects of flow velocity and discharge changes: (i) the total river cross section, many kilometres in width, and (ii) the cross section of the near bank channel, typically below one kilometre in width. Limited interventions along the bank do not change the cross section average flow velocities in alluvial rivers. Areas of faster flow are compensated through areas of slower flow and lower discharges, which on average even out. The average flow velocity and discharge is affected by different river stages with increasing discharges resulting in increasing flow velocities. The lack of systematic measurements limits the present ability of quantifying this satisfactorily.

200. The magnitude and variation of discharge in the Brahmaputra River undergoes drastic changes on seasonal as well as annual basis due to the unique hydro-meteorological and geophysical characteristics of its basin. The potential increase of these natural perturbations in the river hydrograph in the wake of unfolding climate change scenario appears to be more significant compared to any minor change that may be introduced as a result of the proposed activities on or near the river bank. The river being very wide with appreciable channel roughness due the presence of multitudes of sandbars and bed forms, transmission of any minor disturbance in the flow close to the bank to areas midstream or across the channel to the other bank appears quite unlikely. Only major proactive river training interventions like spurs protruding into the river may have direct impact on the flow pattern and channel configuration affecting it significantly.

201. Large numbers of hydroelectric projects (57 Nos. till February 2008 with a total generation capacity of 15,114 MW) are under implementation in the Brahmaputra Basin in Arunachal Pradesh. It is likely that these dams will have a significant effect on mainstream flood

behaviour in the Dibrugarh Reach. Any affect of upstream dams will be to reduce flood peaks. The dams will act as sediment traps on the tributaries and lessen the inflow of sediments to the main stem Brahmaputra River. The impact of this reduction in sediment inflows on main stream channel cross-sections and flood behaviour in the Dibrugarh Reach is difficult to predict, but any effects are likely to lead to a reduction in flood levels as reduced sediment load supports a more stable channel pattern with deeper channels characterized by higher conveyance.

202. **Mitigation Measures**. Flow velocity changes along the bankline will be systematically monitored as part of the near-bank surveys. This includes establishing systematic records of discharges and flow velocities during the hydrological cycle. It is expected that this monitoring will contribute to a better understanding and a gradual optimization of the layout of structural flood and erosion countermeasures. Open revetments, such as dumped stone (rip-rap) placed on geotextile filters or multi-layers of sand-filled geotextile bags shall be preferred. Impermeable bituminous or interlocked revetments shall not be preferred as they have impact on the natural environment by interrupting exchange between flowing water and ground water. Any of the eco-friendly local resource based methods may be used in preference to the impermeable surfaces like bituminous or cement slab.

5.2.3.5 Impact on Silt Deposition and Bed Level Change

203. **Impacts.** The Brahamputra River carries the second highest sediment load of all major rivers in the world. The high amount of sediment is largely mobilized during the high flood season flows and often leads to dramatic changes of the platform (river appearance on maps). While the riverbed is largely formed by the coarser sediments especially sand and more upstream gravel, the floodplains are built from finer silts and clay. The latter constitute the wash load in the river, which means they are transported within the channels to the sea without settlement. Only after inundation and in areas without noticeable flow do the finer sediments settle. Part of this settlement has been cut-off through the construction of embankments in many places since minimum 25 years (the end of the major embankment construction program). It is noted that the inhibited deposition of the fertile finer clay and silt requires the use of alternative fertilizing methods in order to maintain overall soil fertility.

204. Problematic at this moment are breaches in the embankments, which result in high velocities in the breach area allowing the flowing water to transport coarser, infertile sand through the breached section. This sand gets deposited downstream where the area widens and the flow velocities drop. The resulting sand carpets are disastrous for the overwhelmingly small and marginal farmers as they render the fertile floodplain land unusable and can only be removed at great cost.

205. The impact of the pro-siltation measures proposed at Dibrugarh will have no discernible effect on riverbed levels. Over the last 100 years (ie over the period of record), flood levels at Dibrugarh have increased at more-or-less constant rate of 0.33 m per decade because of continuing aggradation of the riverbed. This aggradation is caused by an excess of sediment inflow over sediment outflow. Any impact of the pro-siltation measures on the southern bank will be indiscernible against this ongoing basin-wide sediment behaviour.

206. **Mitigation Measures**. The bank stabilization and strengthening of the embankment system in the Dibrugarh Reach will reduce the risk of embankment breaches with associated deposition of infertile land in the area of the breach. This will help in supporting agriculture and livelihood of the dominant small and marginal farmers. In general, about 35.5% of the land within an eight kilometres buffer behind the embankments is used for agricultural activities. The

dynamic pattern of silt deposition in the river and areas adjacent to the bank, especially in the vicinity of anti-erosion and river training works, will be monitored at regular intervals in order to contribute to the knowledge base and understanding of the Brahmaputra morphology, and initiate necessary corrective measures if required.

5.2.3.6 Effect on Drainage System

207. **Impacts.** Effect on the natural drainage system can not be totally avoided in the case of a structural intervention such as embankment built along a natural river like the Brahmaputra, but the impact can be minimized if adequate mitigation measures are taken.

208. **Mitigation Measures**. Provision shall be made to the extent possible not to obstruct the natural drainage lines from discharging into the Brahmaputra. The existing drainage system comprising the main drain and its components running through the Dibrugarh town and outfalling into the Brahmaputra downstream needs to be upgraded and properly maintained. The strengthening of the existing embankment structure and provision of necessary cross-drainage facilities like sluice gates, and additionally providing bank protection and river training works at different locations will help improve the drainage system in the reach.

5.2.3.7 Effect on Wetlands/ Beels

<u>Operation Phase</u>

209. **Impacts.** There are only two wetlands in the project area that may be affected (siltation and flow restriction) during this phase, namely the Maijan beel, which is perennial, and the Nagaghuli beel, which is seasonal. Maijan beel is termed as the lifeline of the local fishermen. This beel is located about 500 m away from the existing embankment, but no feeder channel connects it to the Brahmaputra at present.

210. **Mitigation Measures**. Since, various terrestrial and aquatic wildlife species depend on these wetlands, due care should be taken to insure that no direct or indirect impact like siltation or flow of construction waste is caused to any wetland located in the close vicinity of project construction activities.

5.2.3.8 Water Quality

<u>Design and Construction Phase</u>

211. **Impacts**. The major source of surface water pollution during project construction phase will be sewage and wastewater generated from labor camp/ colonies as well as workshop areas. The project construction is likely to last for a period of 6 years. Most of the labourers would come from nearby areas. About 50-60 labour families (total population 250 to 300) are likely to stay in each construction camp. The domestic water requirements in each construction camp will be about 45 m^3/day. It is assumed that about 80% of the water supplied will be generated as sewage. Thus, total quantum of sewage generated is expected to be of the order of 36 m^3/day. However, it may pollute land and other nearby water bodies if discharged untreated, especially during the low flow season. No arsenic pollution is noticed either in river water or ground water in this area. Hence no impact of arsenic is anticipated in this area which is otherwise prevalent problem in West Bengal and adjoining areas. As significant quantity of groundwater is not likely to be extracted as part of this project, any appreciable quantitative impact on ground water because of the construction activities is also ruled out. In addition to that ground water is easily available in 5 m BGL even during the lean periods.

212. **Mitigation Measures**. Septic tanks shall be provided in each camp to treat the domestic sewage. Provision of mobile toilets may also be considered with the provision of channelling the sewage to septic tank in a closed loop system. Discharge of untreated domestic sewage to the Brahmaputra River or to any natural waters will not be permitted. No debris shall be dumped in the water bodies. Impact on ground water quality is not likely due to the project activities as the wastewater generated from the project will be trapped for treatment before it will discharge/ percolate from the project sites

Operation Phase

213. **Impacts.** No impact is anticipated due to the project in this phase.

5.2.4. Climate

Design and Construction Phase

214. **Impacts.** Short term impact in terms of minor increase in temperature may happen in the immediate vicinity of the embankment due to the construction activities and cutting of trees falling in the project intervention zone. Based on field assessment, about 83,375 trees of different varieties have been observed in the 100 m core zone around the embankment which is likely to be affected due to the project intervention. Out of these, Sationa and Bogori trees were observed in abundance.

215. **Mitigation Measures**. Efforts have to be made to minimize cutting of the trees while designing the embankments. Compensatory tree plantation to be undertaken on the basis of 3 trees planted against each tree cut[28].

Operation Phase

216. **Impacts.** No direct impact is anticipated on the climate of the study area due to the proposed project. However, changes in the catchments area of the river and extreme events due to possible climate change (global warming) can have indirect impacts on the project and project area. With respect to the proposed project, climate change can play a major role due to its implications on water resources, water availability, and inland/ fresh water wetlands. The climate change impacts on water resources for throughout the country were studied as part of India's Initial National Communication (Natcom 1) Project[29]. The study revealed that climate change impacts on the inland wetlands would be a complex issue dependent on several variables, including temperature increase, rate of evaporation, changes in precipitation of the catchment, changes in nutrient cycling and the responses of a variety of aquatic species. Although tropical lakes are less likely to be impacted by climate change as compared to temperate lakes, an increase in temperature would alter the thermal cycles of lakes, oxygen solubility and other compounds, and affect the ecosystem. Shallow-water marshes and swamps would be even more vulnerable to increased temperatures and lower precipitation. The increased evaporation of water and reduced inflow from rainfall could desiccate the marshes, swamps and shallow lakes. GCM model projections (by HadCM2) for India indicate an increase

[28] The rate of compensatory afforestation mentioned here is as per the consultation with Chief Conservator of Forests, Forest Department, and as per Assam Government's Guidelines for Compensatory Afforestation, 2000.

[29] The SWAT water balance model has been used in this study for the river basins to carryout the hydrologic modelling of the country. The SWAT model has been used on each of the river basins separately using daily weather generated by the HadRM2 control climate scenario (1981-2000). The model has been run using climate scenarios for the period 2041 to 2060, without changing the landuse pattern. The outputs of these two scenarios have been analyzed with respect to the possible impacts on the run-off, soil moisture and actual evapotranspiration.

in precipitation by up to 30% for the north-eastern region in addition to a relatively moderate increase in temperature of about 2°C by the period 2041-2060. This could increase the incidence of flooding in the Brahmaputra basin. Since, there are divergent views on the above findings; these can not be taken into consideration for any design change at this stage till more specific and dependable information related to climate change effect on river hydrology in this region is available.

217. **Mitigation Measures**. The likely impact framework shown above is generalized. However more information has to be collected based on newer studies and monitoring data. Further action on this account can be considered only in the following phases of the project. The flood pattern shall have to be closely analyzed during proposed life span of the embankment and take appropriate timely protective measures in case the flood levels increase earlier than the projected levels for 2041-2060 due to climatic changes.

5.2.5. Air Environment

5.2.5.1 Design and Construction Phase

218. **Impacts.** The ambient air quality of the area is good. The level of SPM, RSPM, NOx, SO_2, Pb, CO, is much lower at both the locations monitored (Majirgaon and Khanajan) than the prescribed National Ambient Air Quality Standards for rural areas (Refer Table 3.11). While various construction activities will increase the ambient air quality but the level is likely to remain within the prescribed standards. During the construction phase, there will be two main sources of air emissions, i.e. mobile sources and stationary sources. Mobile sources are mostly vehicles involved in construction activities, whereas emissions from stationary sources include construction equipments and machinery, diesel generator sets, excavation/ grading activities etc. Hot Mix Asphalt (HMA) plants will be one of the major sources of emission, which will be used for road carpeting. In addition to these, fugitive emissions will also form a major proportion of air pollution in the form of particulate matter from storage and handling of construction material. HMA plants have two major categories of emissions: ducted sources (those vented to the atmosphere through some type of stack, vent, or pipe), and fugitive sources (those not confined to ducts and vents but emitted directly from the source to the ambient air). Dryers are the most significant ducted sources of emissions from both batch mix and drum mix HMA plants. Emissions from these sources consist of water (as steam evaporated from the aggregate); PM; products of combustion (carbon dioxide [CO_2], NOx, and sulfur dioxides [SO_2]); CO; and small amounts of organic compounds of various species (including VOC, methane [CH4],). The CO and organic compound emissions result from incomplete combustion of the fuel and also are released from the heated asphalt.

219. Fugitive dust sources associated with construction phase include vehicular traffic generating fugitive dust on paved and unpaved roads, aggregate material handling, and other aggregate processing operations. Fugitive dust generated from these activities may range from 0.1 µm to more than 300 µm in aerodynamic diameter. The emission of particulate matter during the construction phase will be generated from the activities like receipt, transfer and screening of aggregate, crushing activity, road dust emissions. The likely emission levels from these sources are indicated at Appendix 4.1:. In addition to that emissions from various construction machinery fueled by diesel and from mobile source will be in the form of PM_{10}, VOC, CO, NOx and SO_2. The emissions from stationary and mobile diesel engines with respect to their working/ movement are presented in Table 5.1:

Table 5.1 Exhaust Emissions for Stationary and Mobile Machinery

Source	PM_{10}	VOC	CO	NOx	SO_2
Diesel exhaust emissions (idle)	0.043 g/min	0.208 g/min	1.57 g/min	0.917 g/min	18.8 S g/l
Diesel exhaust emissions (moving)	0.4 g/mile	3.18 g/mile	18.82 g/mile	8.5 g/mile	18.8 S g/l

220. **Mitigation Measures**. Hot mix plants should be located away from the populated areas and be fitted with the air pollution control devices. They should be tested and certified to confirm that emissions comply with National/ State Pollution Control Board standards. Further, the hot mix plants must be sited at least 1 km in the downwind direction from the nearest human settlement. It shall be ensured that the dust emissions from the crusher and vibrating screen of the stone quarries do not exceed the standards. While vehicles delivering loose and fine materials like sand and fine aggregates shall be covered to reduce spills on existing road. Water may be sprayed on earthworks, on a regular basis. During and after compaction of the sub-grade, water will be sprayed at regular intervals to prevent dust generation.

221. The following mitigation measures will also be taken to mitigate the dust entrainment and fugitive emissions from the various sources in Dibrugarh Reach:

- Covering of loads in trucks, and the paving of access areas to unpaved lots or construction sites, are examples of preventive measures. Examples of mitigation controls include water flushing, and broom sweeping and flushing.
- Redistribution of loose material onto the travel lanes will actually produce a short-term increase in the emissions. In general, preventive controls are usually more cost effective than mitigation controls.
- Sprinkling water will control fugitive dust entrainment.
- Sprinkling of water on the dust prone areas and construction yard.
- Regular maintenance of machinery and equipment will be carried out.
- Ambient air quality monitoring should be carried out during construction phase. If monitored parameters are above the prescribed limits, suitable control measures must be taken.
- Care shall be taken to keep all material storages adequately covered and contained so that they are not exposed to situations, where winds on site could lead to dust/ particulate emissions.
- Fabrics and plastics for covering piles of soils and debris is an effective means to reduce fugitive dust from the material stores/ warehouses.
- Spills of dirt or dusty materials shall be cleaned up promptly so that the spilled materials do not become a source of fugitive emission.
- Spilled concrete slurries or liquid wastes shall be contained/ cleaned up immediately before they can infiltrate into the soil/ ground or runoff in nearby areas.
- All slopes and embankments will be turfed as per best engineering practices to help minimize the dust generation during operation of the road.

- Plantation along the embankment should be maintained.
- Ambient air quality monitoring should be done for the first 3 years of the operation phase. If monitored parameters are above the prescribed limits, suitable control measures must be taken.

222. A wide variety of options exist to control emissions from unpaved roads in the form of:

- Vehicle restrictions that limit the speed, weight or number of vehicles on the road;
- Surface improvement, by measures such as (a) paving or (b) adding gravel or slag to a dirt road; and
- Surface treatment, such as watering or treatment with chemical dust suppressants.

5.2.5.2 Operation Phase

223. **Impacts.** The prime source for air pollution during operation phase will be vehicular movement on the paved road on top of the embankment, which will be used for transportation as well as maintenance of the embankment.

224. **Mitigation Measures**. Plantation along the embankment and turfing on the embankment slopes should be maintained and their survival rates should be monitored. In addition to that regular maintenance of the road on the top of embankment as well as connecting roads shall be done for reducing fugitive emissions.

5.2.6. Noise

<u>Design and Construction Phase</u>

225. **Impacts.** During construction phase, noise will be generated from various activities such as site clearing, excavation, land shaping, and finishing. The general noise levels during construction phase due to working of heavy earth moving equipments and machineries installation may reach 100 dB(A) or more at the work sites[30]. However, it needs to be noted that a lot of manual labor will also be involved in the embankment construction, and hence, the impact of construction machineries will be limited. As a worst case scenario, considered for prediction of noise levels during construction phase, it has been assumed that all these equipments generate noise from a common point. The increase in noise levels[31] due to operation of various construction equipments is expected to increase the noise level from 100.3 dB (A) at a distance of 1m to 52.4 dB (A) at a distance of 250 m from the sources. The predicted levels are presented at Table 5.2:

[30] The noise level from various construction equipment /machinery is (all levels are in dB(A)): Dozers (95-100), front Loaders (72-84), Backhoes (72-93), Tractors (76-96), Toppers/Truckes (82-94), Concrete mixers (75-83), Concrete pumps (75-83), Concrete pumps (81-83), Cranes (movable) (75-86), Vehicular Traffic (contruction material and plant and Machinery) (85-98), Dg Set (90-95), Pumps (69-71), Compressors (74-86), Pneumatic Wrenches (83-88), Jack Hammer and rock drills (81-98), Pile Drievrs (peak) (95-105)

[31] In absence of the data on actual location of various construction equipments and machinery, all the equipments have been assumed to operate at a common point. This assumption leads to over-estimation of the increase in noise levels. However, the noise levels shall attenuate as the sound wave passes through a barrier. The transmission loss values for common construction materials like brick, light concrete, dense concrete, concrete block with a thickness of 4 to 6 inches vary in the range of 30 to 40 dB(A). Thus, the walls of various houses will attenuate at least 30 dB(A) of noise. In addition there will be attenuation due to Air absorption, atmospheric in homogeneities, vegetal cover.

Table 5.2 Increase in Noise Levels due to Operation of various Construction Equipments

Distance (m)	Ambient Noise Levels dB(A)	Increase in Noise Level dB(A)	Increase in Ambient Noise Levels dB(A)
1	51.0	100.3	49.3
10		80.3	29.3
50		66.3	15.3
100		60.3	9.3
150		56.8	5.8
200		54.3	3.3
250		52.4	1.4

226. In addition, there will be significant increase in vehicular movement for transportation of construction material. At present, vehicular movement near the project site is of the order of 5 to 10 vehicles/ hour. During construction phase, the increase in vehicular movement is expected to increase to a maximum of 40 to 50 trucks/ hour.

227. As a part of the EIA study, impact on noise level due to increased vehicular movement was studied using Federal Highway Administration model. The results of modeling are outlined in Table 5.3:

Table 5.3 Increase in Noise Levels due to Increased Vehicular Movement

Distance (m)	Ambient Noise Level dB(A)	Increase in Noise Level dB(A)	Increase in Ambient Noise Level dB(A)
10	51	72	21
20		67	16
50		61	10
100		57	6
200		52	1

228. During construction phase, increase in noise is expected from 25 to 30%. However, the increase in noise levels will be localized, temporary in nature and mostly will be during daytime only.

229. **Mitigation Measures**. Following noise control measures shall be adopted:

- Site Controls: Stationary equipments shall be placed along un-inhabited stretches meeting the National Noise Quality standard, particularly for residential areas (Category C) and silence zones (Category D: hospitals, educational institutions, courts, religious places, etc.), keeping the distance at least 150m (Category C) and 250m (Category D), to minimize objectionable noise impacts. In the envent potential nose sensitive receptors are identified who will fact higher noise due to construction, appropriate temporary noise barriers will be established.
- Scheduling of Project Activities: Operations will be scheduled to when people would be least likely to be affected. Construction activities shall be restricted between 10 P.M. and 6 A.M. near residential areas.

- Protection devices (ear plugs or ear muffs) will be provided to the workers operating in the vicinity of high noise generating machines.
- Construction equipment and machinery shall be fitted with silencers and maintained properly.
- Noise measurements shall be carried out along the reach as well as in nearby villages, to ensure the effectiveness of mitigation measures.
- Use of manual labor will be promoted.

Operation Phase

230. **Impacts**. The prime source of noise pollution during operation phase will be the vehicular movement. However, as the roads will be paved and will provide smooth traffic movement, the impact due to vehicular movement will be less significant.

231. **Mitigation Measures**. Adequate signage shall be provided restricting use of pressure horn particularly in noise sensitive locations particularly near schools, hospitals and populated areas. Noise measurements shall be carried out along the road to ensure the effectiveness of mitigation measures. Tree barriers between the road and village, semi urban and urban area shall be developed in a layered manner as suggested under air environment mitigation measures.

5.2.7. Terrestrial Ecology

5.2.7.1 Disturbance to Vegetation

Design and Construction Phase

232. **Impacts**. There would be no major impact on terrestrial flora except cutting of trees during project intervention in the Dibrugarh Reach, as there is no protected forest, reserved forest or sanctuary etc. present in this area. The entire natural terrestrial ecosystem (biodiversity) has already been damaged by the heavy floods and erosions in the past in this area. The present vegetation is the cultural one which can always be compensated by aforestation programme. The proposed project will help to improve the terrestrial biodiversity of the area. The baseline survey along the Dibrugarh Reach, taking into consideration of sub-zones 50 m from either side of the embankments revealed a total of 83,375 trees. Out of these, there are 34,270 trees of important nature comprising of medicinal plants (1,480), economically important plan species (15,640), fuelwood (9,545) and timber (7,820) recorded in Dibrugarh reach. The community dominance index of tree species in various study zones along the Dibrugarh reach is shown in Table 5.4:

Table 5.4 Community Dominance Index of Tree Species in various Study Zones

Study Zone	1st Dominant	2nd Dominant	Index Value
Mohanaghat Zero point Inside Embankment	*Annona squatamosa*	*Ficus rumphii*	86.66
Mohanaghat Zero point Outside Embankment	*A. squatamosa and Anthrocephalus cadamba*	*Acacia auriculiformes and Mengifera indica*	81.08
Pachali Inside Embankment	*Gmelina arboria*	*Annona squatamosa*	75

Study Zone	1st Dominant	2nd Dominant	Index Value
Pachali Outside Embankment	*Ficus religiosa*	*Annona squatamosa*	56.66
Phulbagan Outside Embankment	*Melia azedarach*	*Polialthia longifolia, and Musa balbasiana*	54.84
Koilaghat (Phulbagan)Inside Embankment	*Ficus religiosa*	*Tectona grandis*	92.86
Tinikuria Outside Embankment	*Alstnia scolaris*	*Gmelina arboria and Moringa oleifera*	72
Tinikuria Inside Embankment	*Bombax ceiba and A.squatamosa*	Nil	100
Maijan Borsaikia Outside Embankment	*Artocarpus heterophyllus*	*Mengifera indica*	60.46
MaijanBorsaikia Inside Embankment	*Ficus religiosa*	*Gmelina arboria*	100
MaijanThakurbariI Outside Embankment	*Zizyphus jujuba*	*Anthrocephalus cadamba*	57.45
MaijanThakurbariI Inside Embankment	Nil	Nil	Nil
Maijanbeel MaijanTE Inside Embankment	*Ficus rumphii*	*Gmelina arboria and Alstnia scolaris*	68.25
Maijanbeel MaijanTE Outside Embankment	*Alstnia scolaris*	*Albizia lebek and Delonix regia*	100
MotlaTE Inside Embankment	*Zizyphus jujuba*	*Albizia lebek*	58.97
MotlaTE Outside Embankment	*Zizyphus jujuba*	*Albizia lebek*	62.86
Nagaghuli Armycamp Inside Embankment	*Zizyphus jujuba*	*Ficus rumphii*	54.34
Nagaghuli Armycamp Outside Embankment	*Zizyphus jujuba*	*Ficus rumphii*	54.34
NagaghuliStone spur Inside Embankment	Zizyphus jujuba	Cocos nucifera,, A. scolaris and Moringa oleife	78.18
NagaghuliStone spur Outside Embankment	Zizyphus jujuba	A. scolaris and Pungamia pinnata	76.19
Oackland TE Zero Outside Embankment	Areca catechu	A. scolaris and Musa balbasiana	95.85
Oackland TE Zero Inside Embankment	Alstnia scolaris	Nil	100

233. There will be less impact on the terrestrial ecosystem due to project intervention. The project site has not supported much terrestrial vegetation except tea gardens. So, the protection of tea gardens is more important than any other loss of terrestrial ecosystem.

234. **Mitigation Measures**. Provision shall be made for planting 3 trees for every tree cut. Plantation programme shall be initiated from the initial parallel to construction activity. The native and existing vegetation profile shall be maintained during plantation programme, so that local inhabitants can utilize their resources. The indigenous plants namely Jati-bet- Calamus erectus, Bamboo- Bambusa balcooa, Bamboosa tulda, Delbergia sisso, Artocarpus heterophylus, Dimoru-Ficus lipidosa and Ahot-Ficus religiosa shall be preferred. A green belt is necessary along the sides of embankment for transitional wildlife species like birds and herpitofauna as well as fuel wood for local inhabitants

Operation Phase

235. **Impacts.** No direct impact is anticipated during operation stage except accidental damages or absence of tree management.

236. **Mitigation Measures**. Arrangement shall be made for tree management to ensure survivability of the tree plantation. The Social Forestry Wing of the Department of Forestry and Environment may be consulted or involved in this programme. The tree survivability audit shall also be conducted at least once in a year to assess the effectiveness of the programme.

5.2.7.2 Habitat Fragmentation and Destruction

Design and Construction Phase

237. **Impacts.** No habitat fragmentation will be happened due to project intervention, because no such important habitat was found nearby.

Operation Phase

238. **Impacts**. Inappropriate opening of the sluice gate may have substantial damage to the eco system.

239. **Mitigation Measures**. Appropriate management will have to be made for the operation of the sluice gate as resident around are not very favourable to its effective operation and fear of increased flood from Brahamputra. The maintenance of this water connection is important for the movement of the aquatic life between river and lake.

5.2.7.3 Animal Distribution/ Migratory Route

Design and Construction Phase

240. **Impacts.** There is no migratory route of wildlife species in entire Dibrugarh reach area; hence, there is no possibility of impact on animal distribution. On the other hand, dolphins are seen particularly in the rainy season near Maijan confluence (Figure 3.18). Dolphin is sensitive to polluted water and any obstruction of the channels at this stage may disturb the breeding activities. No impact envisaged on to the dolphins in other seasons (except breeding period) since, they are confined to the deep water channels of the River Brahmaputra.

241. **Mitigation Measures.** All care shall be taken to ensure that construction waste does not find its way to water in this area and pollute it. Care shall also be taken to ensure those channels are not obstructed in any way. Given that the breeding season for almost 80% of fish

species starts in April and ends in August (i.e., during the pre-monsoon and monsoon seasons), construction will be restricted during this period at the concerned breeding and spawning sites.

Operation Phase

242. **Impacts**. No impact is anticipated during operation stage with regards to animal distribution and migration. There was no endemic wildlife species found in the study area, but few species of endangered species were recorded during survey. Study recorded 2 endangered mammalian fauna, 5 reptilian species and 10 endangered avian faunas in Dibrugarh reach. But the project activity shall not affect these species in any way.

5.2.8. Aquatic Ecology

5.2.8.1 Effect on Fishing Activities/productivity

Design and Construction Phase

243. **Impacts**. There would be no major impact on aquatic ecology during project intervention in the Dibrugarh site. However, the breeding habitat of the riparian zones must not be disturbed. Heavy silting due to construction activities would result in high turbidity should be avoided. Temporary flushing of the fish species towards the deeper part of the river may happen during construction of bank line protection measures. The construction of spurs and deflectors will not affect the fish activity in the river as they move with the river current. The construction activity may increase the turbidity on the bank temporarily, however, fish species are accustomed to high siltation level and no impact is anticipated.

244. **Mitigation Measures**. Adequate provision shall be made in the design to ensure access to the fish landing site/ boatghat. Adequate requisite facilities shall be restored or maintained for undisturbed movement of the fisherman. The provision of sanitary facilities and concreted platform area with grease trap for collection of spill over or waste oil shall be provide at fish landing site/ boatghat to prevent contamination of river water specially at boatghat which is also the fish/ Dolphin breeding site.

Operation Phase

245. **Impacts.** No impact is anticipated during operation stage with regards to fish activities.

5.2.8.2 Migratory Routes

246. **Impacts**. There is no migratory route of fish in the Dibrugarh Reach, which can be affected due to the proposed project. The migratory fish species like Hilsa (anadromus[32]) and Anguilla (catadromous[33]) migrate through the main channel of the river i.e. through the deeper zones of the river. Therefore, project will not have any impact on the migratory route of these fishes.

5.2.8.3 Effect on Spawning and Breeding Grounds

Design and Construction Phase

247. **Impacts**. A few spawning and breeding grounds were observed near the riverbank along the Dibrugarh Reach. During construction of the revetment works and placement of pro-siltation

[32] Migration of fish from sea to fresh water for breeding.
[33] Fish that lives in fresh water and breeds in sea.

flow retarding screens, fish species may be temporarily flushed towards the deeper part of the river. Construction may also increase the turbidity on the bank temporarily, although fish species are accustomed to this and little impact is expected.

248. **Mitigation Measures**. Possible impacts to the identified breeding and frequented area near the Maijan confluence (Fig. 3. 18) will be minimize by scheduling the construction activity and avoid breeding season. Given that the breeding season for almost 80% of fish species starts in April and ends in August (i.e., during the pre-monsoon and monsoon seasons), construction will be restricted during the period at the concerned breeding and spawning sites. In addition, channel between the Maijan beel and the Brahmaputra will be kept permanently open during the construction period. All care shall be taken to ensure that construction waste does not contaminate the river waters.

Operation Phase

249. **Impacts**. No impact is anticipated during operation stage with regards to fish activities.

5.2.8.4 Effect on Pond Fisheries

250. **Impacts**. No pond fisheries activities are found along the existing embankment. However, pond fisheries are found in the study area, and current productivity of these places are low. Once the structural measures are implemented, siltation problem is minimised and fish productivity will improve.

251. **Mitigation Measures**. The fish productivity can be improved substantially with use of better fish culture and increasing the capacity of fish ponds as well institutional strengthening support. Fish productivity audit may also be undertaken to assess the effect of institutional support.

5.2.9. Socio Economic

5.2.9.1 Demography

Design and Construction Phase

252. **Impacts**. Owing to the proposed project, there will be establishment of construction camps that will add to the population of the study area. Migrant workers will have the potential impacts of conflicting culture and lifestyle compete with local labourers over job opportunities, and potential health issues such as HIV/AIDS. This shall also exert pressure on the natural resources in the project area. However, this will only be a temporary phase lasting only during the construction period.

253. **Mitigation Measure**. Early consultations will be made by the contractor with the local communities to determine the appropriate location of work camp sites with the encouragement that local people are given preference in employment when they meet basi job requirements. All migrant workers will undergo workshop/briefings to sensitize them on local culture and lifestyle awareness.

5.2.9.2 Establishments

<u>Design and Construction Phase</u>

254. **Impacts**. Good number of houses and establishments are located close to the existing embankment. Even some of the habitat has their hutments on the embankment itself. The household likely to be affected shall be detailed under the RAP report.

255. **Mitigation Measures**. The household likely to be affected shall be detailed under the RAP report.

5.2.9.3 Establishments

<u>Design and Construction Phase</u>

256. **Impacts.** Various educational, physical or cultural heritage facilities are located close to the embankment in 50 m impact corridor, which may affected partially/ fully due to construction activities. The locations of such facilities as presented in Figure 3.20:

257. **Mitigation Measures**. Efforts shall be made to prevent any relocation or demolition of these establishments. Where inevitable, the social infrastructure shall be rehabilitated with corresponding social and cultural values. Temporary noise barrier will be installed close to school and place of worship during the construction stage. Thick plantation shall be made close to these establishments.

5.2.9.4 Archaeological Sites to be Impacted

258. **Impacts**. No archaeological sites will be impacted due to the proposed construction of river embankment along the Dibrugarh Reach

5.2.9.5 Places of Pilgrimage and Tourism to be Impacted

259. **Impacts**. There are no pilgrimage or tourist spots along the Dibrughar Reach. Hence, no impact to this valuable component is expected. In fact, with the strengthening of embankment and improvement of roads will have positive impact on the accessibility of the villages along the reach.

5.2.9.6 Water Supply and Sanitation

<u>Design and Construction Phase</u>

260. **Impacts**. Local residents are dependent on ground water for meeting their drinking water supply. The quality of ground water in this reach was found fit for drinking purposes. Project activities are not likely to affect the water supply of the area. Sanitation facilities are poor in the rural areas. Residents go to river bank for their daily needs. Many places along the bank have been damage to create access to the river. Drinking water and sanitation becomes one of the major problems during floods. In the Dibrugarh municipal area, untreated domestic as well as commercial/ industrial wastes create a high pollution load. The present dumping ground for municipal solid waste is located close to the Brahmaputra embankment on the river side within 50 meters from the settlement areas.

261. **Mitigation Measures**. Access shall be provided to river near community settlements. Awareness shall be created among the residents about the upkeep of the embankment.

Garbage shall be collected at designated locations. No sewage shall be discharged into the surroundings, especially the water bodies. The dumping ground for municipal wastes shall be removed from its present river bank location close to the existing embankment to a suitable location. No significant impact on water, surface as well as ground water, with regard to abstraction of water is anticipated in and around the Dibrugarh Reach. Provision shall be made for providing mobile toilets and drinking facilities during the floods. Provision of hand pumps at flood platform near the residential area may be explored for the same.

Operation phase

262. **Impacts.** Unplanned development, encroachment of the embankment, tree plantation on the embankment may effect the stability of the embankment

263. **Mitigation Measures**. Uncontrolled and unplanned development should be prevented. Awareness shall be created amongst the people for the upkeep of the embankment.

5.2.10. Land Use

Design and Construction Phase

264. **Impacts**. A large number of households get affected by flood and erosion. In the Dibrugarh reach about 69.15% of household surveyed by socio-economic team under this TA are affected due to flood and erosion. The proposed project will bring relief to all the residents in this area. The project will also provide employment to a large number of people for about 6 years. The project will also boost the local economy as small businessmen and entrepreneurs will provide the daily needs of the workers and officers of the proposed project. The project intervention will cause impact on land and structures affecting the households.

265. Some of the subproject infrastructure would require land acquisition and resettlement, including the renovation of existing embankments. Riverbank protection, sluice gates and associated structures will also require a certain amount of land acquisition and resettlement of embankment squatter population. Nevertheless, the first tranche works will be implemented within the existing right-of-way of the WRD, although 310 non-titleholder households are affected, of which 56 are affected significantly.

266. The subproject area also has existing embankments and associated structures of which land acquisition process has not been completed. It is a strong demand of the concerned local population that the past dues of the land acquisition and resettlement payments should be provided in association with the improvements of the concerned infrastructure.

267. **Mitigation Measures.** Embankment strengthening will be designed to minimize the impacts of land acquisition. All resettlement activities will be implemented in accordance with ADB's voluntary resettlement and other social safeguards policies, as well as the applicable laws and regulations of the Government of India and the Assam State. In the context of the project, a resettlement framework (RF) and indigenous people's development framework (IPDP) were prepared to cover the subproject infrastructure. To mitigate the impact and to ensure there is no impoverishment or affected HH, a detailed Resettlement Plan was prepared for tranche-1 civil works, and further plans will be prepared and implemented to ensure timely payment of compensation and restoration of assets and livelihoods of all affected households. Their specific scopes will be finalized following the detailed design and prior to the tendering of the concerned civil works.

268. Regarding the pending compensation of past structure works, if any subproject sections to be covered by the proposed project have any outstanding grievances from past acquisition for embankments that are being strengthened and/or improved, a due diligence would be undertaken to assess the scope of the problem with detailed recommendations to address the grievances prior to launching the subproject work.

269. With the stabilisation of the area and prevention of land loss due to erosion every year (about 103 ha/year) land availability for multiple crops will increase bringing positive impact on the local economy.

270. **Benefits and Enhancement Measures.** The project will also provide employment to a large number of people for about 6 years. The project will also boost the local economy as small businessmen and entrepreneurs will provide the daily needs of the workers and officers of the proposed project. It is recommended that the PAPs are given preference as daily wage labourers. Proper income generation program should be included in RAP for the post construction period. The training programmes for agriculture and fish production improvement shall be implemented so that the local economy is positively impacted by the proposed project. Farmers can also consider switching over to shallow water rice cultivation means from anaerobic verity to aerobic variety of rice cultivation. Farmers will be able to get three crops instead of two crops. Appropriate provision shall be made to provide alternate fish landing station so that economic activities of the fishermen are not disturbed due to project activities.

5.2.11. Accidents and Safety

Design and Construction Phase

271. **Impacts.** The risks associated with the proposed project are minimal. However, roads being narrow, efforts shall be made that no hazardous traffic conditions are created due to construction vehicle movement. Local people may encroach to construction area and get hurt.

272. **Mitigation Measures.** Adequate lighting and fluorescent signage shall be provided at the construction sites. Signage shall be made in local language. Workers shall be provided with necessary Personal Protective Equipments and a First Aid unit including adequate supply of dressing materials, transport means, nursing staff and an attending doctor, shall be available at each construction site. Health check up camps shall also be organized every year.

Operation Phase

273. **Impacts**. Due to improved road condition, drivers may have tendency to drive fast on embankment road resulting in accidents.

274. **Mitigation Measures**. Speed limits shall be prescribed for vehicular movement on the embankment road to avert the accidents. Adequate signage and light reflectors shall be places along the road side.

5.2.12. Navigation

Design and Construction Phase

275. **Impacts**. This river section is navigated by people for moving to one place to another located at river bank and moving to char lands for fishing & farming. They use small motor boats and fish landing sites or boat Ghats for these movements. There are various fish landing sites in this sub project area. These landing sites could be temporarily disturbed due to project

activities. However there will not be any impact on the general navigability of the river due to the project since project activities are limited to river bank and beyond.

276. **Mitigation Measures**. During construction, contractors are asked to provide alternate landing sites (ghats) with similar berthing facilities, access, and other common infrastructure, as part of the tender documents. In places the riverbank protection will provide steps to facilitate landing of local boats in support of trade and river crossings. The project design has additional provisions to closely monitor the general river behavior as well as its response to the new works and, within the concept of adaptive approach, to mitigate any negative impacts (through phased implementation).

5.3. Summary of Impacts

5.3.1. Residual Impacts

277. With implementation of proposed mitigation measures the residual impact in most of cases is expected to be minimized. The summary of impacts/ mitigation measures and residual impacts is given at Appendix 7.1:.

6. ENVIRONMENTAL MANAGEMENT PLAN (EMP) AND MONITORING PLAN (EMOP)

278. The aim of the Environmental Management Plan (EMP) is to ensure that the various adverse impacts associated with the project are properly mitigated; either by preventing the impacts or by mitigating those to reduce the effect to an acceptable level by adopting the most suitable techno-economic option. The EMP also ensures that the positive impacts are conserved and enhanced.

6.1. The EMP

279. The Environmental Management Plan (EMP) consists of a set of mitigation, monitoring and institutional measures to be taken during the design, construction and operation stages of the project. The plan also includes the actions needed for implementation of these measures. The major components of the Environmental Management Plan are:

- Mitigation of potentially adverse impacts
- Monitoring during project implementation and operation
- Institutional Capacity Building and Training
- Implementation Schedule and Environmental Cost Estimates
- Integration of EMP with project planning, design, construction and operation

280. The Environmental Management Plan is detailed at Appendix 7.2:.

281. An environmental guideline will be prepared by the AIFRERM Agency with the assistance of the institutional strengthening and project management consultants focusing on effective implementation of mitigation measures suggested. The performance indicators may also be developed for assessing the effectiveness of mitigation measures.

6.1.1. Implementation Timetable for Mitigation Measures

282. The mitigation measures shall be implemented depending on the nature and time of impact. The implementation schedule has been prepared considering 72 months of construction phase starting from year 2009 and operating phase for 30 years. The proposed implementation schedule is enclosed as Appendix 7.3:.

6.1.2. Social development program

283. A separate social impact assessment study has been undertaken and social development programme is addressed as per SIA. The various impacts having significant impact of social nature like agriculture, fish catch etc. have also been addressed under this study. The mitigation measures including training aspects has been covered under this section and detailed at Chapter 5.

6.1.3. Contingency Response Plan

284. Field study, public consultation, and consultant’s experience reveal that this project may have only two environmental emergency i.e. accidents on paved roads and consequent spillage, Breach of Embankment/overtopping of embankment.

285. It is suggested that the communication and response system be developed and practiced to minimize the response time. This should be covered under environmental guidelines to be prepared for effective implementation of mitigation measures. The local

people/fishermen should be informed about likely accidental spills, nature of contamination and response. The project authorities (WRD) should ensure accidental spill management either by developing in-house capabilities or by associating with any competent third party.

286. Improved flood forecasting and warning by the WRD to communities is one of the components of this Project to be developed during Year 1 of implementation. A variety of national (CWC, IMD), State (WRD, Revenue and Disaster Management Department) and local government (deputy commissioners of district administration) agencies participate in the flood forecasting-warning process in Assam. The crucial element of this process is the provision of timely and accurate warning of villagers about an impending flood. Discussions to date indicate that most villagers receive no formal flood warnings. They generate their own warning by watching the river during the flood season, taking into account local rainfalls. Local villagers seem to be highly flood aware and flood resilient. Improvements to 'upstream' elements of the FFW process will be pointless if they are not translated into more effective responses at the community level. *Again, it would seem that improvements to the FFW system at the national and State levels will not provide a panacea to flood risk management in Assam.* It is noted that during the flood season, WRD station officers at 5 km intervals patrol the embankments, measure flood levels and report back to the flood control centre. These front-line observers have the training to provide effective and accurate local flood warnings with levels meaningful to villages along their respective 5-km sections of embankment.

287. The Project will review the various elements of FFW process, paying special attention to warning needs at the village level and possible improvements (i) at the community level and (ii) at the flood emergency management level. It is anticipated that an important element of an improved FFW system will be the provision of local forecasts by WRD, i.e. the translation of regional forecasts by CWC into clear and easily understandable warnings at the village level. Local communities will be centrally involved in this process. The Project will work with CWC and IMD regarding FFW.

6.1.4. Authorities and Their Responsibilities for Implementation of the EMP

288. The authorities and responsibilities for the implementation of the environmental management plans shall be tiered based on the activity. The suggested hierarchy and information flow is given in at **Error! Reference source not found.**.

289. All the policy decisions, including incorporation of the EMP requirements in compliance to loan covenants shall be the responsibility of the recommended Assam Integrated Flood Control and Riverbank Erosion Risk Management (AIFRERM) Society as the executing authority and will be registered under the Societies Act. The AIFRERM Society will be composed of representatives from State: departments of water resources, agriculture, char development, finance, fisheries, forest and environment, planning and coordination, public works, disaster management and revenue, rural development, soil conservation, and welfare of plain tribes and backward classes.

290. A Program Management Unit (PMU) will be established in AIFRERM Society that will have multi-disciplinary structure. One of the units in the PMU will be the social and environmental unit, which will include a senior environmental specialist seconded from the State Forestry and Environment Department or engaged externally from the market. The PMU will be assisted by a multidisciplinary team of consultants for institutional strengthening and project management (ISPM) for capacity development, quality control, and project management. The PMU-Social and Environmental Unit (SEU) will ensure that the environmental mitigation

measures are being implemented by the subproject implementation offices (SIOs). The PMU will, among others ensure that the EIA Reports comply with national and Bank guidelines, monitor the status of implementation, and preparation of monitoring reports. The regional office of ADB, in close consultation with RSDD, is recommended to confirm the compliance with ADB's safeguard policies by the PMU.

291. In each subproject, there will be SIO comprising technical team (SIO-T) and disaster risk management and coordination team (SIO-DRMC). The SIU-DRMC will have experts engaged from the market on environmental management and social safeguards, who will implement or cause the implementation of the monitoring and mitigation measures under the supervision of the PMO-SEU. The head of the SIO-DRMC, a nodal officer of the district administration in disaster risk management, will be assigned as chief safeguards officer.

6.1.5. Mechanisms for Feedback and Adjustment

292. The SIU with the help of contractors will submit a monthly progress report on implementation level of EMP to the SIU and PMU. Any deviation from the contract requirements with respect to proposed EMP should be corrected within a fortnight and records maintained for the same.

As part of the feedback mechanism, the SIU shall monitor project compliance with respect to Environmental Management Plan and Applicable laws, rules and regulations. Public involvement shall be encouraged and ensured throughout the lifecycle of the project. The SIU shall gather and maintain information on any damage or public concern that may be raised by the local people, NGOs and local authorities. While immediate solutions are to be worked out with the help of contractor, a detailed report will be submitted to the SIU for information or detailed consideration, as the case may be. The SIU will be responsible to bring it to the notice of the PMU. Resulting decisions shall be communicated back to SIU and contractor for correction and future implementation. An operation-period workshop may be required for effective implementation of the EMP.

6.2. Environmental Monitoring Plan (EMoP)

293. The aim of environmental monitoring during the construction and operation phases is to compare the monitored data against the baseline condition collected during the study period to assess the effectiveness of the mitigation measures and the protection of the ambient environment based on national standards.

294. A monitoring schedule has been drawn up based on the environmental components that may be affected during the construction and operation of the project. Since project is likely to have impact on various components of environment, a comprehensive monitoring plan covering wildlife, fisheries, cropping pattern, soil erosion, drainage congestion, tree plantation, air quality, noise and vibration are provided as Appendix 7.4:. Monitoring Plan has been separately suggested for construction phase and operation phase. Monitoring points have been selected based on the sensitivity of the location with respect to sensitive receptors.

6.2.1. Monitoring Schedule

295. The monitoring schedule has been developed based on the possible occurrence of impacts and required mitigation actions. However, this monitoring schedule is subject to change depending on the analysis results obtained.

6.2.1.1 River Hydrology, Morphology, and Sediment Transport

296. No significant external negative impacts on river hydrology, morphology, and sediment transport is expected due to the nature of the Project to support the strengthening of the existing embankment systems that will maintain or restore the intended functions of those systems and thus formalize the existing flooding behaviour that has persisted since these embankments were first constructed. Riverbank protection measures–with their focus on revetments and pro-siltation measures along the naturally developing bank lines in an adaptive manner–will not alter the existing unstable channel formation pattern of the Brahmaputra morphology. However, the project will put into operation systematic monitoring of river hydrology, morphology, and sediment transport and build sound knowledge base as an important component of the overall investment. This will facilitate the identification of any localized impacts in the subproject areas.

6.2.1.2 Terrestrial and Aquatic Fauna including Fisheries

297. The fish productivity monitoring are important and sensitive issues. In case, any significant decline in terms of fish productivity in the beels/wetlands or pond is noticed the monitoring frequency be increased till the effectiveness of mitigation measures are established.

6.2.1.3 Soil Erosion and Drainage Congestion

298. No significant soil erosion problem is anticipated due to the project either in the construction phase or in the operation phase. However, in the construction phase, some localised soil erosion may be noticed owing to construction activities. However, if soil erosion is noticed during construction and operation phase, the corrective action shall be initiated and frequency of check be increased to assessed the tendency of recurrence.

299. The performance and impacts of existing and strengthened embankment systems on the natural drainage including the wetlands within the systems will be closely monitored to facilitate appropriate mitigation measures such as provision of sluice gates and their proper operation to reduce post-monsoon drainage congestion and allow water level management in wetlands.

6.2.1.4 Air and Noise Quality

300. Due to the variability of the construction activities, namely changes in batch composition, type of construction activity and other anthropogenic influences, the air quality in the project area may change. If the air quality with respect to any parameter exceeds by more than 25% of its last monitored value, the monitoring frequency shall be doubled and cause of the increase investigated. If the construction activities are found to be the reason for this increase, suitable measures should be adopted.

301. Similarly due to the variability in traffic movement, namely changes in traffic volume, traffic compositions and other anthropogenic influences, the noise quality in the project area is likely to change. If the noise quality exceeds by 20% of the applicable ambient noise quality standard or 5% of its last monitored value, the monitoring frequency shall be increased cause of the increase investigated. If the construction activities are found to be the reason for this increase, suitable measures should be adopted.

6.2.1.5 Water Quality

302. No significant change in water quality is perceived due to the project in the operation phase. However, in the construction phase owing to construction activities the monitored values for pH, BOD, COD, TDS, DO and Oil and Grease might change. Hence, it is suggested that if the monitored value for any water quality parameter exceeds by more than 20% of its last monitored status the monitoring frequency shall be increased.

6.2.1.6 Tree Plantation

303. The 75% survival rate of replantation shall be monitored on the first year of the operation phase. If the survival rate is found below 70%, survival rate monitoring shall be again taken up after 3 years. This cycle should continue until the 70% survival rate is achieved.

6.2.2. Authorities and their Responsibilities for Implementation of EMoP

304. The most essential component of the Environment Monitoring Plan is the execution of the Plan in accordance with the monitoring schedule provided therein. The SIU-DMCT will be responsible for timely monitoring of various parameters and compliance with the mitigative measure proposed. A resultant data base is proposed to be maintained. A Management Information System (MIS) is also put in place for effective flow of information between various levels and functions within PMU.

6.3. Institutional Capacity

305. The proposed organisation structure to implement the IFRERM Assam and the environmental management plan is shown at **Error! Reference source not found.**.

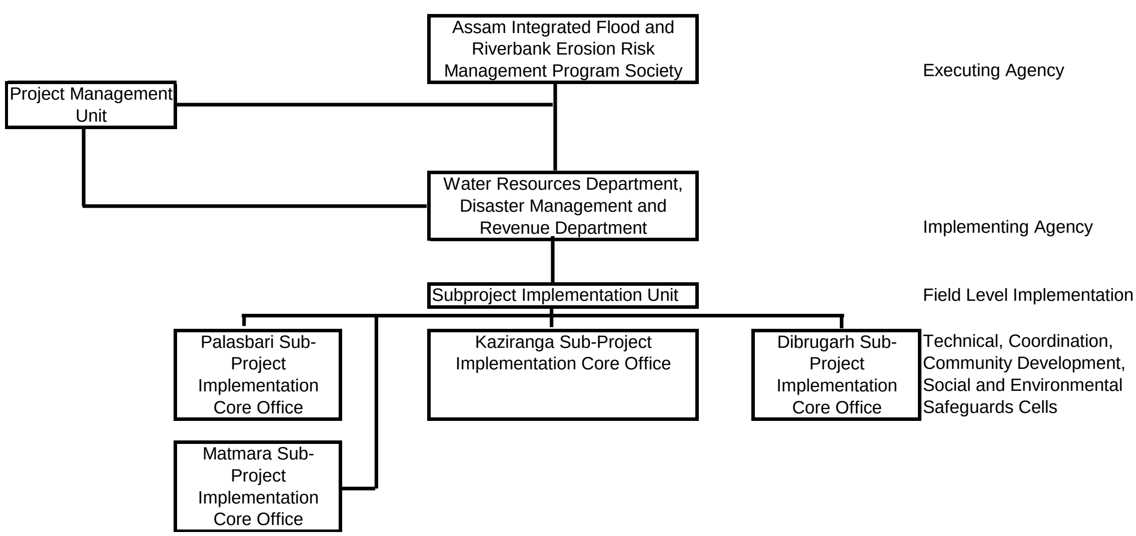


Figure 6.1 Proposed Organisation Structure

306. To enhance the capacity of the SIU for effective implementation of proposed mitigation measures and monitoring the resultant effect, some training programs are proposed. The detailed training plan is provided at **Error! Reference source not found.**.

307. It would be essential to understand the legislative framework and enhance capacity of WRD officials for analyzing the applicability of various environmental legislations and

clearances, approvals and compliance monitoring requirements. An environmental legislation applicability matrix and legislative framework has already given in Chapter 2 above for ready reference.

6.4. Mitigation, Monitoring and Institution Strengthening Cost

308. The environmental budget has been worked out for the entire four projects together since various costs are common in nature. However summary table below highlights sub projects specific costs component. The mitigation cost, inclusive of monitoring cost and training during the project life cycle (construction and operation phase) amounts is estimated to be Rs 77.94 million for all the sub project put together. The mitigation cost including monitoring is estimated as Rs 57.89 million during construction phase and Rs 5.46 Million during operation phase. The costs of establishment and training are estimated as Rs 7.5 million. The detailed break up is given at Appendix 7.6: and summarised in Table 6.1 below.

Table 6.1 Summary of Mitigative, Monitoring and Institutional Costs

Component	Total Amount (In Million Rs)	Costs Breakdown where applicable (in Million Rupees)		
		Palasbari Reach	Kaziranga reach	Dibrugarh Reach
Design & Construction Stage				
Technical Support for preparation of Environmental Guidelines	0.5			
Flora- Tree plantation	42.12	23.40	3.12	15.60
Fisheries –Institutional support for improving fish productivity	3.0	1.0	1.0	1.0
Monitoring Fish Productivity	1.2	0.4	0.4	0.4
Water & Soil contamination prevention system /soak pits at construction camps	2.04	0.68	0.68	0.68
Health Check Up	1.8	0.6	0.6	0.6
Environmental Monitoring During Construction Phase	7.23	2.41	2.41	2.41
Operation Phase				
Tree survival and Additional Tree plantation	3.0			
Environmental Monitoring During Operation Phase	2. 46	0.82	0.82	0.82
Establishment & Training				
Establishment	3.5			
Training	3.0			
Management Information Systems	1.0			
Contingencies	7.09			
Total :	Rs. 77.94 Million			

(The components which are covered under engineering costs R & R Budget or Regular maintenance costs during operation phase are not highlighted above)

7. ECONOMIC ASSESSMENT OF THE ENVIRONMENTAL IMPACTS

7.1. The Need for Economic Assessment

309. The proposed project shall cause various short/ long term and primary/ secondary impacts on the study area. These are externalities of the proposed project investments on the proposed project in the study area. There is however mitigation measures and environmental management plan proposed, non-conformance to which will lead to much higher costs in terms of social and environmental concerns than the cost of the proposed mitigation measures. Hence, an environmental cost-benefit analysis has been carried out to evaluate the significant environmental impacts identified and their related mitigation costs.

7.2. Approach and Methodology

310. To carry out the environmental economic assessment of the project, economic value of different environmental aspects of the Integrated Flood and Erosion Management project has been quantified and evaluated. Various impacts expected during the construction and operation phases, without any mitigation measures and the cost of implementation of the proposed mitigation measures (Costing of mitigation measures has been computed in Chapter 6) are regarded as the costs to the project while positive benefits from the project after adequate implementation of these measures are taken as the benefits from the project. All the three reaches has been analysed together for the purposes of cost benefits analysis. Different aspects considered for the environmental cost-benefit analysis is given in the following sections.

7.2.1. Erosion

311. **Impact Cost:** The River Brahamputra is considered to be amongst the most vulnerable rivers in India. Every year considerable productive land is regularly lost to erosion by the river flow at various places along the river bank. The net project Erosion and average erosion considered for Dibrugarh reach under the proposed Integrated Flood and River Bank Erosion Management Project are as follows:

Net Projected Erosion in (ha/year)	102.90
Average Erosion meter /year	49.00

312. In addition to protection of land from erosion, the farmers will be able to get definite third crop. There will be some land acquisition for embankment shifting but the loss of productive land will be minimal and hence not included here for analysis purposes. The erosion control is only a positive impact and there is no adverse impact cost associated with it. There would however be some impact during construction that has been address under air and noise pollution section of this chapter

313. **Mitigation Cost:** The cost of bank erosion control measures is included under the engineering cost of the project.

314. **Benefit Cost**: Although there is no impact or mitigation cost from erosion, the benefit is considerable. As per land use record of Govt of Assam majority of the land in

the project benefit area is agriculture which is about 62%. The major crops grown are Rice, Rabi, Khariff, Mustard and Tea. The maximum share is of rice crop (66%). Considering the land use and existing cropping pattern a total benefit of Rs 1.48 mn per annum or US $ 0.037 mn for Dibrugarh reach can be achieved. Refer Table 7.1 for calculation basis. These benefits can further improve with improved cropping pattern and use of HYV seeds. With availability of land, even non-polluting industries as agro-based and cottage industries may also be promoted in the area.

Table 7.1 Benefits due to Prevention of Land Loss due to Erosion

Projected erosion	**Eroded agriculture land**	**Crop Composition**		**Allotted land**	**Riverbank Length (km)**	**Average erosion (meter/yr)**	**Value added per ha.**	**Total benefits**	**Total benefits**
(ha/yr)	**(ha/yr)**	**Crop**	**E.f**	**ha**			**(Rs'000/mt)**	**(Rs' mn)**	**mn.US$**
102.90	37.23	Rice	1.01	37.7	21	49	0.02	0.61	0.015301769
		Rabi veg	0.02	0.8			0.09	0.07	0.001839724
		Khariff veg	0.05	2.0			0.07	0.15	0.00365985
		Mustard	0.15	5.4			0.01	0.08	0.001961244
		others	0.07	2.6			0.02	0.05	0.001309
		Tea		24.5			0.02	0.52	0.012939116
								1.48	0.037010704

315. **Net Benefit:** Since there is no impact cost, or mitigation cost, the net benefit equals the benefit which is Rs 1.48 mn per annum or Rs. 44.4 mn in thirty years.

7.2.2. Plantation

316. **Impact Cost:** The project also entails cutting of about 10000 trees in Dibrugarh Reach due to renovation/construction of new dyke and other project activities. Needless to mention that the trees play an important role in the environment as oxygen purification, checking soil erosion, habitat of numerous different fauna etc. The Bamboo and Simul trees are found in maximum quantity in all the sub project areas. The maturity period of Bamboo tree is about 3 years and Simul is about 10 years' means most of the trees are fast growing. The economic benefit has been worked out based on direct sale value of a matured tree. The average value of a Simul tree is Rs 1500/tree and that of Bamboo is Rs 4000/ per Bunch[34]. For calculation purposes 60% tree are considered as Bamboo and 40% as Simul. On this basis the cost of tree loss is calculated as Rs 30 Million

317. **Mitigation Cost:** With regards to mitigation measures, it is planned to plant three times the tree cut. Means a total of 30,000 trees are to be planted. The cost of plantation and 3 years of maintenance is estimated at Rs 1.56 Million. Additionally the cost of monitoring and additional tree plantation is estimated as Rs 0.075 Million.

318. **Benefit:** Considering that 80% tree only will survive, a total of 24000 trees will be of economic value. Considering the same ratio of 60% Bamboo and 40% Simul, the economic value of these trees would be Rs 57.6 Million.

[34] One bunch of Bamboo tree has about 100 bamboo tree. Depending of its variety it is sold @ rate of Rs 35-80 per tree. For computation purposes average bunch cost has been considered as Rs 4000.

319. **Net Benefit:** Hence, against the ecological loss of Rs 30 Million and mitigation cost including monitoring of Rs 1.635 Million, an ecological gain of Rs 57.6 million is expected. The net ecological benefit from the proposed mitigation measures is thus Rs 25.965 million.

7.2.3. Agriculture

320. The agricultural gain has been computed in the form of gain from prevention of soil erosion above. In addition to this gain farmers in the project benefit area are likely to gain from definite third crop.

7.2.4. Fishes

321. **Impact Cost:** Due to the proposed project no direct impact is anticipated on fisheries/fish productivity. However with the institutional support, the fish productivity can be enhanced which will have all positive impact.

322. **Mitigation Cost:** There is nil direct mitigation costs. However provision has been made for institutional support of Rs 1.0 Mn and Monitoring fish productivity of Rs 0.4 Million.

323. **Benefit**: Currently the fish productivity from pond fisheries and beel is of the order of average 100 to 120 kg/ha/annum (It varies though from 10 kg/ha to 250 kg/ha). This productivity can be doubled with proper institutional support. The area under fisheries in Dibrugarh reach area is of the order of 175 ha. This means a total gain of fish productivity of about 21000 kg per annum (@ increase of fish productivity of about 120 kg/ha/annum). Considering a very average rate of Rs. 50/kg the total gain works out to be Rs 1.05 Million

324. **Net Benefit:** Hence against the (i) Rs 1.4 Million support cost (ii) a benefit of Rs 1.05 Million (iii) the net gain being Rs (-)0.35 million.

7.2.5. Water, Air and Noise Pollution

325. **Impact Cost:** The noise and emission generation from construction operations and the induced traffic after road construction on the embankment are likely to increase the ambient noise and air pollutant (mainly SPM) levels in the project area. This may cause disturbances to sensitive locations as schools, medical centres and religious places disturb sleep of the local people resulting in fatigue etc. This could not be quantified owing to absence of any specific studies conducted to quantify the same. The waste water is likely to be generated from camp and workshop which will be treated before disposal.

326. **Mitigation Cost:** The induced noise and air pollution levels are however expected to be mitigated by the proposed plantation costs and noise barriers at select locations. The cost of plantation is already accounted for in the Plantation section while the cost towards construction of noise barriers is considered part of engineering costs. The costs of waste treatment and oil and Grease trap are estimated to be Rs 0.68 Million. The total environmental monitoring including Air and Noise monitoring has also been proposed for the construction and operation phases to keep the levels in check. A budget of Rs 0.82 Million has been allocated for the same.

327. **Benefit:** It is expected that with the adequate implementation of the proposed mitigation measures, the adverse impacts will be nullified. There are however, no additional benefits anticipated from the implementation of these mitigation measures.

328. **Net Benefit:** Hence, as the benefits are expected to nullify the adverse impacts, the net befit will equal the mitigation costs which is in the negative i.e. Rs. 1.5 Million

7.3. Conclusion

329. Summary of the economic assessment of the project is given in the succeeding Table, it can be concluded, that the net result from the project is positive environmental gains.

Table 7.2 Summary of cost benefit analysis (in Million Rs.)

Issue	Impact Cost (I)	Mitigation Cost (M)	Benefits (B)	Net Benefit N = B – (I + M)
Erosion	--	--	44.4	(+) 44.4
Plantation	30.0	1.635	57.6	(+) 25.965
Fisheries	--	1.4	1.05	(-) 0.35
Air, Water and Noise Pollution	--	1.5	--	(-) 1.5
Total	**30.0**	**4.535**	**103.05**	**(+) 68.515**

Hence, net positive gain from the project is estimated as Rs. 68.515 million, making the proposed project an environmentally viable project.

8. PUBLIC CONSULTATION

330. The mode of consultation employed during the course of the study was informal consultations. Government officials from different departments that have relevance to the project were consulted. Public consultations were held during field visits to different sectors of the study reach in December 2007, February and March 2008 covering various stakeholders in the impact corridor. Local people were also consulted from different socio-economic backgrounds in the villages along the Dibrugarh reach of the project. In addition to that two workshops on interim progress of the project were also conducted during the months of December 2007 and June 2008 in Guwahati.

331. In addition, two state level workshops were conducted. The first workshop was held in December 2007 on the interim progress of project preparation, and the second workshop in June 2008 on the draft findings of the study. Stakeholder consultations and socio economic and poverty surveys were done in 6 villages in the first phase up to Sept 2007, followed by more detailed surveys in 13 villages (out of 134 villages) and 2 urban wards (out of 22 urban wards), along with one village in the char land and another village outside of the subproject area, using focus group meetings (FGMs) and participatory rural appraisal techniques. Group discussions with women facilitated by Women Enumerators on impact of disaster on their livelihood and their present coping mechanism were held in each village surveyed.

- **Public Consultation Milestone**

332. Different people contacted and consulted during the course of the project are given below. However, since the consultations were informal, no brochures were supplied to the participants.

PARTICIPANTS

Government Regulators

1. Department of Environment

Representatives	**:**	Dr. A. K. Baruwa, Director Assam Science, Technology and Environment Council and Assam Energy Development Agency
Mode of Consultation	**:**	**Informal Consultation**
Date	**:**	**December 2, 2007**

2. Department of Environment and Forests

Representatives	**:**	Mr. B. B. Hagjer (IAS) Secretary of Environment and Forests Government of Assam
Mode of Consultation	**:**	**Informal Consultation**
Date	**:**	**December 3, 2007**

3. Government of Assam

Representatives	**:**	Mrs. E. Choudhary (IAS)

		Principal Secretary, Soil Conservation Government of Assam
Mode of Consultation	**:**	**Informal Consultation**
Date	**:**	**December 3, 2007**

4. Water Resource Department

Representatives	**:**	Mr. Biren Thukuria Executive Engineer
Mode of Consultation	**:**	**Informal Consultation**
Date	**:**	**December 2, 2007**

5. State Pollution Control Board

Representatives	**:**	**Dr. Rafiqua Ahmed**
Mode of Consultation	**:**	**Informal Consultation**
Date	**:**	**April 25, 2008**

6. Department of Minority Welfare

Representatives	**:**	**Mr. Md. Allauddin**
Mode of Consultation	**:**	**Informal Consultation**
Date	**:**	**December 3, 2007**

7. Charland Development Directorate

Representatives	**:**	
Mode of Consultation	**:**	**Informal Consultation**
Date	**:**	**December 3, 2007**

NGOs

8. ASRSG

Representatives	**:**	Dr. Bibhab Kumar Talukdar Co-chair (South Asia) IUCN SSC Asian Rhino Specialist Group
Mode of Consultation	**:**	**Informal Consultation**
Date	**:**	**March 3, 2008**

9. Carrier Care Group

Representatives	**:**	Mr. Mintu Handique, Co-ordinator Mr. Gaurav Borgohain, Co-ordinator
Mode of Consultation	**:**	**Informal Consultation**
Date	**:**	**March 5, 2008**

10. CE-NES

Representatives	**:**	Mr. Sanjay Hazarika
Mode of Consultation	**:**	**Informal Consultation**
Date	**:**	**March 10, 2008**

Stakeholders
11. Dibrugarh Reach

Representatives	**:**	Dilip Munda, Koylaghat
	:	Kamal Das, Mohanaghat
	:	Laxman Tati, Maijan Tea Estate
	:	Pranoy Sarkar, Phulbagan
	:	Abul Aziz, Graham Bazar
Mode of Consultation	**:**	**Informal Consultation**
Date	**:**	**February 29, 2008**

12. Dibrugarh Reach

Representatives	**:**	Mrs. Janti Gohain, Kumar Gaon, Dekom
	:	Allaudin Ahmed, Paach Ali
	:	Mukta Bori, Paach Ali
	:	G. Kalita, Paach Ali
	:	P. Gogoi, Near Water Pump, Dibrugarh
Mode of Consultation	**:**	**Informal Consultation**
Date	**:**	**March 28, 2008**

13. Dibrugarh Reach

Representatives	**:**	Basant Ben, Fulbagan
	:	Raman Thapa, Tinikonia Area
	:	Bhabesh Kalita, Thakur Bari
	:	Dinesh Kakati, Thakur Bari
	:	Bhagirath Pegu, Nagahooli
	:	Madan Pegu, Nagahooli
	:	Adar Barman, Paach Ali
	:	Khagen Das, Koilaghat
	:	Harilal Pegu, Koilaghat
	:	Kaliran Pegu, Maijan Beel
	:	Mihir Doley, Oakland Tea Estate
Mode of Consultation	**:**	**Informal Consultation**
Date	**:**	**March 28, 2008**

8.4. Information Disclosed

333. The discussions were primarily focused on receiving maximum inputs from the participants regarding their acceptability and environmental concerns arising out of the project. Issues were discussed in depth with the government officials and NGOs while in case of the villagers those issues were touched upon which are relevant to them. To begin with, they were given a brief outline of the project's objectives, type and components of the project in a simplified manner and in their native language. A set of pre-determined common questions were put to the stakeholders for whom their opinion were sought.

334. The discussions with the stake-holders were focussed mainly on the following points:

- Problem(s) related to environment as a result of flood and erosion of the Brahmaputra River,

- Whether the proposed project will help in providing safety to the people, their property and environment of the area,
- Any significant negative impact of the project on the overall environment of the area,
- Possible impacts of the project on agriculture, wetlands, drinking water facilities, and local economy,
- Any impact on fishing activity and terrestrial ecology.

335. Impact on the flora and fauna was mainly discussed with the officers of the forest department. The effect of air and noise pollution due to the project (during the design and construction stage) and disturbance in river water was discussed at length.

336. The consultation process was undertaken after studying the project design and identifying the possible impacts due to the project execution and commissioning. The impact assessment study focused mainly on the findings of the assessment and acceptability of the proposed mitigation measures. Issues of tree cutting, impact on physical environment, disturbance on fishing activities and fish productivity, productivity of beels in the study area and proposed mitigation measures were discussed at length.

8.5. Major Comments Received

337. While a wide range of people from different administrative, social and economic backgrounds were consulted, their concerns can be summarized in the following three categories of discussion of issues.

Local people's Comments

338. The project received unanimous support and consent from all local people including those who will be rehabilitated, provided adequate compensation is paid. Environmental awareness and likewise concern were found low and issues such as probable reduction in fish catch also did not raise any significant concern amongst the fishermen. The only concern of the villagers was pertaining to compensation against loss of land and the mode of payment. People are looking forward for quick compensation and early start of the project. People in Dibrugarh reach welcomed the project wholeheartedly as the project will benefit the complete area by saving the town and tea industry from flood and erosion. They also highlighted the need of its urgent implementation. People affected should be properly and promptly rehabilitated and/or compensated

339. The local stakeholders were especially supportive of the project as it can reduce the flood inundation scenario as well as protect the land from erosion, which will result in significant safety scenario as well as socio-economic development of the region. The local people did not perceive any adverse impact due to the proposed project.

340. The potential project affected people repeatedly stated their resettlement and compensation worries and on being informed of increased air and noise pollution from induced traffic and construction activities, remarked that it does not concern them much.

NGOs' Comments

341. There are very limited NGOs' active in the study area and directly dealing with environmental issues. All the NGOs' consulted had welcomed the flood control project and said that it will help in protection of agricultural land, domestic animals, fishermen

communities etc. They also highlighted the importance of maintaining the natural drainage system along the project site. The NGOs during interaction also highlighted the relief work they are carrying out during the flood situations. They also suggested increasing forest cover through afforestation programme. Dr Sanjay Hazarika of CE-NES also indicated the need of enhancing institutional capacity and strengthening review mechanism. He also emphasis on the following :

- Prevent any change to natural drainage,
- Consider provision of alternate platform then only attached to embankment for use by animals and people during flood, and
- Protection of the fish spawning grounds during construction and operation.

Local Officers' Comments

342. Dr. Baruwa from Environmental Council of Assam had raised concern of leaching of arsenic into groundwater which is generally used for drinking water supply from the river bank filtration wells in the floodplains of Brahmaputra River and also asked about the possibility of integration of drinking water and irrigation projects. The analysis of water quality of surface and ground water samples taken in Dibrugarh reach revealed very low arsenic content in river water as well as ground water and the water quality was found well within the desirable standards as per IS 10500:1991.

343. Mr. Biren Thukuria (EE, WRD) has highlighted the importance of study for impact on fish productivity due to reduced siltation, which can emerge as a benefit to local fishermen. Mr. B. B. Hagjer (Secretary, Department of Environment and Forests) has pointed out requirement of study of impact downstream and upstream of the reach which can be affected after protection of the reach.

344. During the interaction, Mrs. E. Choudhary (Principal Secretary, Soil Conservation) raised the issues of bed level raising, seepage of embankment/ softening of embankment, erosion and increase in sedimentation as well as the requirement of catchments area treatment plan. He also revealed the requirement of soil conservation, study of earthquakes and its effect on siltation in the river.

345. The interaction with Department of Minority Welfare and Charland Development Directorate revealed that most of the chars in Brahmaputra are semi-permanent and as per their record there are 2,251 char villages. Drinking water is mainly supplied from the handpumps and tubewells. The department also supports in the form of seed distribution, construction of raised platforms with and without sheds, repairing of schools, vocational training to local villagers,

346. The interaction with Chief Conservator of Forests, Forest Development Department and Head Assistant of the CCF office on May 19, 2008 has provided the useful comments and suggestions on possible intervention of proposed project on Forest and Wildlife. No specific suggestion or comment was made with respect to Dibrugarh reach as no protected area is located in the project area. However, prior permission is needed from the Chief Conservator of Forests (Wildlife) for cutting of trees within the boundary demarcated as wildlife sanctuaries and national parks. If land is outside the protected areas, then the permission is not necessary from CCF or Forest Department. However, afforestation is needed if there is any loss of tree species during project intervention. At least three plants must be planted in place of one such tree cut during

project intervention. For afforestration programme, bamboo, simul trees and banana plants must be planted along the side of embankment. These trees have no side roots to destroy the embankments. Again in the borrowing sites water resistant plants such as Salix tetrasperma, Buwal and Pani hizol should be planted.

347. For the purpose of the state-level workshop, the executive summaries of the study findings were shared in advance with the invited participants including the NGOs. The first workshop presented and discussed the interim findings of the project preparatory studies, including the problems and issues related flooding and riverbank erosion in Assam including lessons, key strategic elements for integrated FRERM, and peoples' perspectives on living conditions and aspirations. The second workshop presented the draft final findings, including the rationale and preliminary objective and scope of the IFRERM Assam, social impact assessment and safeguards, and environmental impact assessments. After the workshops, press briefings were organized with the circulation of the executive summaries. The presented materials at the workshops are posted in the following ADB websites on the IFRERM-Assam:

1st Workshop held on 1 December 2007 at Administrative Staff College of India, Guwahati (http://www.adb.org/Documents/Reports/Consultant/38412-IND/38412-IND-TACR.pdf)

2nd Workshop on 25 June 2008 at the Institute of Engineers Conference Hall, Guwahati (http://www.adb.org/Documents/Reports/Consultant/38412-IND/38412-01-IND-TACR.pdf

3rd Workshop held on 4 February 2009 at Brahmaputra Hotel, Guwahati (http://www.adb.org/Documents/Reports/Consultant/38412-IND/38412-02-IND-TACR.pdf).

8.6. Integration of comments

348. As observed from their responses, almost everyone interviewed was supportive of the project and believes that it will help provide the much needed protection against the recurrent ravage of erosion and flood and bring prosperity to the region

349. During discussions, notes were taken for any issue raised and suggestions made. These were then tabulated for a comprehensive analysis of the concerns raised. References have been taken from public opinion where no official data were available, while the officially available data have been extensively used for understanding of the study area characteristics. Each of the issue was then analysed on practical and scientific basis and accorded a likewise importance in terms of their magnitude in Chapter 4: Impacts and Mitigation. For any significant concern, preventive or mitigation measures have been suggested drawing points from all the suggested measures.

9. CONCLUSIONS AND RECOMMENDATIONS

9.1. Introduction

350. The conclusions are based on EIA carried out for the Dibrugarh Reach, which is one of the three reaches identified as most vulnerable to flood and erosion of the Brahmaputra river, under the Assam Integrated Flood and Riverbank Erosion Risk Management Investment Program (AIFRERM). The project is needed to safeguard the people, property and environment from the risk of devastating floods of the Brahmaputra River. The project involves renovation of existing embankments, construction of retired embankment behind the existing embankments (facing riverbank erosion), and riverbank protection.

351. The project was initially considered as environmental category A by ADB. With the structural works focusing on sustaining the functions of the existing embankment systems through renovation of deteriorated embankments, provision of inner secondary embankment and sluice gates, and riverbank protection works, the present EIA indicates no significant adverse environmental impacts that are sensitive, diverse, or unprecedented, and affect an area broader than the sites.

352. The EIA study was carried out from January to April 2008, and is based primarily on secondary data. However, primary data were also collected where secondary data were not available or not up to date. The environmental study covered the project area, as well as the area of direct and indirect impacts. The environmental assessment report was prepared in accordance with relevant applicable laws and regulations of the Government of India; and in conformity with the Environmental Policy of the ADB, 2002 and the Environmental Assessment Guidelines of the ADB, 2003.

9.2. Environmental Gains Due to Proposed Work Justifying Implementation

353. The project entails various impacts on the project setting. There are many impacts bearing benefits to the area against the limited number and magnitude of negative impacts. These include the following:

- The Brahmaputra River carries more water per unit area of basin than any other river in the world, with the average annual rainfall in the subproject area reaching 4,100 mm. The proposed project–through strengthening the reliability of the existing embankments–will prevent people from the impacts of devastating floods.
- The Dibrugarh Reach has considerable significance from the socio-economic, terrestrial ecological as well as hydrological perspectives. Although the protection of Dibrugarh town from erosion of the Brahmaputra River that started in 1960's is rightly being claimed to be a success story, yet over the years the problem resurfaces itself in new forms as the river configuration vis-à-vis the adjoining river bank areas have changed considerably and reaches upstream and downstream of the town are being affected by chronic erosion hazards eating away large chunks of productive tea cultivated lands. A dense settlement of permanent nature has come up on the river side of the embankment which has undergone considerable degradation and lowering over the years and often affected by seepage during high flood level. Strengthening of Titadimaru Dyke (4.70 km) along south bank of Maijan beel as per highest HFL is equally essential for the protection of vital installations like Airport, Medical College. Therefore, safeguarding the area and protection of tea and oil industries through integrated flood and riverbank erosion management is considered highly essential.

- There are only two wetlands in the subproject area - Maijan beel, and the Nagaghuli beel. These are not likely to be affected due to the project intervention. The proposed project will likely to enhance the fish productivity in these water bodies due to the support programme proposed under this project.
- There is no migratory route of fish, or wildlife species in entire Dibrugarh Reach area; hence, there is no possibility of impact on animal distribution
- The people resides near Brahmaputra Dyke in Dibrugarh are economically very poor, mostly depending on the harvesting natural resources fro livelihood. Majority of the people rely on fishing at river Brahmaputra and Maijan beel for their livelihood. While a; limited number of people depend on selling fuel woods.
- The project area does not pass through any protected area (reserved forests, wild life sanctuaries, national park) or ecologically sensitive areas.
- The afforestation will not only help in compensating loss of trees but also increase tree cover in the long run due to the compensatory afforestation at the rate of 1:3 as per the state government policy.

9.3. Potential Negative Impacts, Mitigation, Management and Monitoring

354. The main adverse environmental impact attributable to the Dibrugarh Sub-project are related to construction activities that includes dust and noise generation, occupational health and safety particularly related to borrow pit and hauling of soil for embankment construction. These impacts are relatively easy to mitigate with good engineering practices and are short-term being co-terminus with the construction phase. These impacts shall be monitored continually by implementing and updating the Environmental Management Plan and Environmental Monitoring Plan The reduction of vegetation specifically along the embankment alignment, estimated at 83,375 trees. Out of these, there are 34,270 trees of important nature comprising of medicinal plants (1,480), economically important plant species (15,640), fuelwood (9,545) and timber (7,820). These affected plants will be replaced at a ratio of 1:3. No sensitive ecosystem will be adversely affected in the Dibrugarh Reach

355. No significant external negative impacts are anticipated on river hydrology, morphology, and sediment transport due to the nature of the project to support the strengthening of the existing embankment systems to maintain or restore their intended functions. They will formalize the existing flooding behaviour that has persisted since these embankments were constructed. Riverbank protection measures–with their focus on revetments and pro-siltation measures along the naturally developing bank lines in an adaptive manner–will not alter the existing unstable channel formation pattern of the Brahmaputra morphology. However, systematic monitoring of river hydrology, morphology, and sediment transport will be put into operation under the project, and due mitigation measures will be provided in case any unexpected effects caused by the subproject are observed. The monitoring will include silt deposition in the river and areas adjacent to the bank, especially in the vicinity of anti-erosion and river training works, and changes in cross-section at regular intervals to detect any changes and initiate corrective measures. The Project concept allows later rectification within the concept of adaptive approach. To this end, the project has substantial contingencies. Also under the Project, numerical hydraulic model will be used to identify low lying areas with a potential risk of deep inundation when major floods occur and systematic annual analysis and prediction of sedimentation and erosion behaviour, which includes the analysis of the structural response to riverbank protection work. The monitoring and numerical analysis will contribute to the knowledge base and understanding of the Brahmaputra morphology. Natural drainage systems shall be left undisturbed to the greatest extent possible; the flooding behaviour of beels and

wetlands will be assessed and where possible improved and/or preserved. Adequate provisions shall be made in designing embankments to withstand extreme meteorological and other geophysical events.

356. There is a possibility that the subproject areas may be affected by the impacts of climate change and other external events including major earthquakes and upstream development works such as hydropower development. While the impacts of these events may well extend the economic life of the subproject investments (of 30 years), available study indicates the possible climate change impact of iincreased precipitation by up to 30% in the north-eastern region by 2040-60, although diverse anticipation still coexists. A large-scale earthquake (and landslides) may exacerbate the sediment loads of the Brahmaputra, whereas the hydropower dams upstream may reduce the sediment inflow. On these accounts, the systematic monitoring of the river dynamics to be strengthened under the project will facilitate the identification and implementation of necessary measures to adapt to any emerging changes in the construction and post-construction phase of the subproject.

357. The Project involves strip acquisition of land for strengthening the existing embankments and associated structural relocation. There are also pending land acquisition cases for infrastructure constructed in the past. The concerned land acquisition and resettlement cases including the pending cases will be addressed following the Government's and the SGOA's laws and regulations, and ADB's Involuntary Resettlement Policy, which has been stipulated in the resettlement framework, based on which resettlement plans are prepared and implemented to address all the cases. For tranche 1 works, extensive public consultation has been carried out, consistent with state guidelines. For affected persons, support will be provided to improve, or at least restore, the pre-intervention income and livelihoods standards, and productive capacity. In addition, the subproject will provide construction labor opportunities and community development assistance to nearby communities and to landowners whose land is acquired or structures be affected, including nontitle holders.

9.4. Irreplaceable Resources

358. Dolphin and other endangered species found in the river Brahamputra and other nearby areas are not exclusive to the project site. No damage to the habitat of these species is anticipated. There are no other environmental sensitive resources found in the project area which is likely to be affected due to the project.

9.5. Post EIA Surveillance and Monitoring

359. While an EIA is meant to provide a comprehensive understanding of the environment status of the area under the study, post EIA surveillance is the means to ensure that the significant impacts identified are adequately mitigated as per the proposed mitigation plan. A detailed monitoring plan has been provided as part of the Environmental Management Plan. Fisheries, cropping pattern, air, surface water quality, ground water quality, noise, soil erosion, drainage congestion and tree survival rate monitoring and reporting along with the follow up actions in case of deviation from the norms have been detailed out. The frequency has been set in consideration of the likely impacts.

9.6. Public Consultations

360. The project received unanimous support and consent from all local people including those who will be rehabilitated, provided adequate compensation is paid. People welcomed the

initiative of the SGOA for strengthening of embankment and providing revetment to the riverbank, as many of them were inundated during 2004 flood. The subproject will result in significant safety scenario as well as socio-economic development of the region. The local people did not perceive any adverse impact due to the proposed project. Environmental awareness and likewise concern were found generally low and issues such as probable reduction in fish catch also did not raise any significant concern amongst the fishermen.

361. Nevertheless, local stakeholders as well as NGOs emphasized on the need to ensure the effectiveness of institutions and their program delivery mechanisms to implement the subproject structural and non-structural measures. In particular, villagers were concerned on the compensation against loss of land and the mode of payment, stating that the compensation payment of past land acquisition is still to be provided. Capacities and willingness of the project organizations to adopt people-centered approach as suggested by the project also remains a constraint. The project has included necessary provisions to address these concerns, including the time-bound actions to address these institutional constraints with institutional reforms and capacity development support.

9.7. Recommendations

362. The EIA was carried out while the feasibility study was being prepared. Therefore, the detailed engineering design was not available. In this regard, any major changes during detailed design, or any major additional work other than the proposed project activities will require preparation of another environmental assessment. This additional assessment will have to be submitted to concerned Government authorities, if any clearance is involved. It shall also have to be sent to ADB for concurrence before civil works commence. Moreover, the executing agencies have to submit the detailed engineering designs to ADB, which will review them and examine whether major changes or major additional works have been included. In this context, changes that need to be reported to ADB involve changes with respect to opening or closing of any gap in the embankment with or without the provision of sluice gate, change in the embankment alignment, and significant change in design specification of the embankment.

363. The flooding and riverbank erosion pattern of the river shall have to be closely monitored and analyzed during the proposed life span of the embankment and riverbank protection measures, and appropriate and timely measures need to be taken to adapt to any changes in the natural river environment. Over the medium to long term, effective knowledge base needs to be established including the modeling of flooding and morphological behavior and sediment transport mechanisms of the Brahmaputra River and its tributaries to quantitatively assess the implications of any past and new water sector investments.

364. WRD has limited capacity to address the environmental measures in house. There is a need to enhance institutional capacity of the WRD with regard to environmental training, monitoring infrastructure and environmental guidelines. Adequate training shall be imparted as proposed under environmental management plan to enhance the capability of concerned EA officials. It is recommended to develop environmental guidelines focused on effective implementation of mitigation measures. Performance indicators may also be developed as part of these guidelines to monitor and assess the effectiveness of the mitigation measures.

365. Awareness programme for public shall be launched for flood embankment strengthening and river bank protection works, and conservation of natural environment and sanitation during construction and operation phase of the project.

APPENDIX 1. PROGRAM COMPONENTS

The specific components included in the Assam Integrated Flood and Riverbank Erosion Risk Management Investment Program are as follows:

Component 1: Institutional and Knowledge-Base Development

- Policy and strategic planning framework: (a) consultations towards finalizing a state water policy and steps for initiating implementation; and (b) long-term state flood and riverbank erosion risk management (FRERM) plan (building on existing plans, with integration to wider watershed issues).
- Database and knolwedge-base (linking with central and state institutions): (a) database on hydrology, morphology, sediment transport, and topography; (b) tools including flood-risk mapping and short-term erosion prediction system; (c) strengthened of flood warning system; and (d) monitoring and evaluation, and research and development system.
- Institutional strengthening for integrated FRERM: (a) institutional development actions for the Water Resources Department and line departments; (b) improved guidelines and manuals including nonstructural measures, (c) FRERM infrastructure asset management information system, and (d) comprehensive capacity development.
- Regional knowledge and networking: (a) international networks for FRERM and disaster risk management, (b) knowledge exchange.

Component 2: Operationalizing Integrated FRERM in Selected Subproject Sites

(v) FRERM structural measures: (a) upgraded embankments with assured maintenance (with extended platforms as appropriate); (b) systematic riverbank protection exploring cost-effective, adaptive, and sustainable alternatives; and (c) associated infrastructure (e.g., drainage sluices, canals).

(vi) FRERM nonstructural measures: (a) flood and erosion risk mapping; (b) improved warning systems; (c) participatory flood emergency response system; and (d) other flood adaptation measures (e.g., adaptive cropping, fish culture).

(vii) Community-based risk management: (a) participatory systems integrated with local disaster management committees; (b) community FRERM plans; and (c) plan implementation such as community awareness, flood shelters, and associated flood coping and development programs, e.g., adaptive cropping, fisheries, and livelihoods

(viii) Sustainable FRERM infrastructure maintenance.

Component 3: Project Management

(iii) Project management support with community participation (through disaster management systems) with staffs including those seconded from the existing organizations or hired from the market, implementation consultants, and nongovernment organizations (NGOs).

(iv) Training for program-related operations.

APPENDIX 2.1: USE OF GEOTEXTILE BAGS FOR RIVERBANK EROSION MITIGATION

The use of geotextile bags plays a major role in mitigation of erosion in a way that is both economical and flexible. Geotextile bags have the two most important properties for erosion control, the filter function to prevent the undermining of the riverbank and the ability to withstand the hydraulic load of the current. Geotextiles were first introduced in the market in 1950's and their use has increased rapidly due to the properties, flexible use and stability. Nowadays geotextile sand containers are used in the river and coastal engineering field as construction elements for erosion control, scour fill, artificial reefs, groynes, dams as well as in breakwater and dune revetments.

Geosynthetic containers are multi-purpose elements that can be manufactured according to almost any demand. The additional functions of geotextile bags, which make them so attractive, are as follows:

> **Filtration:** Filtration restricts the migration of fine soil while remaining permeable to water movement at least greater than or at least to the permeability of the protected soil.
> **Reinforcement**: The geotextile bags must also withstand the hydraulic load of the current which can reach up to 3m/s. This function involves the stabilization of a soil mass by providing a closed compartment.

The gradual natural changes to environment may not have much impact as it occurs slowly and fish may get opportunity to adapt. However, any man made and quick changes might have a more important impact. The various field studies and observations show that the overall number of species were better in geotextile bag areas than in areas exposed to erosion or protected by CC-blocks. So geotextile bags do not have any negative impact on fisheries rather the situation is slightly better. Small pockets in between bags, where flow velocity is decreased, may create shelter places for fishes (Munir Ahmed, 2007). After the geotextile gets the characteristics of the environment, fish species adapt to the new environment and hide in the shelter holes. During diving inspection, they feel the fishes and shrimp (Atiqur Afur, 2007).

There are no negative effects known on the flora if geotextile bags are used for river bank protection. The roots are small enough to pass through the geotextile. However, roots have negative effects on geotextile bags and on the whole protection design. In particular when roots dry out after having passed through the geotextile big pores remain where sand can be washed out. In this case the stability of the structure is reduced.

Under normal conditions polypropylene does not present any toxic hazard, either from skin contact or inhalation. The material is inert and shows no toxicity (Dow, 2007). Additionally, it can be said that polypropylene fibers are widely accepted. It is assumed that restrictions in these industries are much tighter. So it can be postulated that PP fibers for geotextile are harmless from a toxicological point of view. (Naue Fasertechnik, 1995). Hence, the use of geotextile bags has no negative effect on the environment, neither to the water quality nor the flora and fauna.

APPENDIX 2.2: RAPID ENVIORNMENTAL ASSESSMENT (REA) CHECKLIST FOR IRRIGATION SECTOR

Instructions:

- This checklist is to be prepared to support the environmental classification of a project. It is to be attached to the environmental categorization form that is to be prepared and submitted to the Chief Compliance Officer of the Regional and Sustainable Development Department.
- This checklist is to be completed with the assistance of an Environment Specialist in a Regional Department.
- This checklist focuses on environmental issues and concerns. To ensure that social dimensions are adequately considered, refer also to ADB checklists and handbooks on (i) involuntary resettlement, (ii) indigenous peoples planning, (iii) poverty reduction, (iv) participation, and (v) gender and development.
- Answer the questions assuming the “without mitigation” case. The purpose is to identify potential impacts. Use the “remarks” section to discuss any anticipated mitigation measures.

Country/Project Title:	NEIFREM – II (Sub Projects: Palasbari, Kaziranga, Dibrugarh, Matmara)
Sector Division:	Flood Management, River Bank Erosion Management

Note: This checklist has been used just for reference purposes being river based project even though project is not directly irrigation related.

Since categorization is generally made on the basis of the components of the entire project, this checklist has been prepared considering all the four selected sub projects.

SCREENING QUESTIONS	Yes	No	REMARKS
A. Project Siting Is the Project area adjacent to or within any of the following environmentally sensitive areas ?			
• Protected Area	☒	☐	Kaziranga Reach is located close to Kaziranga National Park. However all project components/activities are outside the park boundary. No protected area is falling in the vicinity of all other three subprojects
• Wetland	☒	☐	There are many wetlands (Deepor Beel a designated Ramsar Site, Mora Kulsi, Bejisuti-Kalidas Beel in Palasbari Reach, Shohola Beel in Kaziranga Reach and . Maijan Beel in Dibrugarh reaches). The productivity of these Beel also depends on flow of flood water of Brahamputra river or its tributaries. None of these Beels are likely to be affected by the

			proposed project component. None of the channel of flow of water from Brahamputra river to these Beels like in case of Deepor Beel is proposed to be altered or closed under this project.
• Mangrove	☐	■	
• Estuarine	☐	■	
• Buffer zone of protected area	☐	■	
• Special area for protecting biodiversity	■	☐	Proximity to Kairagna National Park in case of Kaziranga Sub project
B. Potential Environmental Impacts Will the Project cause…			
• loss of precious ecological values (e.g. result of encroachment into forests/swamplands or historical/cultural buildings/areas, disruption of hydrology of natural waterways, regional flooding, and drainage hazards)?	■	☐	The project priority is bankline protection. Primarily activities are confined to existing embankment alignment with its retirement at certain locations. The impacts therefore are likely to be confined primarily to Design and construction stage. Some impacts shall occur during post implementation (operational) stage as well. Impacts are likely to be positive as well as negative. Positive Impacts are related to erosion control, land use, recurring loss due to flood, siltation control/ productivity improvement of beels, pond fisheries etc. The other impacts are likely to be related to change if any in Hydrology and Morphology (Upstream and Down Stream effects), Changes in river water levels, flow velocity, discharge intensities, Terrestrial ecology (disturbance to vegetation, habitat, Animal movement), Aquatic ecology-Dolphin (Fish productivity, Spawning site, Breeding site including for Dolphin , pond fisheries), Air Quality, Water quality and Socio economic

• conflicts in water supply rights and related social conflicts?	☐	☒	
• impediments to movements of people and animals?	☐	☒	Temporary disturbance may occur during construction phase to people. No movement path of terrestrial animals is either likely to be affected. The movement of Dolphin and other fishes to breeding sites may be affected during their breeding period (generally from May to August) if construction activities are continued around the breeding sites in this period
• potential ecological problems due to increased soil erosion and siltation, leading to decreased stream capacity?	☐	☒	This project rather will prevent soil erosion resulting in reduced siltation
• Insufficient drainage leading to salinity intrusion?	☐	☒	Salinity may increase in the Beels during flood if flow of flood water to Beels wherever these are directly connected to river Brahamputra is not controlled
• over pumping of groundwater, leading to salinization and ground subsidence?	☐	☒	
• impairment of downstream water quality and therefore, impairment of downstream beneficial uses of water?	☐	☒	
• dislocation or involuntary resettlement of people?	☒	☐	Embankment retirement and other project activities do involve land acquisition.
• potential social conflicts arising from land tenure and land use issues?	☐	☒	
• soil erosion before compaction and lining of canals?	☐	☒	
• noise from construction equipment?	☒	☐	
• dust?	☒	☐	Likely during construction phase
• labor-related social problems especially if workers from different areas are hired?	☐	☒	Adequate sanitation and other facilities will have to be provided at labour camps.
• water logging and soil salinization due to inadequate drainage and farm management?	☐	☒	No disturbance is expected to existing drainage pattern
• leaching of soil nutrients and changes in soil characteristics due to excessive application of irrigation water?	☐	☒	

• reduction of downstream water supply during peak seasons?	☐	☐	
• soil pollution, polluted farm runoff and groundwater, and public health risks due to excessive application of fertilizers and pesticides?	☐	☐	
• soil erosion (furrow, surface)?	☐	☐	It will be rather positive effect
• scouring of canals?	☐	☐	
• logging of canals by sediments?	☐	☐	
• clogging of canals by weeds?	☐	☐	
• seawater intrusion into downstream freshwater systems?	☐	☐	
• introduction of increase in incidence of waterborne or water related diseases?	☐	☐	

APPENDIX 3.1 WATER QUALITY CRITERIA FOR DESIGNATED BEST USE

Designated-Best-Use	**Class of water**	**Criteria**
Drinking Water Source without conventional treatment but after disinfection	**A**	Total Coliforms Organism MPN/100ml shall be 50 or less pH between 6.5 and 8.5 Dissolved Oxygen 6mg/l or more Biochemical Oxygen Demand 5 days 20°C 2mg/l or less
Outdoor bathing (Organised)	**B**	Total Coliforms Organism MPN/100ml shall be 500 or less pH between 6.5 and 8.5 Dissolved Oxygen 5mg/l or more Biochemical Oxygen Demand 5 days 20°C 3mg/l or less
Drinking water source after conventional treatment and disinfection	**C**	Total Coliforms Organism MPN/100ml shall be 5000 or less pH between 6 to 9 Dissolved Oxygen 4mg/l or more Biochemical Oxygen Demand 5 days 20°C 3mg/l or less
Propagation of Wild life and Fisheries	**D**	pH between 6.5 to 8.5 Dissolved Oxygen 4mg/l or more Free Ammonia (as N) 1.2 mg/l or less
Irrigation, Industrial Cooling, Controlled Waste disposal	**E**	pH between 6.0 to 8.5 Electrical Conductivity at 25°C micro mhos/cm Max.2250 Sodium absorption Ratio Max. 26 Boron Max. 2mg/l
	Below-E	Not Meeting A, B, C, D and E Criteria

APPENDIX 3.2 NATIONAL AMBIENT AIR QUALITY STANDARDS

Pollutants	**Time-weighted average**	**Concentration in ambient air**			**Method of measurement**
		Industrial Areas	Residential, Rural and other Areas	Sensitive Areas	
SulphurDioxide (SO_2)	Annual Average*	80 µg/m^3	60 µg/m^3	15 µg/m^3	- Improved West and Geake Method - Ultraviolet Fluorescence
	24 hours**	120 µg/m^3	80 µg/m^3	30 µg/m^3	
Oxides of Nitrogen as (NO_2)	Annual Average*	80 µg/m^3	60 µg/m^3	15 µg/m^3	- Jacob and Hochheiser Modified (Na-Arsenite) Method
	24 hours**	120 µg/m^3	80 µg/m^3	30 µg/m^3	- Gas Phase Chemiluminescence
Suspended Particulate Matter (SPM)	Annual Average*	360 µg/m^3	140 µg/m^3	70 µg/m^3	- High Volume Sampling, (Average flow rate not less than 1.1 m3/minute).
	24 hours**	500 µg/m^3	200 µg/m^3	100 µg/m^3	
RespirableParticulate Matter (RPM) (size less than 10 microns)	Annual Average*	120 µg/m^3	60 µg/m^3	50 µg/m^3	- Respirable particulate matter sampler
	24 hours**	150 µg/m^3	100 µg/m^3	75 µg/m^3	
Lead (Pb)	Annual Average*	1.0 µg/m^3	0.75 µg/m^3	0.50 µg/m^3	- ASS Method after sampling using EPM 2000 or equivalent Filter paper
	24 hours**	1.5 µg/m^3	1.00 µg/m^3	0.75 µg/m^3	.
Ammonia1	Annual Average*	0.1 mg/ m^3	0.1 mg/ m^3	0.1 mg/m^3	.
	24 hours**	0.4 mg/ m^3	0.4 mg/m^3	0.4 mg/m^3	.
CarbonMonoxide (CO)	8 hours**	5.0 mg/m^3	2.0 mg/m^3	1.0 mg/ m^3	- Non Dispersive Infra Red (NDIR)
	1 hour	10.0 mg/m^3	4.0 mg/m^3	2.0 mg/m^3	Spectroscopy

Pollutants	**Time-weighted average**	**Concentration in ambient air**			**Method of measurement**
		Industrial Areas	Residential, Rural and other Areas	Sensitive Areas	
*	Annual Arithmetic mean of minimum 104 measurements in a year taken twice a week 24 hourly at uniform interval.				
**	24 hourly/8 hourly values should be met 98% of the time in a year. However, 2% of the time, it may exceed but not on two consecutive days.				

APPENDIX 3.3 NATIONAL AMBIENT AIR QUALITY STANDARDS IN RESPECT OF NOISE

Area code	Category of Area / Zone	Limits in dB(A) Leq*	
		Day Time	Night Time
(A)	Industrial area	75	70
(B)	Commercial area	65	55
(C)	Residential area	55	45
(D)	Silence Zone	50	40

Note:-

1. Day time shall mean from 6.00 a.m. to 10.00 p.m.
2. Night time shall mean from 10.00 p.m. to 6.00 a.m.
3. Silence zone is an area comprising not less than 100 metres around hospitals, educational institutions, courts, religious places or any other area which is declared as such by the competent authority
4. Mixed categories of areas may be declared as one of the four above mentioned categories by the competent authority.

* **dB(A) Leq** denotes the time weighted average of the level of sound in decibels on scale A which is relatable to human hearing.

A "decibel" is a unit in which noise is measured.

"A", in **dB(A) Leq,** denotes the frequency weighting in the measurement of noise and corresponds to frequency response characteristics of the human ear.

Leq: It is an energy mean of the noise level over a specified period.

Note : The Principal Rules were published in the Gazette of India, vide S.O. 123(E), dated 14.2.2000 and subsequently amended by the Noise Pollution (Regulation and Control) (Amendment) Rules, 2000 vide S.O. 1046(E), dated 22.11.2000 and by the Noise Pollution (Regulation and Control) (Amendment) Rules, 2002 vide S.O. 1088(E), dated 11.10.2002, under the Environment (Protection) Act, 1986.

APPENDIX 3.4 LOCATION OF THE DATA COLLECTION AND ITS GPS LOCATIONS AND REMARKS

Sl. No.	Name of the Locations	Lat/Long	Problems	Remark
1	Mohonaghat Zero Point Humidity %: 35 T°C: 26.5 Date: 29/02/2008	27°29′11″N 94°54′33″E	No	No
2	Phulbagan- Spur 2 (Outside) Koylaghat (inside)	Not taken	No	No
3	Maijan (Borsaikia Goan) 1st Spur of Dibrugrah Kahai Spur	27°30′10″N- 94°56′26″E **94m msl.**	No	Kahai Spur built during 1954-55 by Jawaharlal Nehru.
4	Maijan Thakurbari Spur1 (Recently built)	27°30′14″N- 94°56′55″E **92 m**	---------	---------
5	City garbage Dumping Centre 87 m msl.?	27°29′59″N- 94°56′14″E **87m msl**	The Important natural river	---------
6	Maijan Tea Estate entry gate	27°30′05″N 94°57′10″E	---------	---------
7	Maijan Beel Dolong 101m	27°30′15″N 94°58′06″E	---------	---------
8	(Hockey stick shape) Land Spur Motla Tea estate (7400ft land spur)	27°30′41″N 94°58′07″E **89m msl**	---------	Motla Tea estate (7400ft Earth spur build in 1974)
9	Erosion Site (Maijan Tea estate)	27°30′58″N 94°59′20″E **92 m msl**	---------	---------
10	Nagaghuli Phery Ghat	27°31′16″N 95°00′18″E **95m msl**	---------	---------
11	Last Spur (Stone Spur Nagaghuli side)	27°31′50″N 95°02′14″E **90 m msl**	---------	---------
12	Zero Point (Nagaghuli) Oakland division, Thanai Tea Estate	27°31′32″N 95°03′00″E **95 m msl**	---------	---------

APPENDIX 3.5 COUNTING OF TOTAL IMPORTANT TREE SPECIES IN EMBANKMENT SITE

Tree Species	Abbrebiatiaed forms of Tree Species	Total Numbers
Pakori-Ficus rumphii	FR	5750
Acacia-Acacia auriculiformes	AA	575
Sagina-Moringa oleifera	MO	2415
Amlakhi-Phylanthus ambilica	PA	115
Bhimkol-Musa balbasiana	MB	4025
Atlas-Annona squatamosa	AS	3910
Owtenga-Dillenia indica	DI	345
Jatibanh-Bambusa tulda	BT	460
Aam-Mengifera indica	MI	2530
Kadam-Anthrocephalus cadamba	AC	2875
Ahot-Ficus religiosa	FG	6900
Bot-F. bengalensis	FB	690
Simul-Bombax ceiba	BC	920
Gamari-Gmelina arboria	GA	5290
Narikol-Cocos nucifera	CN	1495
Jolphai-Elaeocarpus fleribundus	EF	460
Segun-Tectona grandis	TG	2530
IndianRubber-Ficus elastica	FE	115
Ghoranim-melia azedarach	MA	1380
Deodaru-Polialthia longifolia	PL	575
Satiana-Alstnia scolaris	Asc	11500
Amita-Carica papaya	CP	345
Kathal-Artocarpus heterophyllus	Ahs	2185
Bogori-Zizyphus jujuba	ZJ	10925
Siris-Albizia lebek	AL	5980
Rangakanchan-Bauhinia purpurea	BP	805
Krishnasura-Delonix regia	DR	1150
karash-Pungamia pinnata	PP	1150
Areca catechu	Acat	5750
Bijuli Banh-Bambusa pallida	BAP	230
Total		**83375**

APPENDIX 3.6 COMMUNITY DOMINANCE INDEX OF TREE SPECIES IN VARIOUS STUDY ZONES OF DIBRUGARH REACH

Zones	Study Zone	1st Dominant	2nd Dominant	Index Value	Lat./Long.
1a	Mohanaghat Zero point Inside Embankment	*Annona squatamosa*	*Ficus rumphii*	86.66	27°29′11″N 94°54′33″E
1b	Mohanaghat Zero point Outside Embankment	*A. squatamosa and Anthrocephalus cadamba*	*Acacia auriculiformes and Mengifera indica*	81.08	27°29′11″N 94°54′33″E
2a	Pachali Inside Embankment	*Gmelina arboria*	*Annona squatamosa*	75	---------
2b	Pachali Outside Embankment	*Ficus religiosa*	*Annona squatamosa*	56.66	----------------
3a	Phulbagan Outside Embankment	*Melia azedarach*	*Polialthia longifolia, and Musa balbasiana*	54.84	---------------------
3b	Koilaghat (Phulbagan)Inside Embankment	*Ficus religiosa*	*Tectona grandis*	92.86	------------------
4a	Tinikuria Outside Embankment	*Alstnia scolaris*	*Gmelina arboria and Moringa oleifera*	72	-----------------
4b	Tinikuria Inside Embankment	*Bombax ceiba and A.squatamosa*	Nil	100	---------------
5a	Maijan Borsaikia Outside Embankment	*Artocarpus heterophyllus*	*Mengifera indica*	60.46	27°30′10″N-94°56′26″E
5b	MaijanBorsaikia Inside Embankment	*Ficus religiosa*	*Gmelina arboria*	100	27°30′10″N-94°56′26″E
6a	MaijanThakurbariI Outside Embankment	*Zizyphus jujuba*	*Anthrocephalus cadamba*	57.45	27°30′14″N-94°56′55″E
6b	MaijanThakurbariI Inside Embankment	Nil	Nil	Nil	27°30′14″N-94°56′55″E
7a	Maijanbeel MaijanTE Inside Embankment	*Ficus rumphii*	*Gmelina arboria and Alstnia scolaris*	68.25	
7b	Maijanbeel MaijanTE Outside Embankment	*Alstnia scolaris*	*Albizia lebek and Delonix regia*	100	
8a	MotlaTE Inside Embankment	*Zizyphus jujuba*	*Albizia lebek*	58.97	
8b	MotlaTE Outside Embankment	*Zizyphus jujuba*	*Albizia lebek*	62.86	
9a	Nagaghuli Armycamp Inside Embankment	*Zizyphus jujuba*	*Ficus rumphii*	54.34	
9b	Nagaghuli Armycamp Outside Embankment	*Zizyphus jujuba*	*Ficus rumphii*	54.34	
10a	NagaghuliStone spur Inside Embankment	Zizyphus jujuba	Cocos nucifera,, A. scolaris and Moringa oleife	78.18	
10b	NagaghuliStone spur	Zizyphus jujuba	A. scolaris and	76.19	

	Outside Embankment		Pungamia pinnata		
11a	Oackland TE Zero Outside Embankment	Areca catechu	A. scolaris and Musa balbasiana	95.85	
11b	Oackland TE Zero Inside Embankment	Alstnia scolaris	Nil	100	

APPENDIX 3.7 COMPREHENSIVE LIST OF AVIAN FAUNA RECORDED IN DIBRUGARH REACH

English Name	Family/Scientific Name	Status	Status of IWPA/GS/habitat
Little Cormorant	Phalacrocoracidae Phalacrocorax niger	*R*	aq
Little Egret	*Ardeidae* *Egretta garzetta*	*R*	aq
Intermediate Egret	*Mesophoyx intermedia*	*R*	aq
Cattle Egret	*Bubulcus ibis*	*R*	aq
Great Egret	*Casmerodius albus*	*R*	aq
Indian Pond Heron	*Ardeola grayii*	*R*	aq
Black-Crowned Night Heron	*Nycticorax nycticorax*	*R*	aq
Grey Heron	*Ardea cinerea*	*R*	aq
Purple Heron	*Ardea purpurea*	*R*	aq
Chinese Pond Heron	Ardeola bacchus	*R*	aq
Yellow Bitern	*Ixobrychus sinensis*	*R*	aq
Black Bittern	*Dupetor flavicollis*	*R*	aq
Cinnamon Bittern	*Ixobrychus cinnamomeus*	*R*	aq
Little Bittern	*Ixobrychus minutes*	*R*	aq
Asian Openbill	Ciconidae *Anastomus oscitans*	*R*	aq
Lesser Adjutant Stork	*Leptoptilos javanicus*	*R*	GT, aq
Greater Adjutant	L. dubius	*R*	Schedule-I/GT,aq
Lesser Whistling-Duck	*Dendrocygna javanica*	*R*	--------
Bar-Headed Goose	Anatidae *Anser indicus*	*M*	Schedule-I/GT,aq
Grey-Lag geese	*Anser anser*	*M*	GT, aq
Ruddy Shelduck	*Tadorna ferruginea*	*M*	aq
Gadwall	*Anas strepera*	*M*	aq
Mallard	*Anas platyrhynchos*	*M*	aq
Spot-billed Duck	*Anas poecilorhyncha*	*M*	aq
Common Teal	*Anas crecca*	*M*	aq
Garganey	*Anas querquedula*	*M*	aq
Northern Pintail	*Anas acuta*	*M*	aq
Northern Shoveler	*Anas clypeata*	*M*	aq
White-breasted Waterhen	Rallidae *Amaurornis phoenicurus*	*R*	aq
Water Cock	*Gallicrex cinerea.*	*R*	aq
Common Moorhen	*Gallinula chloropus*	*R*	aq
Water Rail	*Rallus aquaticus*	*R*	aq
Common Coot	*Fulica atra*	*M*	aq
Pheasant-tailed Jacana	Jacanidae *Hydrophasianus chirurgus*	*R*	aq
Bronze-winged Jacana	*Metopedius indicus*	*R*	aq

English Name	Family/Scientific Name	Status	Status of IWPA/GS/habitat
Painted Snipe	*Rostratulidae* *Rostratula bengalensis*	*R*	aq
Common Snipe	Scolopacidae *Gallinago gallinago*	*R*	aq
Solitary Snipe	*Gallinago solitaria*	*R*	aq
Common Sandpiper	*Actitis hypoleucos*	*M*	aq
Marsh Sandpiper	*T. stagnatalis*	*M*	aq
Little Stint	*Calidris minuta*	*M*	aq
Collared Patrincole	*Glareolidae* Glareola lecta	**M**	aq
Small Indian Patrincole	*G. pratincola*	*M*	aq
Red-wattled Lapwing	*Vanellus indicus*	*R*	aq
Grey-headed Lapwing	*Vanellus cinereus*	*M*	aq
Northern Lapwing	*Vanellus vanellus*	*M*	aq
River Tern	Laridae *Sterna aurantia*	*M*	aq
Whiskered Tern	*Chlidonias hybridus*	*R*	aq
Osprey	Accipitridae *Pandion haliatus*	*R*	Schedule-I/GT,T
Black Kite	*Milvus migrans*	*R*	T
Red-headed Vulture	*Sarcogyps calvus*	*R*	GT,T
Crested Serpent Eagle	*Spilornis cheela*	*R*	T
Eurasian Marsh-Harrier	*Circus aeruginosus*	*M*	T
Pied Harrier	*Crcus melanoleucos*	*M*	T
Hen Harrier	*C. cyaneus*	*M*	T
Pallied Harrier	*C. macrourus*	*M*	T
Shikra	*Accipiter badius*	*M*	Schedule-I/GT,T
Lesser Kestrel	*Falco naumanni*	*M*	Schedule-I/GT,T
Common Kingfisher	Alcidinidae *Alcedo atthis*	*R*	aq
Blyth's Kingfisher	*Alcedo hercules*	*R*	aq
Blue-eared Kingfisher	*Alcedo meninting*	*R*	aq
White-throated Kingfisher	*Halcyon smyrnensis*	*R*	aq
Stork-billed Kingfisher	Dacelonidae *Halcyon capensis*	*R*	aq
Pied Kingfisher	Cerylidae *Ceryle rudis*	*R*	aq
	Passeridae	*R*	T
House Sparrow	*Passer domestica*	*R*	T
Tree Sparrow	*Passer montanus*	*R*	T
Blackheaded Munia	*Lonchura malacca*	*R*	T
White-rumped Munia	*Lonchura striata*	*R*	T
White Wagtail	*Motacilla alba*	*M*	aq
Yellow Wagtail	*Motacilla flava*	*M*	aq

English Name	Family/Scientific Name	Status	Status of IWPA/GS/habitat
Grey Wagtail	*Motacilla cinerea*	*M*	aq
Paddy-field Pipit	*Anthus rufulus*	*M*	aq
Richard's Pipit	*Anthus richardi*	*M*	aq
Citrine Wagtail	*Motacilla citriola*	*M*	aq
Golden Fronted Leaf bird	Irinidae *Chloropsis auriforns*	*R*	T
Orange Billed Leaf bird	*Chloropsis hardwiskii*	*R*	T
Black-hooded Oriole	Corvidae *Oriolus xanthornus*	*R*	T
Rufous Treepie	*D endrocitta vagabunda*	*R*	T
House Crow	*Corvus splendens*	*R*	T
Large-billed Crow	*Corvus macrorhynchos*	*R*	T
Black Drongo	*Dicrurus macrocercus*	*R*	T
Crow-billed Drongo	*Dicrurus annectans*	*R*	T
Common Iora	*Aegithina tiphia*	*R*	T
Ashy Wood Shallow	*Artamus fuscus*	*M*	T
Blue Throated Barbet	Megalaimidae *Megalaima asiatica*	*R*	T
Coppersmith Barbet	*Megalaima haemocephala*	*R*	T
Lineated Barbet	*Megalaima lineata*	*R*	T
Blue-eared Barbet	*Megalaima australis*	*R*	T
Asian Pied Starling	Sturnidae *Sturnus contra*	*R*	T
Common Myna	*Acridotheres tristis*	*R*	T
Jungle Myna	*Acridotheres fuscus*	*R*	T
White-vented Myna	*A. grandis*	*R*	T
Grey-headed Myna	*Sturnus malabaricus*	*R*	T
Creg Martin.	Hirundinidae *Hirundo rupestris*	*M*	T
Barn Swallow	*Hirundo rustica*	*R*	T
Northern House Martin	*Delichon urbica*	*R*	T
Sand Martin	*Riparia riparia*	*M*	T
Red-Whiskered Bulbul	Pycnonotidae *Pycononotus jocosus*	*R*	T
Red-Vented Bulbul	*Pycononotus cafer*	*R*	T
Blue-tailed Bee-ater	Meropidae *Merops philippinus*	*R*	T
Green Bee-eater.	*Merops orientalis*	*R*	T
Chestnut-headed Bee-eater	*Merops leschenaulti*	*R*	T
Purple Sunbird	*Necterinidae:Nectarinia asiatica*	*R*	T
Purple-throated Sunbird	*Necatrinia seperata*	*R*	T
Mrs Gould's Sunbird	*Aethopyga gouldiae*	*R*	T
Crimson Sunbird	*Aethopyga siparaja*	*R*	T

English Name	Family/Scientific Name	Status	Status of IWPA/GS/habitat
Plain Flower-packer	*Dicaeum concolor*	*R*	T
Common Tailor Bird	Sylvidae *Orthotomus sutorius*	*R*	T
Jungle Babbler	*Turdoides striatus*	*R*	T
Oriental Magpie Robin	Muscicapidae *Copsichus saularis*	*R*	T
Dark-sided Flycatcher	*Muscicapa sibirica*	*R*	T
Black-headed Shrike-Babbler	*Pteruthius rufiventer*	*R*	T
Common Stonechat	*Saxicola torquata*	*M*	T
Great Tit	Paridae *Parus major*	*R*	T
Graybacked Shrike	Lanidae *Lanius tephronotus*	*M*	T
Indian Roller	Coracidae *Coracias benghalensis*	*R*	T
Oriental Skylark	Alaudidae *Alauda gulgula*	*M*	T
Crested Lark	*Galirida cristata*	*M*	T
Rufous-winged Bushlark	*Mirafra assamica*	*M*	T
Common Swift	Apodidae *Apus apus*	*R*	T
House Swift	*Apus affinis*	*R*	T
Alpine Swift	*Tachymarptis*	*R*	T
Fork-tailed Swift	*Apus pacificus*	*R*	T
Asian Palmswift	*Cypsturus balasiensis*	*R*	T
Rose-ringed Parakeet	Psittacidae *Pisttacula karmeri*	*R*	T
Alexandrine Parakeet	*Psittacula eupatria*	*R*	T
Blossom-headed Parakeet	*Psittacula roseata*	*R*	GT,T
Spotted Dove.	Culombidae *Streptopelia chinensis*	*R*	T
Red Collared Dove	*Streptopelia tranquebarica*	*R*	T
Eurasian Collared Dove	*Streptopelia decaocto*	*R*	T
Oriental Turtle Dove	*Streptopelia orientalis*	*R*	T
Emerald Dove	*Chalcophaps indica*	*R*	T
Yellow-footed Green Pigeon.	*Treron phoenicoptera*	*R*	T
Orange-breasted Green Pigeon	*Treron bicincta*	*R*	T
Black-rumped Flameback.	Picidae *Dinopium bengalensis*	*R*	T
Yellow-crowned Wood pecker	*Dendrocoposmahrattensis*	*R*	T

English Name	Family/Scientific Name	Status	Status of IWPA/GS/habitat
Grey-capped Pygmy Woodpecker	*Dendrocopos canicapillus*	*R*	T
Greater Coucal	Centropodidae *Centropus sinensis*	*R*	T
Lesser Caucal	*Centropus bengelensis*	*R*	T
Asian Koel	Cuculidae *Eudynamys scolopacca*	*R*	T
Common Hawk Cuckoo	*Hierococcyx varius*	*R*	T
Hodgson's hawk Cuckoo	*Hierococcyx fugax*	*R*	T
Large Hawk Cuckoo	*Hierococcyx sparverioides*	*R*	T
Indian Cuckoo	*Cuculus micropterus*	*R*	T
Oriental Cuckoo	*Cuculus canorus*	*R*	T
Lesser Cuckoo	*Cuculus poliocephalus*	*R*	T
Chestnut-winged Cuckoo	*Clamator coromandus*	*M*	T
Pied Cuckoo	*Clamator jacobinus*	*M*	T
Plantative Cuckoo	*Cacomantis merulinus*	*M*	T
Green-billed Malkoha	*Phaenicophaeus tristis*	*R*	T
Common Hoopoe	Upopidae *Upupa epops*	*R*	T
Spotted Owlet	Strigidae *Athene brama*	*R*	T
Collared Scops Owl	*Otus bakkamoena*	*R*	T
Asian Barred Owlet	*Glaucidium cuculoides*	*R*	T
Jungle Owlet	*Glaucidium radiatum*	*R*	T
Great Eared Nightjar	*Eurostopodus macrotis*	*R*	T
Brown Fish Owl	*Ketupa zeylonensis*	*R*	T

(Note: aq = Aquatic; T= Terrestrial habitat; IWPA: Wildlife Protection Act 1972; GT: Globally threatened)

APPENDIX 3.8 COMPREHENSIVE LIST OF MAMMALIAN FAUNA RECORDED IN DIBRUGARH REACH

S. No.	English Name	Order/Family/ Scientific Name	Status of IWPA, 1972
1	Himalayan Hoary-bellied Squirrel	Order: Rodentia: Family: Sciuridae Callosciurus pygerythrus	-
2	House Shrew	Family: Soricidae Suncus murinus	-
3	House Mouse	Family: Muridae *Mus musculus*	-
4	Large Bandicota -Rat	*Bandicota indica*	-
5	Lesser bandicota-Rat	*Bandicota bengalensis*	-
6	Black Rat	*Rattus rattus*	-
7	Indian flying fox.	Order: Chiroptera: Family: Pteropodidae Pteropus gigenteus	-
8	Long-winged tom bat	*Family: Emballonuridae* *Taphozous longimanus*	-
9	Rhesus Macaque	Order: Primate Family: Cercopithecidae *Macaca mulatta*	-
10	Asiatic Jackel	Order: Carnivora:Family: *Canidae* *Canis aureus*	-
11	Leopard	Panthera pardus	**Schedule-I**
12	Common Otter	Family: Mustelidae *Lutra lutra*	-
13	Large India Civet	Family: Viverridae *Viverra zibetha*	-
14	Small India Civet	*Viverricula indica*	-
15	Indian Mongoose	Family: Herpestidae *Herpestes javanicus*	-
16	River Dolphin	*Order: Primate: Family:* Planista gengeticus	**Schedule-I**

APPENDIX 3.9 COMPREHENSIVE LIST OF AMPHIBIAN FAUNA IN DIBRUGARH REACH

Amphibian Species	Study Zones										
	Mohana ghat	Phul bagan	Kahai Spur	Maijan Thakurbari	Tinik-unia	Naga ghuli	Near land Spur	Maijan beel	Motla Tea Estate	Oakland Tea Estate	Pancali
Rana typiensis	1	1	1	1	1	1	1	1	1	1	1
Haplobtrachus tigerina	1	1	1	1	1	1	1	1	1	1	1
Rana syanophylectes	1	1	1	1	1	1	1	1	1	1	1
Fezerzerya pieri	1	1	1	1	1	1	1	1	1	1	1
F. synhendrense	1	1	1	1	1	1	1	1	1	1	1
Polypedatus leucomystes	1	1	1	1	1	1	1	1	1	1	1
Buffo melanostictus	1	1	1	1	1	1	1	1	1	1	1
Rana leptoglosus	1	1	1	1	1	1	1	1	1	1	1

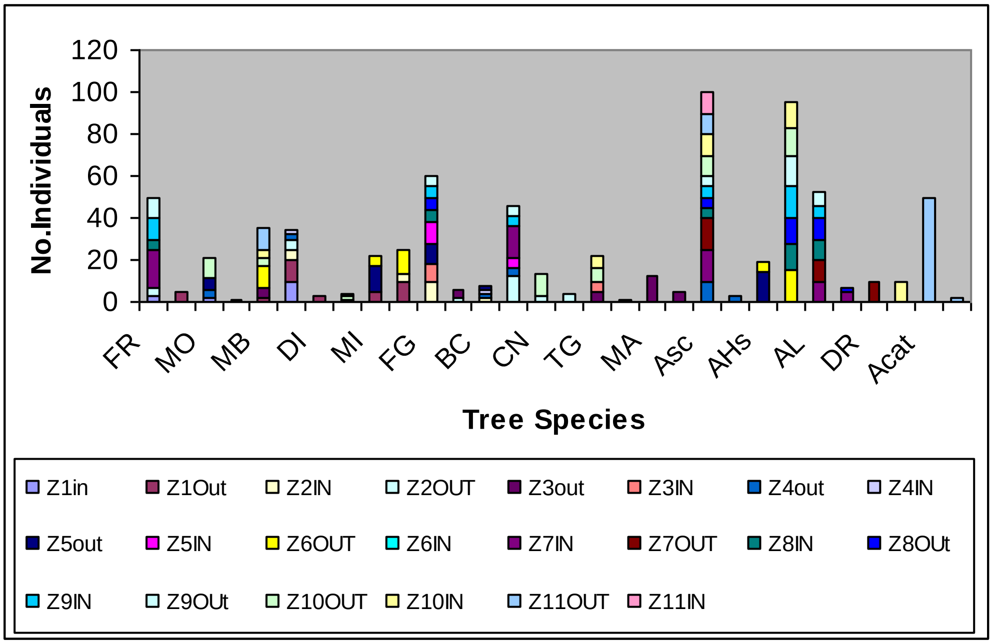
APPENDIX 3.10 COMPREHENSIVE LIST OF REPTILIAN FAUNA IN DIBRUGARH REACH

Reptilian Species/family	Present absent data of Reptilian fauna in different study sites										
	Mohana ghat	Phul bagan	Kahai Spur	Maijan Thakurbari	Tinik-unia	Naga ghuli	Near land Spur	Maijan beel	Motla Tea Estate	Oakland Tea Estate	Pancali
Typhlopidae: *Typhlops diardii* Schlegel, 1839	1	1	1	1	1	1	1	1	1	1	1
Colubridae *Ptyas mucosa* (Linnaeus 1758)	1	1	1	1	1	1	1	1	1	1	1
Oligodon albocinctus (Cantor, 1839)	1	1	1	1	1	1	1	1	1	1	1
Dendreaphis pictus (Gmelin, 1789)	1	1	1	1	1	1	1	1	1	1	1
Lycodon aulicus (Linnaeus, 1758)	1	1	1	1	1	1	1	1	1	1	1
Xenochrophis piscator (Schneider, 1799)	1	1	1	1	1	1	1	1	1	1	1
Amphiesma stolatum (Linnaeus, 1758)	1	1	1	1	1	1	1	1	1	1	1
Amphiesma platyceps (Blyth, 18540)	1	1	1	1	1	1	1	1	1	1	1
Enhydris enhydris (Schneider, 1799)	1	1	1	1	1	1	1	1	1	1	1
Elapidae : *Naja kaouthia* Lesson, 1831	1	1	1	1	0	0	1	1	1	1	1
Bungarus caeruleus (Schneider, 1801)	1	1	1	1	1	1	1	1	1	1	1
Agamidae *Calotes versicolor* (Daudin 1802)	1	1	1	1	1	1	1	1	1	1	1
Gekkonidae: *Hemedactylus frenatus* Schlegal 1836	1	1	1	1	1	1	1	1	1	1	1
Hemedactylus garnoti Dum. And Bibr. 1836	1	1	1	1	1	1	1	1	1	1	1
Hemedactylus brooki Gray, 1845	1	1	1	1	1	1	1	1	1	1	1

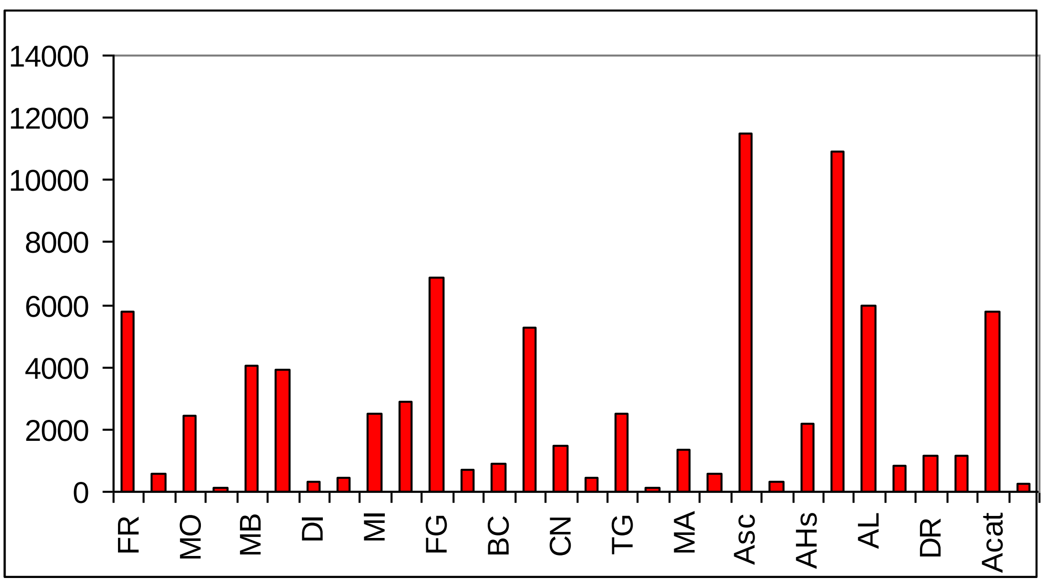
Reptilian Species/family	Present absent data of Reptilian fauna in different study sites										
	Mohana ghat	**Phul bagan**	**Kahai Spur**	**Maijan Thakurbari**	**Tinik-unia**	**Naga ghuli**	**Near land Spur**	**Maijan beel**	**Motla Tea Estate**	**Oakland Tea Estate**	**Pancali**
Scincidae *Mabuya carinata* (Schneider, 1801)	1	1	1	1	1	1	1	1	1	1	1
Sphenomorphys maculatus (Blyth, 1853)	1	1	1	1	1	1	1	1	1	1	1
Riopa punctata (Linnaeus, 1766)	1	1	1	1	1	1	1	1	1	1	1
Anguidae *Varanus bengalensis* (Linnaeus, 1758)	1	1	1	1	1	1	1	1	1	1	1
Kachuga tecta (Gray)	1	1	1	1	1	1	1	1	1	1	1
Kachuga smithi (Gray)	1	1	1	1	0	0	1	0	0	0	0
Geoclemys hamiltoni (Gray)	1	1	1	1	1	1	1	1	1	1	0
Hardella thurgii (Gray)	1	1	1	1	1	1	1	1	1	1	1
Lacepede *Lissemys punctata*	1	1	1	1	1	1	1	1	1	1	1
Trionix hurum (Gray)	1	1	1	1	1	1	1	1	1	1	1
Chitra Indica (Gray)	1	1	1	1	1	1	1	1	1	1	1
Trionix gangeticus	1	1	1	1	1	1	1	1	1	1	1

APPENDIX 3.11 BIO-DIVERSITY INDEX

Altogether 83375 individuals of trees counted near embankment site that were likely to be loss during project intervention.



Counting of tree species in Dibrugarh Project Site in Different Study Zones (Abbreviations: 1: Mohana ghat; 2:Phulbagan; 3: Kahai Spur; 4: Maijan Thakurbari; 5: Tinik-unia; 6: Naga Ghuli; 7: Near land Spur; 8: Maijan beel; 9: MotlaTE; 10: Oakland; 11: Pancali)



Counting of Total Number of Tree Species in Dibrugarh Project Site

APPENDIX 3.12 SURVEY POINTS OF AQUATIC BIOLOGY

S. No.	Survey point	GPS position	S. No.	Survey point	GPS position
1.	Mahana Ghat (Ch 9.42km)	N: $27^{0}29^{/}11^{//}$ E: $94^{0}54^{/}33^{//}$	2.	Pachali (Ch 14.00Km)	N: $27^{0}29^{/}10^{//}$ E: $94^{0}54^{/}37^{//}$
3.	Ful Bagan (3^{rd} spar)	N: $27^{0}29^{/}09^{//}$ E: $94^{0}54^{/}40^{//}$	4.	Koilaghat (Ch 14.00Km)	N: $27^{0}29^{/}15^{//}$ E: $94^{0}54^{/}36^{//}$
5.	Tinikonia (4^{th} spar)	N: $27^{0}30^{/}10^{//}$ E: $94^{0}56^{/}26^{//}$	6.	Maizan Bor Saikia Gaon (2^{nd} spar)	N: $27^{0}30^{/}14^{//}$ E: $94^{0}57^{/}33^{//}$
7.	Maizan Thakur Bari (Stone spar-1)	N: $27^{0}30^{/}05^{//}$ E: $94^{0}57^{/}80^{//}$	8.	Maizan Beel (Ch 0.0Km)	N: $27^{0}30^{/}15^{//}$ E: $94^{0}58^{/}06^{//}$
9.	Hocky stick spar	N: $27^{0}30^{/}41^{//}$ E: $94^{0}58^{/}07^{//}$	10.	Nagaghooli ghat	N: $27^{0}30^{/}58^{//}$ E: $94^{0}59^{/}20^{//}$
11.	Nagaghooli	N: $27^{0}31^{/}50^{//}$ E: $95^{0}02^{/}19^{//}$	12.	Oackland tea estate (Ch 9.10Km)	N: $27^{0}31^{/}32^{//}$ E: $95^{0}03^{/}00^{//}$

APPENDIX 3.13 LIST OF AQUATIC SPECIES AVAILABLE IN EACH POINT

	Stations												**Cons.**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Stat.**
Fish Sp.													
Anguilla bengalensis	-	+	+	-	-	-	-	-	-	-	-	-	EN
Gudusia chapra	-	-	-	+	+	+	-	-	-	-	+	-	LRlc
Hilsa ilisha	-	-	+	+	+	-	-	-	-	-	-	-	Vu
Chagunius chagunio	+	+	-	-	-	+	-	-	+	-	+	-	NE
Cirrhinus reba	+	+	-	-	-	-	+	-	-	+	-	-	Vu
Labeo calbasu	-	-	-	-	-	-	-	-	-	-	+	+	LRnt
Labeo gonius	-	+	+	+	-	-	+	+	+	-	-	-	LRnt
Osteobrama cotio	+	+	+	+	+	+	+	+	+	+	+	+	LRnt
Puntius sarana	-	+	+	-	+	+	-	-	-	-	+	+	Vu
Puntius ticto	-	+	+	-	-	-	-	-	-	-	-	-	LRnt
Puntius sophore	-	+	-	-	-	-	+	+	-	-	-	-	LRnt
Tor putitora	+	+	-	-	-	-	+	-	-	-	-	-	EN
Tor tor	-	+	-	-	-	+	-	-	-	+	-	-	EN
Salmophasia bacaila	+	+	-	-	-	-	-	-	-	-	-	-	LRlc
Barilius barna	-	+	+	+	-	-	+	+	-	-	-	-	LRnt
Barilius	-	+	+	+	+	-	-	+	+	+	-	-	LRnt
Danio Devario	+	+	+	+	+	+	+	+	+	+	+	+	LRnt
Danio aequipinnatus	-	-	+	+	+	+	-	-	-	+	+	+	LRnt
Devario devario	-	+	+	-	+	+	-	-	-	-	+	+	LRnt
Raiamas bola	-	+	+	-	-	-	-	-	-	-	-	-	Vu
Crossocheilus latius	-	+	-	-	-	-	+	+	-	-	-	-	DD
Garra gotyla	+	+	-	-	-	-	+	-	-	-	-	-	Vu
Garra nasuta	+	+	-	-	-	-	-	-	-	-	-	-	NE
Psilorhynchus balitora	-	+	+	+	-	-	+	+	-	-	-	-	NE
Acanthocobitis botia	-	+	+	+	+	-	-	+	+	+	-	-	LRnt
Schistura scaturigina	-	-	-	-	-	-	+	+	-	-	-	-	Vu
Lepidocephalichthys guntea	-	+	+	+	+	-	-	+	+	+	+	+	NE
Cantophrys gongota	+	-	-	-	-	-	-	+	-	-	-	-	LRnt
Botia Dario	-	-	-	-	+	+	-	-	-	-	+	+	NE
Sperata aor	-	-	-	-	-	-	-	-	-	+	-	+	NE

	Stations												Cons. Stat.
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	
Batasio batasio	-	+	+	-	-	-	+	-	+	-	-	-	NE
Ailia coila	-	-	+	-	-	-	-	-	-	-	-	+	Vu
Clupisoma garua	-	-	-	+	-	-	+	-	-	+	+	+	Vu
Eutropichthys vacha	+	-	-	+	-	-	+	-	-	-	+	+	NE
Pseudeutropius atherinoides	-	-	+	-	-	-	-	+	-	-	+	+	NE
Bagarius bagarius	-	-	-	-	-	-	-	-	-	+	-	+	Vu
Erethistes pussilus	+	+	-	-	-	-	+	+	-	-	+	+	NE
Erethistoides montana	-	-	+	+	+	-	-	-	-	-	-	-	CR
Gagata cenia	-	-	-	-	-	+	-	-	-	+	+	+	NE
Gagata gagata	-	-	-	-	-	-	-	-	-	-	+	+	NE
Glyptothorax telchitta	-	-	-	-	-	+	-	-	-	-	-	+	LRnt
Hara hara	-	+	-	-	+	+	+	-	-	+	-	+	NE
Pseudochenesis sulcatus	+	+	-	-	-	-	-	-	-	-	-	+	Vu
Laguvia shawi	+	+	+	+	+	-	+	+	+	+	+	+	EN
Clarias batrachus	+	+	+	+	+	-	+	+	+	+	+	-	Vu
Heteropneustes fossilis	-	-	-	-	-	-	-	-	-	+	+	+	Vu
Olyra longicaudata	+	+	-	+	+	-	-	-	+	+	+	-	NE
Xenentodon cancila	-	-	-	-	-	-	-	-	+	+	+	+	LRnt
Macrognathus pancalus	-	-	-	-	-	-	-	-	-	+	-	+	NE
Mastacembelus armatus	-	-	+	-	+	-	-	-	-	+	-	+	NE
Chanda nama	-	+	+	+	+	+	-	+	+	+	+	+	NE
Parambassis ranga	-	+	+	+	+	+	-	+	+	+	+	+	NE
Glossogobius giuris	-	-	-	-	-	-	-	-	-	+	+	+	LRnt
Channa punctatus	-	-	-	-	-	-	-	-	-	+	+	-	LRnt
Channa striatus	-	-	+	+	+	-	-	-	-	-	-	-	LRnt
Gastropods													
Pila globosa	+	+	-	+	+	+	+	-	+	+	+	+	

	Stations												Cons.
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Stat.**
Pila scutata	+	+	-	+	+	+	+	-	+	+	+	+	
Paludomus pustulosa	+	-	+	-	+	-	-	+	+	-	+	-	
Prawn													
Macrobrachium malcomsoni	+	-	+	-	+	-	+	-	-	-	-	+	
M. lanchesteri	-	+	+	-	+	-	+	+	+	+	+	+	
Crabs													
Sterteriane spinigera	+	-	+	-	+	+	-	+	+	+	+	+	
Peratelphusa eduntula	+	-	+	-	+	+	-	+	+	+	-	-	
P. spingera	+	-	+	-	+	+	-	+	+	+	+	+	
Potaman woodmansoni	+	-	+	-	+	+	-	+	+	+	-	-	
Amphibians													
Chirixalus simus	+	+	+	+	+	-	-	+	+	+	+	-	
Bufo melanostictus	+	+	-	+	-	+	+	-	-	-	-	+	
Hoplobatrachus tigerinus	+	+	+	+	+	-	-	+	+	+	+	-	
Limnonectes laticeps	+	+	-	+	-	+	+	-	-	-	-	-	
Turtles and Tortoises													
Kachuga sylhetensis	+	-	+	-	+	+	+	-	+	+	+	+	**Sc-I**
Aspideretes gangeticus	+	+	-	-	-	+	+	+	-	-	-	+	
Kachuga tecta	+	+	-	-	-	+	+	+	-	-	-	+	**Sc-I**
Lizards													
Gecko gecko	+	-	+	+	+	-	+	-	+	+	+	+	
Varanus bengalensis	+	+	-	-	-	+	+	+	-	-	-	+	
Varanus salvator	+		+	-	+	+	+		+	+	+	+	
Calotes emma	+	+	+	-	-	+	+	+	+	+	-	+	
Calotes maria	-	-	+	+	+	+	-	-	+	+	+	+	
Snakes													
Ophiophagus hannah	-	-	-	+	+	-	-	+	-	-	-	+	
Naja naja	+	+	-	+	+	+	+	+	+	-	-	+	
Mammals													
River Dolphin	-	+	-	+	-	+	-	+	-	+	+	-	
Plankton													

	Stations												Cons.
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Stat.**
Bacillariophyceae													
Diatoma	+	+	-	+		+	+	+			+		
Fragilaria	+		+	+	+				+	+		+	
Synedra	+	+	+	+		+	+	+			+	+	
Cocconeis	+	+				+	+	+				+	
Achnanthes	+		+		+	+	+		+	+	+	+	
Eucocconeis		+	+	+		+	+	+		+	+	+	
Navicula	+	+	-	+		+	+	+			+		
Pinnularia	+		+	+	+				+	+		+	
Gyrosigma	+	+	+	+		+	+	+			+	+	
Frustulia	+	+				+	+	+				+	
Gomphonema	+		+		+	+	+		+	+	+	+	
Cymbella	+		+	+	+				+	+		+	
Nitzschia	+	+	+	+		+	+	+			+	+	
Surirella	+	+				+	+	+				+	
Melosira	+		+		+	+	+		+	+	+	+	
Chlorophyceae													
UlothrIx		+	+	+		+	+	+		+	+	+	
Microspora	+	+	-	+		+	+	+			+		
Cladophora	+		+	+	+				+	+		+	
Closterium	+	+	+	+		+	+	+			+	+	
Cosmarium		+	+	+		+	+	+		+	+	+	
Spirogyra	+	+	-	+		+	+	+			+		
Myxophyceae													
Oscillatoria		+	+	+			+	+	+	+	+		
Rivularia	+	+	+	+	+	+							
Anabaena	+	+	+			+	+	+		+	+	+	
Zooplankton													
Vorticella	+			+	+			+	+	+	+	+	
Cyclops	+			+	+	+	+	+		+	+	+	
Daphnia		+	+	+			+	+	+	+	+		
Zoea larva	+	+	+	+	+	+							
Keratella	+	+	+			+	+	+		+	+	+	
Chironomous	+			+	+			+	+	+	+	+	
Gomphus	+			+	+	+	+	+		+	+	+	
Bosmina		+	+	+			+	+	+	+	+		
Ceriodaphnia	+	+	+	+	+	+							
Chydorus	+	+	+			+	+	+		+	+	+	
Nauplis	+			+	+			+	+	+	+	+	
Diaptomus	+			+	+	+	+	+		+	+	+	
Canthocamptus		+	+	+			+	+	+	+	+		
Asplanchna	+	+	+	+	+	+							
Kellicotia	+	+	+			+	+	+		+	+	+	
Arcella	+			+	+			+	+	+	+	+	
Paramecium	+			+	+	+	+	+		+	+	+	

	Stations												Cons.
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Stat.**
Brachionus		+	+	+			+	+	+	+	+		
Asplanchna	+	+	+	+	+	+							
Semiocephalus		+				+	+	+				+	
Moinodaphnia	+		+		+	+	+		+	+	+	+	
Sida			+	+	+	-	+		+	+	+	+	
Macrothrix	+	+	-	+		+	+	+			+		
Epistilis	+		+	+	+				+	+		+	
Rotifer eggs	+	+	+	+		+	+	+			+	+	
Gomphus		+				+	+	+				+	
Benthos													
Nais	-	-	+	+	+	+	-	+	+	-	+	-	
Tubifex	+	+	-	-	-	+	+	+	-	+	+	+	
Chironomus	+	+	+	-	+	+	+	-	+	+	+	+	
Viviparus	-	-	+	+	+	-	-	-	+	-	-	-	
Gyraulus	+	+	+	-	+	+	+	-	+	+	+	+	
Pisidium	-	-	+	+	+	-	-	-	+	-	-	-	

APPENDIX 3.14 IDENTIFICATION OF ENDEMIC/ THREATENED AND ENDANGERED SPECIES

Endangered Mammalian Fauna in Dibrugarh Embankment Site

S. No.	English Name	Order/Family/Scientific Name	Status of IWPA
1.	Leopard	***Order: Carnivora: Family: Canidae:*** *Panthera pardus*	Schedule-I
2.	River Dolphin	***Order: Primate: Family:*** *Planista gengeticus*	Schedule-I

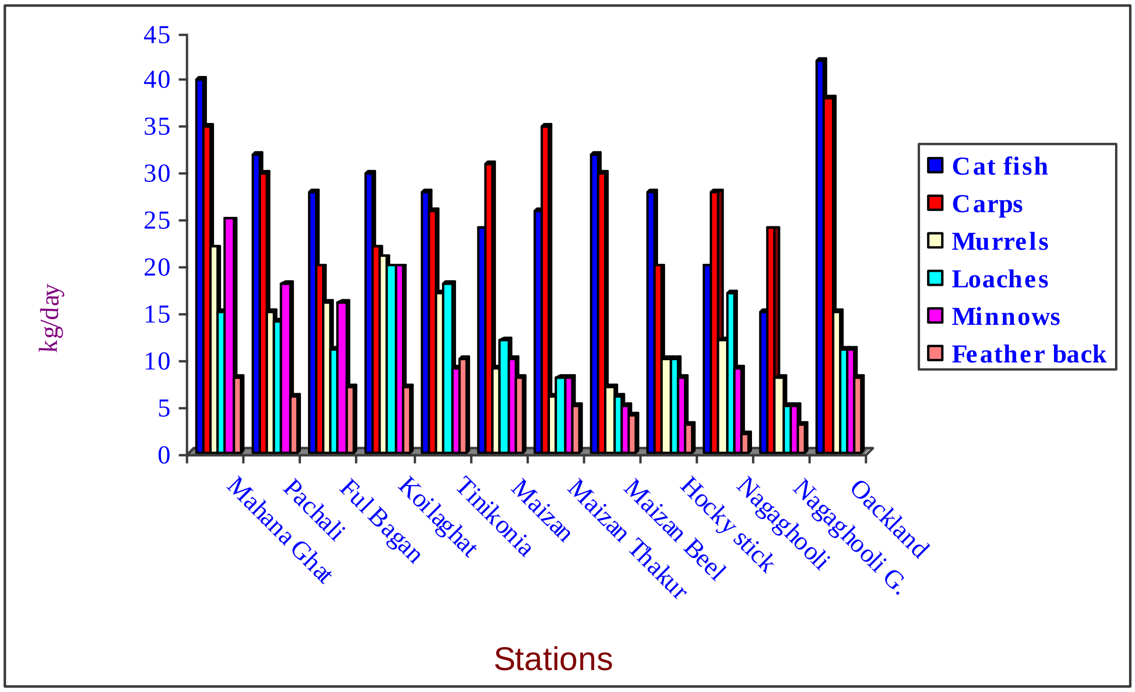
Endangered Reptilian Fauna in Dibrugarh Reach

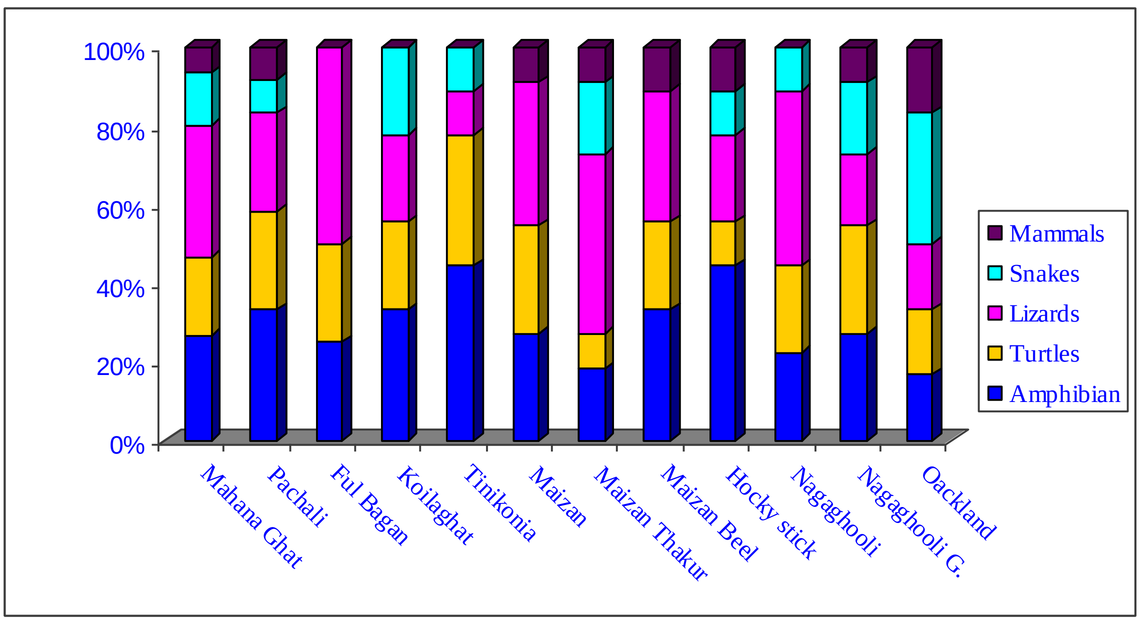
S. No.	Common Name	Scientific Name	Status of IWPA
1	Indian Roofed Terrapin	*Kachuga tecta* (Gray)	Schedule-I
2	Spotted Black Terrapin	*Geoclemys hamiltoni* (Gray)	Schedule-I
3	Indian Mud Turtle	*Lissemys punctata* Lacepede	Schedule-I
4	Peacock Soft-shell	*Trionix hurum* (Gray)	Schedule-I
5	Ganges Soft-shell Turtle	*Trionix gangeticus*	Schedule-I

Endangered/ Globally Threatened Avian Fauna in Dibrugarh Reach

S. No.	English Name	Family/Scientific Name	Status	Status of IWPA/GS
1.	Spot-billed Pelican	*Pelecanus philippensis*	R	Schedule-I/GT
2.	Lesser Adjutant Stork	*Leptoptilos javanicus*	*R*	GT
3.	Greater Adjutant	L. dubius	*R*	Schedule-I/GT
4.	Bar-Headed Goose	*Anatidae* *Anser indicus*	*M*	Schedule-I/GT
5.	Grey-Lag geese	*Anser anser*	*M*	GT
6.	Osprey	*Accipitridae* *Pandion haliatus*	*R*	Schedule-I/GT
7.	Red-headed Vulture	*Sarcogyps calvus*	*R*	GT
8.	Shikra	*Accipiter badius*	*M*	Schedule-I/GT
9.	Lesser Kestrel	*Falco naumanni*	*M*	Schedule-I/GT
10.	Blossom-headed Parakeet	*Psittacula roseate*	*R*	GT

APPENDIX 3.15 LIST OF AQUATIC SPECIES AVAILABLE IN EACH POINT





N.B. Fishes were identified after the methods of Talwar and Jhingran (1991), Nath and Dey (2000) and Vishwanath (2002).
The plankton were identified after Edmonson (1959), Needham and Needham (1966) and APHA (1998).

APPENDIX 4.1: EMISSION FACTORS OF VARIOUS DUST GENERATION PROCESSES

Source	Unit	Emission Factor
Receipt of new aggregate at Hot Mix Plant	g/ton	1.86
Transfer of aggregate from storage to conveyor belt or between conveyor belts in Hot Mix Plant	g/ton	0.021
Screening of aggregate in Hot Mix Plant	g/ton	0.38
RAP crushing	g/ton	0.27
Paved road dust emissions	g/VMT	7.26
Unpaved road dust emissions	g/VMT	925.3

(Note: VMT: Vehicle Mile Traveled)

APPENDIX 7.1: SUMMARY OF IMPACT ASSESSMENT AND RESIDUAL IMPACT

Activity	Environmental Issue/ Component	Nature of Impact	Remedial Measures	Residual Impacts Level after Mitigation Measures
DESIGN AND CONSTRUCTION PHASE				
Landuse				
Change in Landuse	Loss of agriculture land Loss of homestead plantation in 50 m core zone around the embankment	Adverse	Use of uncultivated areas near embankments only for storage and/or handling of construction materials Construction camps on uncultivated areas only with requisite facilities of drinking water supply, sanitation, waste collection and fuel supply No dumping of construction waste on agricultural land Adequate compensation for loss of land and/ or loss of crops Land used for construction camps shall made reusable/ cultivable after closure of construction camp All efforts during the design stage shall be made to minimize the tree felling requirement. Compensatory plantation shall be started during construction phase parallel to the construction activities. Monitoring of tree felling.	Acceptable even though landuse will be changed permanently around the core zone Restoration of sites used for construction material handling and storage as well as construction camps will be required
Borrow area location and rehabilitation	Loss of agricultural land and homestead plantation due to borrowing earth from country side of embankment Permanent disfiguration of land Seepage to the foundations of embankment	Adverse	Borrow pits shall be preferred on river side to embankment as these can get silted in the course of time Use of waste land or excavation or enlargement of existing lank or any hump above ground level for borrowing of earth Strictly following WRD guidelines with respect to borrow area location and rehabilitation Top soil shall be conserved	Acceptable in case of borrow areas will be located on river side Borrow pits on the country side shall be cut and interconnected to permit ordinary drainage and shall be away from the embankment IRC guidelines may also be followed for borrow pits.
Construction material sourcing (Quarrying)	Illegal quarrying may lead to landuse change, unstable rock formation, air and noise pollution	Adverse	Aggregates required for construction of embankment and roads shall be procured from quarries approved by SPCB. Air and noise emissions from quarries shall be well within the prescribed limits. Stone crushers, if required, shall be set up only after consent from SPCB and taking adequate measures for air pollution control. Land earmarked for dumping of construction waste	Stabilization of quarries and dumping sites after use.

Activity	Environmental Issue/ Component	Nature of Impact	Remedial Measures	Residual Impacts Level after Mitigation Measures
			shall be free from any social and R and R issue and away from settlements	
Soil				
Soil erosion	Soil erosion from construction sites during monsoon season Loss of topsoil	Medium	Opening of borrow areas near the embankments shall not be done during monsoon season Identification of potential erosion zones during construction phase Stabilization of soil around the approach roads/ slopes by turfing and tree plantation in ROW Slope stabilization measures on the embankment like selection of less eroding materials	Acceptable but requires continuous monitoring of the stabilized areas and identification of potential erosion zones for advance mitigation for lowering any adverse impacts
Soil compaction	Soil compaction around construction sites, haulage roads, construction camps, and workshops due to transportation of man, machine, and materials Construction waste handling	Medium	Movement of construction vehicles, machinery and equipments in embankment site and pre-defined haulage road Adequate provision for approach roads capable of handling movement and haulage of heavy vehicles and machines	Restoration of compacted sites after construction will be required
Soil contamination	Soil contamination around construction sites, machine maintenance areas, fuelling stations, construction camps, hotmix plant and haulage roads	Medium	Fuelling and maintenance of construction machinery and vehicles shall be carried out at designated place with proper arrangement of waste collection and disposal. Fuel storage and refuelling sites to be kept away from drainage channels. Unusable debris to be dumped in designated places. Provision of oil interceptors Waste oil shall be sold off to recyclers authorized by SPCB/ MoEF.	No further mitigation will be required.
Site clearing etc	Contamination of soil from construction wastes and quarry materials	Medium	All spoils to be disposed off as desired and the site to be restored back to its original conditions before handing over. Non-bituminous wastes from construction activities to be dumped in borrow pits and covered with a layer of the conserved topsoil. Bituminous wastes to be disposed of in identified dumping sites.	No further mitigation required
Hydrology and Morphology				

Activity	Environmental Issue/ Component	Nature of Impact	Remedial Measures	Residual Impacts Level after Mitigation Measures
Flood	Inundation during heavy flood Channel congestions in country side during monsoon season	Medium	Adequate provisions of sluice gates shall be made. Natural drainage systems shall not be disturbed. Wetlands and other water bodies shall be enlarged and deepened Adequate provisions shall be made in engineering design to withstand extreme meteorological and geo-physical events WRD/ local authorities shall modify the existing drainage system and rehabilitate it.	Continuous maintenance and protection of embankments will be required Maintenance of drainage system
Changes in water levels	No significant change due to project intervention	Low	Identification of low lying areas Raised platforms shall be provided in low lying areas	No residual impact
Effect on flow velocity/ discharge intensities	No significant change due to project intervention	Low	Monitoring of flow shall be carried out at regular intervals using field data as well as satellite remote sensing data.	No residual impact
Silt deposition and bed level change	Prevention in silt deposition on agricultural land due to breach of embankments	No	Monitoring of anti-erosion and river training works at regular intervals	No residual impact
Water quality	Impact on surface and ground water quality Contamination of water due to construction waste Contamination of water from fuel and lubricants	Low to Medium	Adequate supply of drinking water to workers. Septic tanks shall be provided to treat the domestic sewage from construction camps. Provision of mobile toilets for use at flood platforms Construction work close to the channels or other water bodies to be avoided. All necessary precautions to be taken to construct temporary devices to prevent water pollution due to increased siltation and turbidity. Oil and grease traps to be provided at fuelling locations, to prevent contamination of water. Slopes of embankment leading to water bodies to be modified and screened so that contaminants do not enter the water channel/ water body. Water quality to be monitored as envisaged in the environmental monitoring plan.	No residual impact
Climate	No direct impact but increase in temperature due to construction activities and trees to be cut	Medium	Minimization of tree cutting while designing the embankment Compensatory tree plantation on the basis of 3 trees plantation against each tree cut	Acceptable as increase in temperature due to project intervention will be minimized
Air Environment	Change in air quality due to construction activities	Low to Medium	Approach roads should be paved and widened All slopes and embankments to be turfed as per best	No residual impact

Activity	Environmental Issue/ Component	Nature of Impact	Remedial Measures	Residual Impacts Level after Mitigation Measures
			engineering practices to minimize the dust generation All the machinery and plants to be placed at the downwind direction with respect to human settlements. All vehicles, equipments and machinery used for construction to be regularly maintained. The hot mix plants, crushers and batching plants to be sited at least 500 m in the downwind direction from the nearest human settlement. Hot mix plants shall comply with applicable National/State Pollution Control Board Standards fro emissions from hot mix plants. Fugitive emissions from handling of construction material, storage as well as from transportation shall be taken care. Speed restriction, surface improvement and surface treatment shall be taken as options for control of emissions from unpaved roads.	
Noise	Increase in sound pressure levels due to construction machineries, vehicles etc.	Low to Medium	Options of noise control by site controls, scheduling of project activities, Protection devices (ear plugs or ear muffs) to be provided to the workers operating in the vicinity of high noise generating machines. Construction equipments and machinery shall be fitted with silencers and maintained accordingly. Construction of temporary noise barriers near the sensitive areas, e.g. schools Noise and vibration level monitoring as per monitoring plan.	No residual impact
Terrestrial ecology				
Disturbance to vegetation	Cutting of trees in core zone during project intervention	Medium to High	Minimization of tree cutting while designing the embankment Compensatory tree plantation preferably on the basis of 3 trees plantation against each tree cut	Monitoring of survival rates of trees planted during afforestation programme
Animal distribution/ migratory route	No Migratory route Impact of water pollution on Dolphins	Low	Construction activities should be restricted during fish breeding period (May to August) at breeding sites. Due to sensitivity of Dolphins with polluted water,	No residual impact

Activity	Environmental Issue/ Component	Nature of Impact	Remedial Measures	Residual Impacts Level after Mitigation Measures
			construction waste should not dumped near the river bank	
Endangered species	No adverse impact	No	A green belt is necessary along the sides of embankment for transitional wildlife species like birds and herpitofauna	
Aquatic ecology				
Fishing activities/ productivity	Impact on fish landing sites/ boatghats Temporary flushing of fish species towards deeper parts of the river	Medium	Adequate provision shall be made in the design to ensure access to the fish landing sites/ boat ghats Undisturbed movement of the fishermen shall be provided	No residual impact
Migratory routes	No migratory route near the embankment/ riverbank	No Impact		No residual impact
Spawning and Breeding Grounds	Disturbance on breeding and spawning grounds	Medium	Restriction of construction activities near the identified breeding and spawning grounds during the breeding period of april to august	
Pond fisheries	No adverse impact	No Direct Impact. Positive impact in terms of productivity enhancement	Limited pond fisheries activities are involved near Dibrugarh reach Fish productivity can be improved substantial with use of better fish culture and increasing the capacity of fish ponds	No residual impact
Socio economic				
Demography	Pressure on natural resources due to establishment of construction camps	Low	Construction camps shall be supported with all basic amenities such as drinking water, fuel, sanitation facilities etc.	No residual impact
Establishments	Impact on houses and establishments near core zone	Medium	Efforts shall be made to prevent any relocation or demolition Social infrastructure shall be rehabilitated with social and cultural values Temporary noise barriers shall be installed close to schools and places of worship Thick plantation shall be made close to these establishments	No residual impact
Socio-economic impact	Beneficial impact due to control in flood and erosion Impact on fish landing sites	Low to Medium	Daily wage workmanship during the construction phase to local people Training programmes for agriculture and fish production improvement Appropriate provisions shall be made to provide	No residual impact

Activity	Environmental Issue/ Component	Nature of Impact	Remedial Measures	Residual Impacts Level after Mitigation Measures
			alternate fish landing stations so that economic activities of the fishermen can not disturb during project intervention	
Safety	Risk of accidents and safety due to narrow roads and encroachment of people near construction areas	Low to Medium	Adequate lighting and fluorescent signage shall be provided at construction sites. Signage in local language Setting up of speed limits Personal protective equipments for workers Health check up camps for workers	Adherence to occupational health and safety norms shall be monitored
OPERATION PHASE				
Landuse				
Change in Landuse and borrow area rehabilitation	Encroachment on embankment for habitation and cultivation Cutting of embankment to create approach to river side Non-rehabilitation of borrow areas	Low	Provision shall be made in the embankment design for providing access to river bank close to the habitats. Construction contractors shall ensure rehabilitation of borrow areas before handling over the project.	No residual impact
Soil				
Soil erosion	Net benefits due to construction of embankment and anti-erosion measures in river banks	Low	Periodic checking of the stabilization measures	No residual impact
Hydrology and Morphology				
Upstream and downstream effects on river morphology	Reduction of flood absorption due to the flood plains of the reach Impact on charlands near to bank line	Medium	Erosion monitoring shall be carried out downstream as well. In case of impact on fringe areas of char, passive type of measures like porcupine screens shall be used.	
Flood	Inundation during heavy flood	Low	Adequate provisions of sluice gates shall be made. Natural drainage systems shall not be disturbed. Wetlands and other water bodies shall be enlarged and deepened Adequate provisions shall be made in engineering design to withstand extreme meteorological and geo-physical events	Continuous maintenance and protection of embankments will be required
Changes in water levels	No significant change	No		No residual impact

Activity	Environmental Issue/ Component	Nature of Impact	Remedial Measures	Residual Impacts Level after Mitigation Measures
Effect on flow velocity/ discharge intensities	No significant change due to project intervention	No	Monitoring of flow shall be carried out at regular intervals using field data as well as satellite remote sensing data.	No residual impact
Silt deposition and bed level change	Prevention in silt deposition on agricultural land during floods	Low	Monitoring of anti-erosion and river training works at regular intervals	No residual impact
Drainage system	Embankment acts like a barrier for the drainage of accumulating country side water into the Brahmaputra during monsoon season.	Medium	Provision shall be made to the extent possible not to obstruct the natural drainage.	No residual impacts
Wetlands/ beels	No Impact	Low	Institutional support will enhance the productivity	Positive impact
Water quality	Discharge of domestic effluents from nearby villages to the river	Low	Sanitation facilities shall be provided	No residual impact
Climate	No direct impact but changes in catchments area of the river and global warming can have indirect impact	Low	Attention shall be given for maintaining inland outflow of water to wetland areas. Provision of sluice gates to be made in the embankment.	Flood pattern shall be closely monitored during the project life span of the embankment.
Air Environment	Change in air quality due to traffic	Low	Plantation along the embankment Turfing of the embankment slopes Regular maintenance of the road on the top of embankment as well as approach roads	No residual impact
Noise	Increase in sound pressure levels due to traffic	Low	Adequate signage to restrict use of pressure horns particularly in noise sensitive locations Tree barriers between the road and village/ semi urban/ and urban areas	No residual impact
Aquatic ecology				
Fishing activities/ productivity	Likley to increase due to institutional strengthening	Positive -Medium		No residual impact

APPENDIX 7.2: ENVIRONMENTAL MANAGEMENT PLAN (EMP)

Activity	Environmental Issue/ Component	Remedial Measures	Legislative Requirement/ Framework	Approximate Location	Time Frame	Mitigation Cost (Rs.)	Institutional Responsibility	
							Implementation	Supervision
Climate Change	No direct impact but increase in temperature due to construction activities and trees to be cut	Minimization of tree cutting while designing the embankment Compensatory tree plantation preferably on the basis of 3 trees plantation against each tree cut	Kyoto Protocol	Through out the stretch of reach	Throughout the construction period	--	Contractor with guidance of Social Forestry Department	WRD and AIFRERM Agency
Change in Landuse	Loss of agriculture land	Use of uncultivated areas near embankments only for storage and/or handling of construction materials	-	Construction sites and service areas throughout the reach	During design and construction phase	Included in construction cost	Contractor	WRD and AIFRERM Agency
		Construction camps on uncultivated areas only with requisite facilities of drinking water supply, sanitation, waste collection and fuel supply		Identified locations of construction camps (2 to 3)		Included under soil contamination prevention costs	Contractor	WRD and AIFRERM Agency
		No dumping of construction waste on agricultural land					Contractor	WRD and AIFRERM Agency
		Adequate compensation for loss of land and/ or loss of crops	As per Social Assessment and R and R	Identified as per the social assessment		Included in R and R Cost	WRD-SIO	WRD and AIFRERM Agency
		Land used for construction camps shall made reusable/ cultivable after closer of construction camp		Sites used as construction camp	After completion of construction	Included in construction cost	Contractor	WRD and AIFRERM Agency

Activity	Environmental Issue/ Component	Remedial Measures	Legislative Requirement/ Framework	Approximate Location	Time Frame	Mitigation Cost (Rs.)	Institutional Responsibility	
							Implementation	Supervision
		All efforts during the design stage shall be made to minimize the tree felling requirement.		Entire project area	During complete construction phase	Included in design engineering cost	Engineering Team/WRD Field Officer	WRD and AIFRERM Agency
	Loss of homestead plantation	Compensatory plantation shall be started during construction phase parallel to the construction activities (1:3)		Entire project area	During construction	2340000	WRD-SIO	WRD and AIFRERM Agency
		Monitoring of tree felling (census of trees, their numbering etc. based on engineering design)		Entire project area	During complete construction phase	Included in the Monitoring Costs (refer Monitoring Plan)	Independent agency	WRD and AIFRERM Agency
Borrow area location and rehabilitation	Loss of agricultural land and homestead plantation due to borrowing earth from country side of embankment	Borrow pits shall be preferred on river side to embankment as these can get silted in the course of time or earth from retired Embankment	WRD guidelines	Identified locations for borrowing of earth	During complete construction phase	Included in construction cost	Contractor/WRD Field Officers	WRD and AIFRERM Agency
	Permanent disfiguration of land	Use of waste land or excavation or enlargement of existing lank or any hump above ground level for borrowing of earth		Identified locations for borrowing of earth	During complete construction phase	Included in construction cost	Contractor	WRD and AIFRERM Agency
	Seepage to the foundations of embankment	Borrowing earth away from the embankment			During construction	Included in construction cost	Contractor	WRD and AIFRERM Agency

Activity	Environmental Issue/ Component	Remedial Measures	Legislative Requirement/ Framework	Approximate Location	Time Frame	Mitigation Cost (Rs.)	Institutional Responsibility	
							Implementation	Supervision
		Strictly following WRD guidelines with respect to borrow area location and rehabilitation		Entire project area	During construction phase as well as after construction	Included in construction cost	Contractor	WRD and AIFRERM Agency
Change in Land use and Borrow Area Rehabilitation	❖ Encroachment on embankment for habitation and cultivation ❖ Cutting of embankment to create approach to river side ❖ Non-rehabilitation of borrow areas	❖ Provision shall be made in the embankment design for providing access to river bank close to the habitats. ❖ Construction contractors shall ensure rehabilitation of borrow areas before handling over the project.		Entire project area and Borrow Areas	Operation Phase	Included in construction cost	Contractor, WRD (Field Staff)	WRD and AIFRERM Agency
Construction material sourcing (Quarrying)	Illegal quarrying may lead to landuse change, unstable rock formation, air and noise pollution	Aggregates required for construction of embankment and roads shall be procured from quarries approved by SPCB.	Environmental Protection Act and Rules, 1986; Water Act, Air Act	River and Hill Quarries approved by Assam Govt.	During complete construction phase	Included in construction cost	Contractor	WRD and AIFRERM Agency
		Air and noise emissions from quarries shall be well within the prescribed limits for the protection of workers health		Quarrying sites	During complete construction phase	--	WRD (Environmental Division)	WRD, AIFRERM Agency and SPCB
		Stone crushers, if required, shall be set up only after consent from SPCB and taking adequate measures for air pollution		Location of stone crushers	During complete construction phase	Included in construction cost	Contractor	WRD, AIFRERM Agency and SPCB

Activity	Environmental Issue/ Component	Remedial Measures	Legislative Requirement/ Framework	Approximate Location	Time Frame	Mitigation Cost (Rs.)	Institutional Responsibility	
							Implementation	Supervision
		control.						
		Land earmarked for dumping of construction waste shall be free from any social and R and R issue and away from settlements		Dumping shall be avoided at the Municipal dumping site of Dibrugarh as it is very close to riverbank	During complete construction phase	Included in R and R Cost	Contractor	WRD and AIFRERM Agency
Soil erosion	Soil erosion from construction sites during monsoon season	Opening of borrow areas near the embankments shall not be done during monsoon season		Identified areas for borrowing earth	Except monsoon season during construction phase	Included in construction cost	Contractor	WRD and AIFRERM Agency
	Loss of topsoil	Identification of potential erosion zones during construction phase		Piling of topsoil for later use as landscaping and turfing of embankments	Especially during monsoon season	Included in construction cost	WRD Field Officers	WRD and AIFRERM Agency
		Stabilization of soil around the approach roads/ slopes by turfing and tree plantation in ROW		Along the embankment and approach roads	Especially before monsoon starts	Included in construction cost	Contractor	WRD and AIFRERM Agency
		Slope stabilization measures on the embankment like selection of less eroding materials		As suggested by the engineering team	During the construction period	Included in construction cost	Contractor	WRD and AIFRERM Agency

Activity	Environmental Issue/ Component	Remedial Measures	Legislative Requirement/ Framework	Approximate Location	Time Frame	Mitigation Cost (Rs.)	Institutional Responsibility	
							Implementation	Supervision
	❖ Net benefits due to construction of embankment and anti-erosion measures in river banks	❖ Periodic checking of the stabilization measures		Project Benefit Area.	Post Operation Phase	Included in Monitoring Costs.	WRD	
Soil compaction	Soil compaction around construction sites, haulage roads, construction camps, and workshops due to transportation of man, machine, and materials	Movement of construction vehicles, machinery and equipments in embankment site and pre-defined haulage road		Construction material dumping sites and construction sites	During the entire construction period	Included in construction cost	Contractor	WRD and AIFRERM Agency
	Construction waste handling	Adequate provision for approach roads capable of handling movement and haulage of heavy vehicles and machines		Approach roads used for material handling	During the entire construction period	Included in construction cost	Contractor	WRD and AIFRERM Agency
Soil contamination	Soil contamination around construction sites, machine maintenance areas, fuelling stations, construction camps, hot mix plant and haulage roads	Fuelling and maintenance of construction machinery and vehicles shall be carried out at designated place with proper arrangement of waste collection and disposal.		Fuel storage and workshop areas	During the entire construction period	3,20,000	Contractor	WRD and AIFRERM Agency
		Fuel storage and refuelling sites to be kept away from drainage channels.		Fuel storage and workshop areas	During the entire construction period	Included in construction cost	Contractor	WRD and AIFRERM Agency

Activity	Environmental Issue/ Component	Remedial Measures	Legislative Requirement/ Framework	Approximate Location	Time Frame	Mitigation Cost (Rs.)	Institutional Responsibility	
							Implementation	Supervision
		Unusable debris to be dumped in designated places.		Identified inert material dumping sites	During construction phase	Included in construction cost	Contractor	WRD and AIFRERM Agency
		Provision of oil interceptors		At fuel handling and workshop areas	During construction phase	Included above	Contractor	WRD and AIFRERM Agency
		Waste oil shall be sold off to recyclers authorized by SPCB/ MoEF.		At fuel handling and workshop areas	During construction phase	Earning from selling	Contractor	WRD and AIFRERM Agency
Site clearing etc	Contamination of soil from construction wastes and quarry materials	All spoils to be disposed off as desired and the site to be restored back to its original conditions before handing over.		Construction material handling areas and construction sites	After completion of construction phase	Part of Construction Costs	Contractor	WRD and AIFRERM Agency
		Non-bituminous wastes from construction activities to be dumped in borrow pits and covered with a layer of the conserved topsoil.		Inert material dumping sites	After completion of construction phase	Included in construction cost	Contractor	WRD and AIFRERM Agency
		Bituminous wastes to be disposed off in identified dumping sites.		Identified dumping sites	After completion of construction phase	Included in construction cost	Contractor	WRD and AIFRERM Agency
Flood	Inundation during heavy flood Clogging of channels	Adequate provisions of sluice gates shall be made.		In proposed embankment	During the construction phase	Included in construction cost	Engineering team and contractor/WRD Field Officer	WRD

Activity	Environmental Issue/ Component	Remedial Measures	Legislative Requirement/ Framework	Approximate Location	Time Frame	Mitigation Cost (Rs.)	Institutional Responsibility	
							Implementation	Supervision
	towards country side due to siltation	Natural drainage systems shall not be disturbed.		Country side of embankment in the buffer zone	During the construction phase as well as operation phase	Included in construction cost	Engineering team and contractor/WRD Field Officer	WRD and AIFRERM Agency
		Institutional support in wetlands and other water bodies shall be enlarged and deepened		Southern part of the reach	During the construction phase as well as operation phase	Included in construction cost	WRD (Environmental Officers)	WRD and AIFRERM Agency
		Adequate provisions shall be made in engineering design to withstand extreme meteorological and geo-physical events		Proposed embankment	During the detailed engineering design stage	Included in engineering design cost	Design Team and WRD	WRD and AIFRERM Agency
Drainage system	Embankment acts like a barrier for the drainage of accumulating country side water into the Brahmaputra during monsoon season.	Provision shall be made to the extent possible not to obstruct the natural drainage. WRD/ local authorities shall modify the drainage system and rehabilitate the drains		Entire project area	During the detailed engineering design stage	Included in engineering design cost	Engineering Team	WRD and AIFRERM Agency
Upstream and downstream effects on river morphology	Reduction of flood absorption due to the flood plains of the reach Impact on charlands near to bankline	Erosion monitoring shall be carried out downstream as well. In case of impact on fringe areas of char, passive type of measures like porcupine screens shall be used.		Entire project area	Operation Phase	Monitoring Costs included under Monitoring Costs Included in engineering design cost.	WRD Field Officer	WRD and AIFRERM Agency

Activity	Environmental Issue/ Component	Remedial Measures	Legislative Requirement/ Framework	Approximate Location	Time Frame	Mitigation Cost (Rs.)	Institutional Responsibility	
							Implementation	Supervision
Effect on flow velocity/ discharge intensities	No significant change due to project intervention	Monitoring of flow shall be carried out at regular intervals using field data as well as satellite remote sensing data.		At upstream and in between the reach	During the lifespan of the project	Part of Engineering Cost	Engineering Team	WRD and AIFRERM Agency
Silt deposition and bed level change	Prevention in silt deposition on agricultural land due to breach of embankments	Monitoring of anti-erosion and river training works at regular intervals		At upstream and in between the reach	During the lifespan of the project	WRD shall take initiative	WRD	WRD and AIFRERM Agency
Impacts from external factors such as climate change, upstream dam construction, and watershed development	Design parameters may need to be changed over the years Impacts may include reduced discharge, artificial change in discharge volumes, reduced sediments	Systematic monitoring of hydrology, morphology, and sediment transport with acquisition of data Establishment of information network of discharges from upstream reservoirs Developing capacities in WRD to cope with changes in environment		Subproject reach in particular, but also include basin wide information and tributaries	During the lifetime of the project	Included in data and knowledge development component of IFRERM ASSAM	WRD	WRD and AIFRERM Agency
Impacts of morphological changes to subproject areas	Upstream and downstream erosion process may affect the sustainability of subproject structures	Systematic monitoring of morphology and sediment transport, with establishment of short term prediction models Preparation and implementation of protection measures to prevent outflanking		Subproject reach in particular, but also include basin wide information and tributaries	During the lifetime of the project	Included in data and knowledge development component of IFRERM ASSAM	WRD	WRD and AIFRERM Agency

Activity	Environmental Issue/ Component	Remedial Measures	Legislative Requirement/ Framework	Approximate Location	Time Frame	Mitigation Cost (Rs.)	Institutional Responsibility	
							Implementation	Supervision
		of structures						
Water quality	Impact on surface and ground water quality	Adequate supply of drinking water to workers.	The Water (Prevention and Control of Pollution) Act, 1974 and amendments thereof	At construction camps and construction sites	During construction phase	3,60,000	Contractor	WRD and AIFRERM Agency
	Contamination of water due to construction waste	Septic tanks shall be provided to treat the domestic sewage from construction camps.		At construction camps	During construction phase			
		Provision of mobile toilets for use at flood platforms		At high altitude areas	During Operation Phase	Included in construction cost	WRD Field Officer	WRD and AIFRERM Agency
	Contamination of water from fuel and lubricants	Construction work close to the channels or other water bodies to be avoided.			During construction phase	--	WRD Field Officer	WRD and AIFRERM Agency
		All necessary precautions to be taken to construct temporary devices to prevent water pollution due to increased siltation and turbidity.			During construction phase	Included in construction cost	Contractor	WRD and AIFRERM Agency
		Oil and grease traps to be provided at fuelling locations, to prevent contamination of water.		Fuel handling and workshop areas	During construction phase	Included in construction cost	WRD Field Officer	WRD and AIFRERM Agency
		Slopes of embankment leading to water bodies to be modified and		Along the reach	During construction phase	Included in construction cost	WRD Field Officer	WRD and AIFRERM Agency

Activity	Environmental Issue/ Component	Remedial Measures	Legislative Requirement/ Framework	Approximate Location	Time Frame	Mitigation Cost (Rs.)	Institutional Responsibility	
							Implementation	Supervision
		screened so that contaminants do not enter the water channel/ water body.						
		Water quality to be monitored as envisaged in the environmental monitoring plan.		As per monitoring plan	During construction phase	Included in the monitoring costs	WRD (Environmental Division)	WRD and AIFRERM Agency
	Discharge of domestic effluents from Dibrugarh town and villages to the river	Sanitation facilities shall be provided		Entire Project Benefit Area	Operation Phase	WRD to Initiate with concerned civic authorities	WRD (Environmental Division)	WRD and AIFRERM Agency
Air Environment	Change in air quality due to construction activities	Approach roads shall be paved and widened	Environmental Protection Act, 1986; The Air (Prevention and Control of Pollution) Act, 1981 and amendments thereof	Approach roads to construction sites	At the start of construction activity	Included in construction cost	Contractor/ WRD	WRD and AIFRERM Agency
		All slopes and embankments to be turfed as per best engineering practices to minimize the dust generation		Construction area	During construction phase	Included in construction cost	Contractor	WRD and AIFRERM Agency
		All the machinery and plants to be placed at the downwind direction with respect to human settlements.			Construction period	Included in construction cost	Contractor	WRD and AIFRERM Agency
		All vehicles, equipments and machinery used for construction to be regularly maintained.		Workshop areas	Construction period	Included in construction cost	Contractor	WRD and AIFRERM Agency

Activity	Environmental Issue/ Component	Remedial Measures	Legislative Requirement/ Framework	Approximate Location	Time Frame	Mitigation Cost (Rs.)	Institutional Responsibility	
							Implementation	Supervision
		The hot mix plants, crushers and batching plants to be sited at least 500 m in the downwind direction from the nearest human settlement.			At the start of construction activity	Included in construction cost	Contractor	WRD and AIFRERM Agency
		Hot mix plants shall comply with applicable National/State Pollution Control Board Standards fro emissions from hot mix plants.						
		Fugitive emissions from handling of construction material, storage as well as from transportation shall be taken care.		Construction and storage sites	During the construction period	Included in construction cost	Contractor	WRD and AIFRERM Agency
		Dust Suppression by water sprinkling		Construction and storage sites	Duringing the construction period	Included in construction cost	Contractor	WRD and AIFRERM Agency
		Monitoring of Ambient Air Quality		near sensitive locations/ human settlements near to construction sites, crushers and hotmix plants	During the construction period as per environmental monitoring plan	Included in the monitoring costs	WRD (Environmental Officer)	WRD and AIFRERM Agency
		Speed restriction, surface improvement and surface treatment shall be taken as options for control of		Approch roads	During the construction period	Included in project cost	WRD (Environmental Officer)	WRD and AIFRERM Agency

Activity	Environmental Issue/ Component	Remedial Measures	Legislative Requirement/ Framework	Approximate Location	Time Frame	Mitigation Cost (Rs.)	Institutional Responsibility	
							Implementation	Supervision
		emissions from unpaved roads.						
	Change in air quality due to traffic	Plantation along the embankment Turfing of the embankment slopes Regular maintenance of the road on the top of embankment as well as approach roads		Entire Project Area	Operation Phase	Included as part of regular Maintenance costs	WRD (Environmental Officer)	WRD and AIFRERM Agency
Noise	Increase in sound pressure levels due to construction machineries, vehicles etc.	Options of noise control by site controls, scheduling of project activities	Noise Pollution (Regulation and Control) Rules, 2000 and amendments thereof	At all construction sites	During the construction period	Included in engineering cost	Contractor	WRD and AIFRERM Agency
		Protection devices (ear plugs or ear muffs) to be provided to the workers operating in the vicinity of high noise generating machines.		At all construction sites of high noise intensities	During the construction period	Part of Contractor Obligation	Contractor	WRD and AIFRERM Agency
		Construction equipments and machinery shall be fitted with silencers and maintained accordingly.		Construction sites	At the start of construction activity and also during the construction phase	Included in construction cost	Contractor	WRD and AIFRERM Agency

Activity	Environmental Issue/ Component	Remedial Measures	Legislative Requirement/ Framework	Approximate Location	Time Frame	Mitigation Cost (Rs.)	Institutional Responsibility	
							Implementation	Supervision
		Construction of temporary noise barriers near the sensitive areas, e.g. schools		At identified sensitive locations near the construction sites	Before start of construction activities near sensitive locations	Included in construction cost	Contractor	WRD and AIFRERM Agency
		Noise and vibration level monitoring as per monitoring plan.		As per monitoring plan	Once in every year	Included under Monitoring Costs	WRD (Environmental Division)	WRD and AIFRERM Agency
	Increase in sound pressure levels due to traffic	Adequate signage to restrict use of pressure horns particularly in noise sensitive locations ❖ Tree barriers between the road and village/ semi urban/ and urban areas						WRD and AIFRERM Agency
Disturbance to vegetation	Cutting of trees in core zone during project intervention	Minimization of tree cutting while designing the embankment		Entire project site	During complete construction phase	--	Engineering Team	WRD and AIFRERM Agency
		Compensatory tree plantation preferably on the basis of 3 trees plantation against each tree cut		Entire project site and nearby areas	Starting from construction phase	Already indicated above	WRD (Environmental Division)	WRD and AIFRERM Agency
Animal distribution/ migratory route and Endangered Species	Impact on fish breeding sites No Adverse Impact of Endangered Species	Construction activities shall be restricted during fish breeding period (May to August) at breeding sites. Due to sensitivity of Dolphins with polluted		Identified breeding sites	During construction phase		WRD (Environmental Division)	WRD and AIFRERM Agency

Activity	Environmental Issue/ Component	Remedial Measures	Legislative Requirement/ Framework	Approximate Location	Time Frame	Mitigation Cost (Rs.)	Institutional Responsibility	
							Implementation	Supervision
		water, construction waste should not dumped near the river bank						
Fishing activities/ productivity, Migratory Route	Impact on boat ghats. No Migratory Route near the embankment	Adequate provision shall be made in the design to ensure access to the fish landing sites/ boat ghats		12 fish landing sites identified along the reach	During construction phase itself	Included in engineering design cost	Contractor	WRD and AIFRERM Agency
	Temporary flushing of fish species towards deeper parts of the river	Undisturbed movement of the fishermen shall be provided		Along the riverbank	During construction phase itself	Included in engineering cost	WRD (Environmental Division)	WRD and AIFRERM Agency
Spawning and Breeding Grounds/Pond Fisheries	Disturbance on breeding and spawning grounds. No Adverse Impact on Pond Fisheries	Restriction of construction activities near the identified breeding and spawning grounds during the breeding period of april to august Fish productivity can be improved substantial with use of better fish culture and increasing the capacity of fish ponds		At identified spawning and breeding grounds	During April to august in construction phase	--	Contractor	WRD and AIFRERM Agency
Wetlands/ beels	Positive impact	Due to various institutional measures proposed		Project Benefit Area	Operation Phase	--	WRD	WRD

Activity	Environmental Issue/ Component	Remedial Measures	Legislative Requirement/ Framework	Approximate Location	Time Frame	Mitigation Cost (Rs.)	Institutional Responsibility	
							Implementation	Supervision
Habitat fragmentation	Inappropriate opening of the sluice gate	Appropriate management to be made for the operation of the sluice gates		Project Benefit Area	Operation Phase	--	WRD	WRD and AIFRERM Agency
Demography	Pressure on natural resources due to establishment of construction camps	Construction camps shall be supported with all basic amenities such as drinking water, fuel, sanitation facilities etc.		Construction camps	During construction phase	Included in construction cost	Contractor	WRD and AIFRERM Agency
Establishments	Impact on houses and establishments near core zone	Efforts shall be made to prevent any relocation or demolition		Near embankment sites	During construction phase	Included in R and R Cost	Contractor	WRD and AIFRERM Agency
		Social infrastructure shall be rehabilitated with social and cultural values		Near embankment sites	During construction phase	Included in construction Costs	WRD	WRD and AIFRERM Agency
		Temporary noise barriers shall be installed close to schools and places of worship		Near identified sensitive sites	During construction phase	Included in construction Costs	WRD	WRD and AIFRERM Agency
		Thick plantation shall be made close to these establishments		Near identified sensitive sites and human settlements	During construction phase	Already included above	WRD	WRD and AIFRERM Agency
Socio-economic impact	Impact on fish landing sites	Training programmes for agriculture and fish production improvement		Project buffer zone	During construction phase	Already included above	WRD	WRD and AIFRERM Agency

Activity	Environmental Issue/ Component	Remedial Measures	Legislative Requirement/ Framework	Approximate Location	Time Frame	Mitigation Cost (Rs.)	Institutional Responsibility	
							Implementation	Supervision
		Appropriate provisions shall be made to provide alternate fish landing stations so that economic activities of the fishermen can not disturb during project intervention		Identified fish landing sites	During construction phase	Included in construction cost	Contractor/ WRD	WRD and AIFRERM Agency
Safety	Risk of accidents and safety due to narrow roads and encroachment of people near construction areas	Adequate lighting and fluorescent signage shall be provided at construction sites.		Construction sites and approach roads	During construction phase	Included in construction cost	Contractor	WRD and AIFRERM Agency
		Signage in local language		Construction sites and approach roads	During construction phase	100,000	Contractor	WRD and AIFRERM Agency
		Setting up of speed limits and speed breakers		Construction sites and approach roads	During construction phase	50,000	Contractor	WRD and AIFRERM Agency
		Personal protective equipments for workers		At construction sites	During construction phase	Included in construction cost	Contractor	WRD and AIFRERM Agency
		Health check up camps for workers		At construction camps	During construction phase	6,00,000	WRD (Environmental Division)	WRD and AIFRERM Agency

APPENDIX 7.3: MITIGATION MEASURES IMPLEMENTATION SCHEDULE

Environmental Issue	EMP	Time line															
		Construction Phase					Operation Phase										
		1	2	3	4	5-6	1	2	3	4	5	6	7	8	9	10	11 -
Technical Support	Preparation of environmental guidelines																
Flora	Compensatory aforestation (minimum 1:3) (plantation and maintenance for one year)																
Agriculture	Technical support to farmers																
	Monitoring of cropping pattern																
Fisheries	Institutional support for productivity improvement for Wetland, beel, and pond fisheries																
	Monitoring of fisheries, breeding and spawning grounds																
	Maintenance and operation of sluice gates																
Drainage Congestion	Provision of adequate opening																
	Monitoring analysis of drainage congestion if any																
Hydrology and Morphology	River bank protection measures																
	Soil conservation																
	Monitoring of river erosion, water levels, and sediments																
Land	Compensation against land acquisition																
	Provision of access to riverbank near habitat areas, Construction of flood platforms																
	Rehabilitation of borrow areas																
Water & Drinking Water Supply	Installation of grease traps at construction sites																
	Construction of soak pits at construction sites																
	Monitoring of surface and ground water quality																
	Ensuring availability of arsenic free drinking water for construction camps																
Air Quality & Dust Management	Water spraying and watering																
	Monitoring of ambient air quality																
Work Safety	Provision of personal protective equipment																
Health Issues	Health checkup camps																
Tree & noise Barriers	Monitoring of tree felling and plantation																
	Maintenance of tree (additional two years)																
	Provision of additional tree plantation																
	Provision of noise barriers																
	Monitoring of noise and vibration																
Establishments	Construction stage																
Training	Environmental training and awareness																
MIS	Establishment and operation																

Legends

- Critical
- High priority
- Medium priority
- Low priority

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APPENDIX 7.4: ENVIRONMENTAL MONITORING PLAN (EMOP)

Environmental Component	Project stage	Parameter	Standards	Location	Duration / Frequency	Cost (Rs.)	Implementation	Supervision
Terrestrial and aquatic fauna	Construction Stage	Surveillance Audit for status of fish species, theiri movement and breeding grounds	None specific	Near the identified spawning and breeding grounds along the reach	Prior to breeding season and during the breeding season (During construction stage)	200,000	Independent Fisheries Expert	WRD and AIFRERM Agency
	Operation Stage	Terrestrial and aquatic fauna status Benefit assessment of the support during the project as a whole	None Specific	Fish landing sites, breeding grounds and near the core zone of the embankment	First two years of construction	200,000	Independent Terrestrial and Aquatic Experts	WRD and AIFRERM Agency
Fisheries	Construction Stage	Fish productivity,	None Specific	Flood plains, beels, rivers and ponds	Once in a year throughout the construction phase	300,000	Survey by Fisheries Experts	WRD and AIFRERM Agency
	Operation Stage	Fish productivity	None Specific	Flood plains, beels, rivers and ponds	Once in a year	100,000	Survey by Fisheries Experts	WRD and AIFRERM Agency
Cropping Pattern	Construction and Operation Stage	Survey of existing cropping pattern and effect of change in cropping pattern in the impacted areas	None Specific	Construction areas, service areas, rehabilitation sites	Once during construction and once after six months of completion of project	Project Management Costs	Institutional support	WRD and AIFRERM Agency

Environmental Component	Project stage	Parameter	Standards	Location	Duration / Frequency	Cost (Rs.)	Implementation	Supervision
Air Quality	Construction Phase	SPM, RSPM, SO2, NOx, CO, Pb	National Ambient Air Quality Standards	With in 100 m of Hot mix plant, construction camp, crusher and near sensitive locations/ settlement	Continuous 24-hourly, twice a week, for two weeks once every year (summer)	750,000 (@RS 1,25,000/year for six year)	Independent Environmental Laboratories approved by SPCB/ MoEF	WRD and AIFRERM Agency
	Operation Phase	SPM, RSPM, SO2, NOx, CO, Pb	National Ambient Air Quality Standards	3 to 4 locations near the embankment sites	Continuous 24-hourly, twice a week, for one week, once in winter and Summer	50,000	Independent Environmental Laboratories approved by SPCB/ MoEF	WRD and AIFRERM Agency
Surface Water Quality	Construction Stage	pH, BOD, COD, TDS , TSS, DO, Oil and Grease	As per CPCB Water Quality Criteria	Brahmaputra River and wetlands/ ponds	Once during the dry season.	300,000 (@ Rs 50,000/year for six year)	Independent Environmental Laboratories approved by SPCB/ MoEF	WRD and AIFRERM Agency
	Operation Phase	pH, BOD, COD, TDS , TSS, DO, Oil and Grease	As per CPCB Water Quality Criteria	Brahmaputra River and wetlands/ ponds	Once during the dry season.	30,000	Independent Environmental Laboratories approved by SPCB/ MoEF	WRD and AIFRERM Agency
Ground water and Drinking Water Quality	Construction Stage	pH, BOD,DO, total coliform, As, Cd, Mn and Ground Water levels	As per IS 10500:1991	Construction site, Rehabilitation site, service areas,	Once at the start of construction	30,000	Independent Environmental Laboratories approved by SPCB/ MoEF	WRD and AIFRERM Agency
	Operation Phase	pH, BOD,DO, total coliform, As, Cd, Mn and water levels	As per IS 10500:1991	Construction site, Rehabilitation site, service areas,	Once at the start of construction	30,000	Independent Environmental Laboratories approved by SPCB/ MoEF	WRD and AIFRERM Agency
Noise and Vibration	Construction Phase	Noise Level in dB (A)	As per National Standards for Noise	Near the construction sites and sensitive locations close to embankment	One day hourly measurement, once in six months	30,000	Independent Monitoring Agency	WRD and AIFRERM Agency

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Environmental Component	Project stage	Parameter	Standards	Location	Duration / Frequency	Cost (Rs.)	Implementation	Supervision
	Operation Phase	Noise Level in dB (A)	As per National Standards for Noise	Near the habitats close to embankment	One day hourly measurement at 3-4 locations once	10,000	Independent monitoring agency	WRD and AIFRERM Agency
Soil Erosion (inland erosion) and siltation	Construction Phase	Visual check for Soil erosion and siltation	--	River bank and River training Structure	After first precipitation	Part of routine action of engineering team	Engineering Team	WRD and AIFRERM Agency
	Operation Phase	Study of Soil erosion and siltation	--	River Training Structure, Up stream and Down Stream of the reach	Once during operation of 1st year	Part of routine action of Engineering Team	Engineering Team	WRD and AIFRERM Agency
Drainage Congestion	Construction Phase	Visual check	--	Project benefit area	After one year of construction.	Part of routine action of Engineering Team	Engineering Team	WRD and AIFRERM Agency
	Operation Phase	Visual check	--	Project benefit area	Once during operation of 1st year	Part of routine action of Engineering Team	Engineering Team	WRD and AIFRERM Agency
River Hydrology, Morphology and Sediment Transport	Construction Phase	Scientific techniques applicable to the monitoring of these components	-	Entire Sub-project area	Regular	Part of routine action of Engineering Team	Engineering Team	WRD and AIFRERM Agency
	Operation Phase	Scientific techniques applicable to the monitoring of these components	-	Entire Sub-project area	Regular	Part of routine action of Engineering Team	Engineering Team	WRD and AIFRERM Agency
Tree Plantation	Construction Phase	Surveillance monitoring of trees felling	As laid out in the detailed design for project	Entire stretch of the project reach	During site clearance in construction phase	600,000	WRD Field Officers	WRD and AIFRERM Agency

Environmental Component	Project stage	Parameter	Standards	Location	Duration / Frequency	Cost (Rs.)	Implementation	Supervision
	Operation Phase	Survival rate of trees success of re-plantation	The survival rate should be at least 70% below which re-plantation shall be done.	Entire stretch of the project reach	Every year for 3 years	300,000	WRD Field Officers with the help of Social Forestry Programme	WRD and AIFRERM Agency
Total Costs of monitoring construction stage						**Rs22,10,000**		
Total Costs of monitoring operation Stage						**Rs7,20,000**		
Transportation for sample collection, contingencies and other logistic support (Rs. 2,00,000 construction stage, and Rs 1,00,000 Operation stage)						**Rs. 300,000**		
Total cost of monitoring						**Rs. 3,230,000**		

APPENDIX 7.5: TRAINING [1]

No.	Target group	Subject(s)	Method	Time Frame
Planning, and Construction Phase[2]				
1	All WRD program staff	**Environmental Overview:** Environmental regulations and national standards, process of impact assessment and identification of mitigation measures, importance of EMP and monitoring, and monitoring methodology	Lectures (by consultants and local training institutes)	Before implementation of the program
2	Environmental engineers, field officers, contractors, supervision consultants	**Implementation of EMPs:** Basic features of an EMP, planning, designing and executing of environmental mitigation and enhancement measures, monitoring and evaluation of environmental conditions during construction and operation	Workshops and seminars (by consultants and trained PMU staff)	Before the construction begins
3	Environmental engineers, field officers, contractors, supervision consultants	**Environmentally Sound Construction Practices:** Soil conservation; vegetation protection; waste management and minimization in construction; pollution control at construction camps, construction sites, hot mix plants, and material transportation; devices and methods for construction sites and equipment; environmental clauses in contract documents and their implications; environmental monitoring during construction	Seminars, lectures and site visits (by consultants and trained PMU staff)	Before the construction begins
4	Environmental engineers, field officers, contractors, supervision consultants	**Monitoring Environmental Performance during Construction:** Monitoring air, water, soil erosion, noise, and their effect on vegetation and fisheries; evaluation and review of results; performance indicators and their applicability; possible corrective actions; reporting requirements and mechanisms	Lectures, workshop, and site visits (by consultants and trained PMU and SIO staff)	During initial phases of construction
5	Construction laborers	**Waste Handling and Sanitation at Construction Sites and Construction Camps:**	Workshops and signage (by consultants and trained SIO staff)	During initial phases of construction

[1] The training programs are to be conducted through in house trainers and hired consultants/professionals. The train the trainer mode delivery may also be considered for in house training capacity development.

[2] During construction phase training/awareness programs will be organised twice a year. During operational phase one workshop/awareness program should be organised every year for the first 3 years. This workshop should highlight the details of environmental condition monitored and tips for environmental protection.

No.	Target group	Subject(s)	Method	Time Frame
During Operation Phase				
6	Environmental engineers, field officers, contractors	**Long-Term Environmental Issues in Program Management:** Designing and implementing environmental surveys for ambient air, noise, biological, and water quality; data storage, retrieval, and analysis; contract documents and environmental clauses; risk assessment and management; contingency planning and management; and value addition	Workshops and seminars (by consultants and local trainint institutes	During implementation of the program
7	Farmers of the area program benefit area, fishers associated with beel and pond fisheries	Cropping Pattern and high yielding crop production techniques	Workshops and seminars (by consultants, and resource persons from research institutes and line departments)	Construction and operations phase
8	Public	Environmental protection awareness program	Workshops and seminars (by consultants and trained PMU and SIO staffs)	Construction and operations phase

EMP = environmental management plan, PMU = program management unit, SIO = subproject implementation office, WRD = Water Resources Department.

Source: Water Resources Department, State Government of Assam.

APPENDIX 7.6: ENVIRONMENTAL BUDGET

Component	Item	Unit	Quantity	Rate	Amount (million Rs)
CONSTRUCTION STAGE					
Technical Support	• Preparation of Environmental guidelines and performance indicators	Lumpsum	-	Rs 0.5 million	0.50
Flora	• Clearing of plantation	km		Covered in engineering costs	
	• Compensatory afforestation (Minimum 1:3) (Plantation and maintenance for one year)	No of tree	45000for Palasbari	Rs. 20 per sampling and RS 500 for maintenance	23.40
			6000 for Kaziranga	Rs. 20 per sampling and RS 500 for maintenance	3.12
			30,000 for Dibrugarh	Rs. 20 per sampling and RS 1500 for maintenance	15.60
	• Technical Institutional Support to farmers for change in cropping pattern and monitoring agriculture productivity	Lump sum		Included in the overall project management costs	
Fisheries	• Intuitional support for Improving fish productivity at wetlands/beel and pond fisheries.)	Rupees per /reach	3 reaches	Rs 1.0 million per reach	3.00
	• Monitoring of Fish Productivity	Rupees per /reach	3 reaches	Rs 0.4 million per reach	1.20
Drainage Congestion	• Provision of adequate opening	Covered in engineering cost			
Navigation	• Adequate lighting & Signals	Covered in engineering cost			
Erosion & Sedimentation	• River Bank Protection Measures	Covered in engineering cost			
Land	• Compensation against land acquisition and Development of Rehabilitation sites	Covered in R&R Budget			
Soil	• Maintenance cost in Soil Conservation	Covered in engineering cost			
Noise	• Provision for Noise Barriers	Covered in engineering cost			
Water	• Installation of oil and grease traps at construction sites and Waste Water Collection & Disposal system	No	4 per reach for three reaches	0.080 million/system	0.96

Component	Item	Unit	Quantity	Rate	Amount (million Rs)
	• Construction of soak pits at construction sites	No	4 per reach	Rs 0.090 million/soak pit	1.08
Dust Management during construction	• Water Sprayer / Watering	Covered in Engineering cost			
Construction Safety	• Accident risks in construction activity	Covered in Engineering cost/insurance			
	• General Safety (provision of PPE like ear muffs, gloves etc.)	No of labour	Av. 1000 labourer/reach	Average 100/labour/year for construction period or six years	To be part of contractors costs
Health	• Health check up camps for construction workers	camps	1camp/year/reach	Rs 0.1 million/camp for six years	1.80
Environmental Monitoring in the construction phase	• Terrestrial and Aquatic Fauna including Fisheries • Cropping Pattern • Ambient air quality • Surface Water Quality • Ground Water /Drinking Water Quality • Noise & Vibration • Soil Erosion & Siltation • Drainage Congestion • Monitoring Tree Felling & Plantation	Cost as mentioned in monitoring plan. Monitoring Costs considered on an average same for each reach. (@ Rs 2.41 Million per reach for entire construction period)			7.23
		SUB TOTAL (CONSTRUCTION STAGE)			57.89
OPERATION STAGE					
Erosion Control and land scaping	• Reserve Fund for Erosion Control and Embankment Protection.	Lump Sump	- To be part of Regular maintenance and operation costs		-
Tree survival	• Survivance monitoring and Provision of additional tree plantation	Lump sum	Costs towards survival monitoring are included in the Monitoring budget.		3.00
Monitoring of performance indicators	• Terrestrial & Aquatic Fauna including Fisheries • Ambient air quality	Cost as mentioned in the Monitoring plan Monitoring Costs considered on an average same for each reach. (@ Rs 0.82 Million per			2.46

Component	Item	Unit	Quantity	Rate	Amount (million Rs)
	• Surface Water Quality • Ground Water Quality & Levels • Noise & Vibration • Soil Erosion & Siltation • Drainage Congestion • Monitoring Tree Plantation and Cropping Pattern	reach for entire construction period)			
		SUB TOTAL (OPERATION PHASE)			5.46
ESTABLISHMENT & TRAINING					
Establishment	• Construction Stage	Per son month s	12	Rs 75,000 per person month + plus expert advise support lumpsum Rs 1.0 Million	1.90
	• Operation Stage	Per son Month s	15	Rs 75,000 per person month (@ 2 person month for five years and one person months for additional five year) plus additional experts support lumpsum Rs 0.5 million	1.60
Training	• Environmental training & awareness	Lump sum	As per training details	-	3.00
Management Information System		Lump sum	-	-	1.00
Subtotal (Establishment & Training)					7.50
Subtotal (Construction, And Operation And Mobilization)					70.85
Contingencies @ 10 % on total environmental costs					7.09
Grand Total (in Rs)					77.94
Grand Total (in US$) (@ 1 US $ = Rs. 40.10)					US $1.94 Million

APPENDIX 8.1: SUMMARY OF PUBLIC CONSULTATION

Date	Name and Address	Topic of Discussion	Important Outcome
2/12/2007	Dr. A. K. Baruwa, Director Assam Science, Technology and Environment Council And Assam Energy Development Board	1.Regarding any specific problem(s) related to environment as a result of flood and erosion of the Brahmaputra 2. If the proposed project will help in providing safety to the people , their property and environment of the area 3. Any significant negative impact of the project on the overall environment of the area 4. Possible impacts of the project on Agriculture,Wetlands, Drinking Water and Local Economy 5. Suggestion or comment on isssues other than those discussed so far	❖ He has raised concern of leaching of arsenic into groundwater which is generally used for drinking water supply from the river bank filtration wells in the floodplains of Brahmaputra River and also asked about the possibility of integration of drinking water and irrigation projects.
3/12/2007	Mr. B. B. Hagier (IAS) Secretary of Environment and Forests, Government of Assam		❖ He has pointed out requirement of study of impact downstream and upstream of the reach which can be affected after protection of the reach.
3/12/2007	Mrs. E. Choudhary (IAS) Principal Secretary Soil Conservation Government of Assam		❖ She has raised the issues of bed level raising, seepage of embankment/ softening of embankment, erosion and increase in sedimentation as well as the requirement of catchments area treatment plan. She also revealed the requirement of soil conservation, study of earthquakes and its effect on siltation in the river.
2/12/2007	Mr. Biren Thukuria EE, WRD		❖ He has highlighted the importance of study for impact on fish productivity due to reduced siltation, which can emerge as a benefit to local fishermen.
25/04/2008	Dr. Rafiqua Ahmed State Pollution Control Agency, Assam		❖ She has highlighted the problem of water contamination in some parts of the Brahmaputra River valley. She was also asked for the pollution problems in the sub-project reaches.
3/12/2007	Mr. Md. Allauddin Department of Minority Welfare		❖ Most of the chars in Brahmaputra are semi-permanent and as per their record there are 2,251 char villages. ❖ Drinking water is mainly supplied from the hand pumps and tubewells. The department also supports in the form of seed distribution, construction of raised platforms with and without sheds, repairing of schools, vocational training to local villagers
19/5/2008	Chief Conservatory	Related to tree cutting, aforestation	❖ Prior permission is needed from the Chief Conservator of Forests

Date	Name and Address	Topic of Discussion	Important Outcome
	of Forests	programme etc.	(Wildlife) for cutting of trees within the boundary demarcated as wildlife sanctuaries and national parks. If land is outside the protected areas, then the permission is not necessary from CCF or Forest Department. However, afforestation is needed if there is any loss of tree species during project intervention. ❖ At least three plants must be planted in place of one such tree cut during project intervention. ❖ For afforestration programme, bamboo, simul trees and banana plants must be planted along the side of embankment. These trees have no side roots to destroy the embankments. Again in the borrowing sites water resistant plants such as Salix tetrasperma, Buwal and Pani hizol should be planted.
3/3/2008	Dr. B. K. Talukdar Co-chair (South Asia) IUCN-SSC Asian Rhino Specialist Group	1.Regarding any specific problem(s) related to environment as a result of flood and erosion of the Brahmaputra 2. If the proposed project will help in providing safety to the people , their property and environment of the area 3. Any significant negative impact of the project on the overall environment of the area 4. Possible impacts of the project on Agriculture,Wetlands, Drinking Water and Local Economy 5. Suggestion or comment on isssues other than those discussed so far	❖ All the NGOs' consulted had welcomed the flood control project and said that it will help in protection of agricultural land, domestic animals, fishermen communities etc. ❖ They also highlighted the importance of maintaining the natural drainage along the project sites. The NGOs during interaction also highlighted the relief work they are carrying out during the flood situations. ❖ They also suggested increasing forest cover through afferoestation programme. Dr Sanjay Hazarika also indicated the need of enhancing institutional capacity and strengthening review mechanism. ❖ Prevent any change to natural drainage. ❖ Consider provision of alternate platform then only attached to embankment for use by Animals and people during flood and protection of the fish spawning grounds during construction and operation.
5/3/2008	Mr. Mintu Handique and Mr. Gaurav Borgohain, Carrier Care Group		
10/3/2008	Mr. Sanjay Hazarika CE-NES		
28/03/2008	Mrs. Janti Gohain Kumar Gaon P.O. Gorpara Dekom, Dibrugarh	1.Regarding any specific problem(s) related to environment as a result of flood and erosion of the Brahmaputra 2. If the proposed project will help in providing safety to the people , their property and environment of the area	❖ We welcome the project as it will benefit the complete area. The town and the tea industry will be saved. No adverse effect anticipated as of now, however, the affected people should be properly compensated. ❖ The project will provide safety to the town and help it prosper. The tea industry and the agricultural lands will be protected. ❖ This is a valuable project to be taken up by the Government. It will provide safeguard to the town and tea industry.

Date	Name and Address	Topic of Discussion	Important Outcome
		3. Any significant negative impact of the project on the overall environment of the area 4. Possible impacts of the project on Agriculture,Wetlands, Drinking Water and Local Economy 5. Suggestion or comment on isssues other than those discussed so far	❖ No ill effect can be thought of. The work needs to be implemented urgently. ❖ People affected should be properly and promptly rehabilitated and/ or compensated. ❖ The project will protect the town and neighboring areas from erosion and flooding. Those affected by the project should be given due compensation before starting the work. ❖ The project will protect the town and adjoining areas from erosion and flood. Government should take up the work. All affected people should get due compensation before the project takes off. There will be no adverse impact seen if properly executed.
	Allaudin Ahmed Paach Ali P.O.- Dibrugarh Assam		
	Mukta Bori Paach Ali P.O. Dibrugarh Assam		
	G. Kalita Paach Ali Dibrugarh		
	P. Gogoi Near water Pump Dibrugarh		
29/02/2008	Dilip Munda Koylaghat (inside the existing embankment) Profession: Tea Labour	1.Regarding any specific problem(s) related to environment as a result of flood and erosion of the Brahmaputra 2. If the proposed project will help in providing safety to the people , their property and environment of the area 3. Any significant negative impact of the project on the overall environment of the area	❖ The proposed embankment project is essential for the local people. It will help a lot to entire people of the area. The existing embankment is in very bad shape, and hence, new permanent embankment is requiring. There are many permanent houses inside the embankment, but, if government will provide us monitory help, then we will vacate the land for project. ❖ If the land and property of the people has been lost during the embankment project, then they should be compensated accordingly. ❖ The fishermen community regularly fishes at Maijan Beel for their daily livelihood. Maijan beel is the lifeline of these people. Hence, it should not be disturbed during embankment project. If the project did not harm

Date	Name and Address	Topic of Discussion	Important Outcome
		4. Possible impacts of the project on Agriculture,Wetlands, Drinking Water and Local Economy 5. Suggestion or comment on isssues other than those discussed so far	the beel then the local people do not have anything to say. ❖ The natural beel and its water feeding cannels should be preserved as it is, because these are the main routes of re-colonization of living biota and the beels are the lifeline for most of the rural people. ❖ It the land and property of the people has been lost during embankment project, then that should be compensated. ❖ The proposed embankment is welcomed because it will help to protect the entire Dibrugarh city and as well as Tea Estates. The present embankment of the river is very weak, so it will create havoc if it will break down and washed away entire city people. The construction of proposed embankment is timely thinking and quite appropriate. ❖ Government is doing good job by constructing a new embankment. The permanent embankment at Dibrugarh township is inevitable to protect the city and people from flood. ❖ The people showed their support to the initiative of the government. They told that almost 20 villages can be saved from flood if embankment will be constructed. Apart from that they also highlighted the need of non-disturbance to aquatic habitat.
	Kamal Das Mohanaghat (inside existing embankment) Profession: farmer		
	Laxman Tati Maijan Tea Estate Profession: Fisherman		
	Pranoy Sarkar Phulbagan Profession: Tea labour		
	Abul Aziz Graham bazaar, Dibrugarh Profession: Tea		

Date	Name and Address	Topic of Discussion	Important Outcome
	Shop owner		
	Basant Ben, Shopkeepar Fulbagan Dibrugarh		
	Raman Thapa, Daily wager Tinikonia area		
	Bhabesh Kalita, Teacher Thakur bari Dibrugarh		
01/03/2008	Dinesh Kakati, Farmer. Thakur-bari	1.Regarding any specific problem(s) related to environment as a result of flood and erosion of the Brahmaputra 2. If the proposed project will help in providing safety to the people , their property and environment of the area 3. Any significant negative impact of the project on the overall environment of the area 4. Possible impacts of the project on Agriculture,Wetlands, Drinking Water and Local Economy 5. Suggestion or comment on isssues other than those discussed so far	❖ It will definitely help us for transportation and cultivation to other places. ❖ The people talked about their dependence on River Brahmaputra and told about the need of transportation through river with other parts. ❖ A few people had told that they do not have land for home and hence they are occupying the existing dyke. They told that government should provide them alternative place and compensation. ❖ If dyke will be constructed, then the people can do the cultivation peacefully, which is affected regularly every year due to flood. This will solve a great problem. ❖ The construction and renovation work is ok, but Government should not close the channel of beel with Brahmaputra
	Bhagirath Pegu Fisherman, Nagahooli		
	Madan Pegu Shopkeepar Nagahooli		
	Adar Barman Farmer, Pachali		
	Khagen Das Teacher, Koilaighat		
	Harilal Pegu Student, Koilaghat		

Date	Name and Address	Topic of Discussion	Important Outcome
	Kaliran Pegu Fishermen, Maizan Beel		
	Mihir Doley Worker, Oakland Tea Estate		

The three state-level workshop materials are available in the following website.

- 1st Workshop (1 December 2007 at Administrative Staff College of India, Guwahati)
  http://www.adb.org/Documents/Reports/Consultant/38412-IND/38412-IND-TACR.pdf

- 2nd Workshop (25 June 2008 at the Institute of Engineers Conference Hall, Guwahati)
  http://www.adb.org/Documents/Reports/Consultant/38412-IND/38412-01-IND-TACR.pdf

- 3rd Workshop (4 February 2009 at Brahmaputra Hotel, Guwahati)
  http://www.adb.org/Documents/Reports/Consultant/38412-IND/38412-02-IND-TACR.pdf

PHOTO DOCUMENTATION (PLATES)

Plate 1: Erosion at Dibrugarh

Plate 2: Erosion near Dibrugarh

Plate 3: Settlement at Embankment

Plate 4: Porcupine in use near Maijan wetland

Plate 5: Tea Garden near the erosion site

Plate 6: Public Consultation with villagers

Environmental Assessment Report

Environmental Impact Assessment
Project Number: 38412
June 2009

INDIA: ASSAM INTEGRATED FLOOD AND RIVERBANK EROSION RISK MANAGEMENT INVESTMENT PROGRAM

KAZIRANGA SUBPROJECT
(ADJACENT TO KAZIRANGA NATIONAL PARK)
GOLAGHAT DISTRICT

Prepared by the Water Resources Department of the State Government of Assam for the Asian Development Bank

CURRENCY EQUIVALENTS

(As of 1 June 2009)

Currency Unit – rupee (Re/Rs)
Re1.00 = $0.02122
$1.00 = Rs47.11

ABBREVIATION

ADB	–	Asian Development Bank
DMO	–	disaster management organization
EA	–	executing agency
EARF	–	environmental assessment and review framework
EIA	–	environmental impact assessment
EIRR	–	economic internal rate of return
EMOP	–	environmental monitoring plan
EMP	–	environmental management plan
FRERM	–	flood and riverbank erosion risk management
IUCN	–	International Union for Conservation of Nature
IWAI	–	Inland Water Transport Authority
KNP	–	Kaziranga National Park
MFF	–	multitranche financing facility
NGO	–	nongovernment organization
PMU	–	project management unit
PPTA	–	project preparatory technical assistance
SEIA	–	summary environmental impact assessment
SIO	–	subproject implementation office
SPCB	–	State Pollution Control Board
WRD	–	Water Resources Department

WEIGHTS AND MEASURES

dBA	–	decibel
Ha	–	hectare
Km	–	kilometer
km^2	–	square kilometer
m	–	meter
mm	–	millimeter
m^3/s	–	cubic meters per second

GLOSSARY

porcupine	–	Tetrahedron-shaped concrete frames commonly made of six concrete members, each 3 meters long connected with bolts, which are placed in an arrayed manner in the riverbed to retard river water flow and induce sedimentation.
revetment	–	A riverbank protection structure constructed on the bottom or banks of a river by placing a layer of material, such as rock, stones, concrete blocks, or mattresses including sand-filled geo-textile containers.
spur	–	A river training structure built from the bank of a river in a direction transverse to the current, by placing a large quantity of rocks, stones, or concrete blocks (or earth armored with these heavy materials).

NOTES

(i) The fiscal year (FY) of the Government of India ends on 31 March. FY before a calendar year denotes the year in which the fiscal year ends, e.g., FY2009 ends on 31 March 2009.

(ii) In this report, "$" refers to US dollars.

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1. INTRODUCTION

1. The Water Resources Department (WRD) of the state government of Assam, India engaged consultants to undertake an environmental impact assessment (EIA) of a multitranche financing facility (MFF) for the Assam Integrated Flood and Riverbank Erosion Risk Management Investment Program. The Program aims to enhance the effectiveness and reliability of flood and riverbank erosion risk management (FRERM) systems in three existing flood embankment systems (or subprojects) protecting urban, suburban, and other strategic areas of Assam: (i) Palasbari reach (74 kilometers [km]) in Kamrup (south) district; (ii) Kaziranga reach (29 km) in Golaghat district, adjacent to the Kaziranga National Park (KNP); and (iv) Dibrugarh reach (25 km) in Dibrugarh district. The Program also aims to strengthen the policy, planning, and institutional bases to support better FRERM operations. Comprehensive and adaptive structural and nonstructural FRERM measures will be provided in the three subproject areas. These are provided in two tranches during the 7-year implementation period, based on the local priorities.

2. The following presents the EIA undertaken to determine what are the likely significant environmental changes as a result of the project implementation, and if these changes are negative, what mitigation measures are included in the environmental management plan.

1.1. Background

3. The state government of Assam submitted an investment proposal to ADB in 2006 for strengthening key existing FRERM infrastructure along the vulnerable reaches of the Brahmaputra River that is protecting the vital economic, social, and ecological interests of the state. The Brahmaputra River is the main cause for erosion and flooding in the Assam. This river instability (river bank erosion and flooding) hampers development and poverty reduction in the state. In response to the proposal, Technical Assistance (TA No. 4896-IND) has been provided to WRD in two phases. Phase I (May through September, 2007) covered the strategy and options studies included in the pre–feasibility of four priority sites. Phase II (November 2007 through June 2008) included subproject option finalization and feasibility studies, institutional assessments, and project packaging.

1.2. IFRERM Assam Subproject Locations and Kaziranga Subproject

4. Under this TA, three most vulnerable reaches located in the State of Assam (Latitude 24°08' N & 27°59' N and Longitude 89°42' E & 96°01' E) along the bank of Brahmaputra River have been selected. The locations of the subproject reaches are (i) Majirgaon - Nagarbera (Palasbari Reach) in south bank of Kamrup district, (ii) Oakland-Bogibeel (Dibrugarh Reach) in Dibrugarh district, (iii) Bankoal-Moraiholla-Diffalupathar (Kaziranga Reach) in Golaghat district are shown in Figure 1.1: This report covers the EIA of subproject for the Kaziranga Reach.

1.3. Nature, Size and Location of Sub-Project: Kaziranga Reach

5. The proposed Bankoal-Moriaholla-Diffalupathar sub-project (Kaziranga Reach) is about 37.0 km long from Nikori PWD Road to Diffalupathar. The subproject will be implemented in two Tranches; Tranche 1 in general, focuses on controlling erosion while Tranche 2 will rehabilitate and strengthen existing flood control embankments. More specifically, Tranche 1 involves the construction of inner embankment to connect Diffalupathar to National Highway (NH) 37, construction of drainage sluices in Diffalupathar

– Moriaholla embankments, revetment/ pro-siltation measures in front of Krishibund and Moriaholla areas. Tranche 2 involves the rehabilitation and strengthening of dyke in Moriaholla area, rehabilitation and strengthening of dyke from Moriaholla to Diffalupathar, construction of drainage sluices in Diffalupathar – NH 37 embankments, and revetment/ pro-siltation measures in front of Krishibund. It is also planned to construct a paved road on the top of the embankment. Riverbank anti-erosion measures include revetment works to protect eroding embankments, bed bar/porcupine screen to promote siltation on critical areas, renovation of existing spurs and construction of boulder deflectors to influence river flow. The sub-project alignment is shown in Figure 1.2.

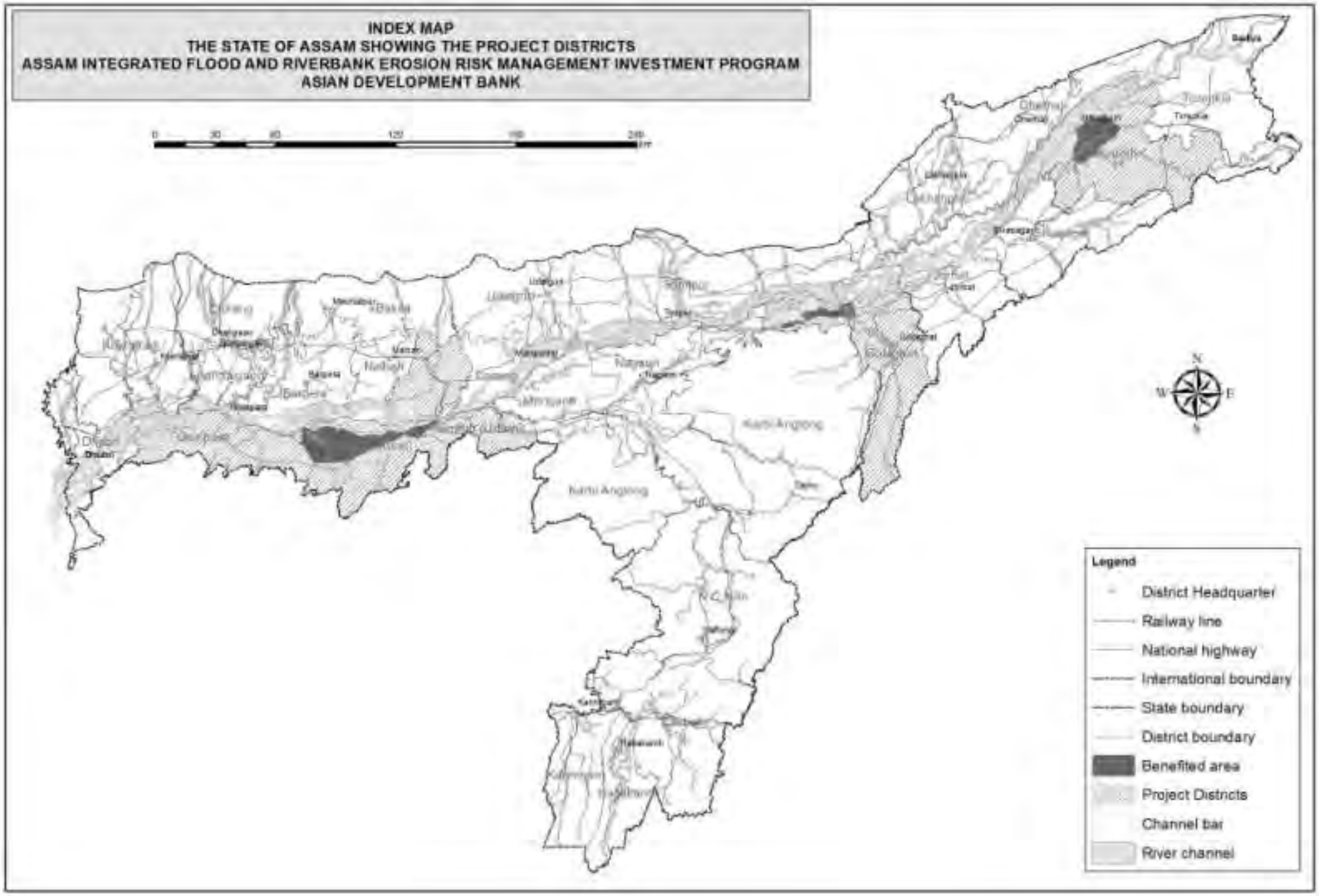


Figure 1.1 Location Map of the Project (Selected Sub-Projects)

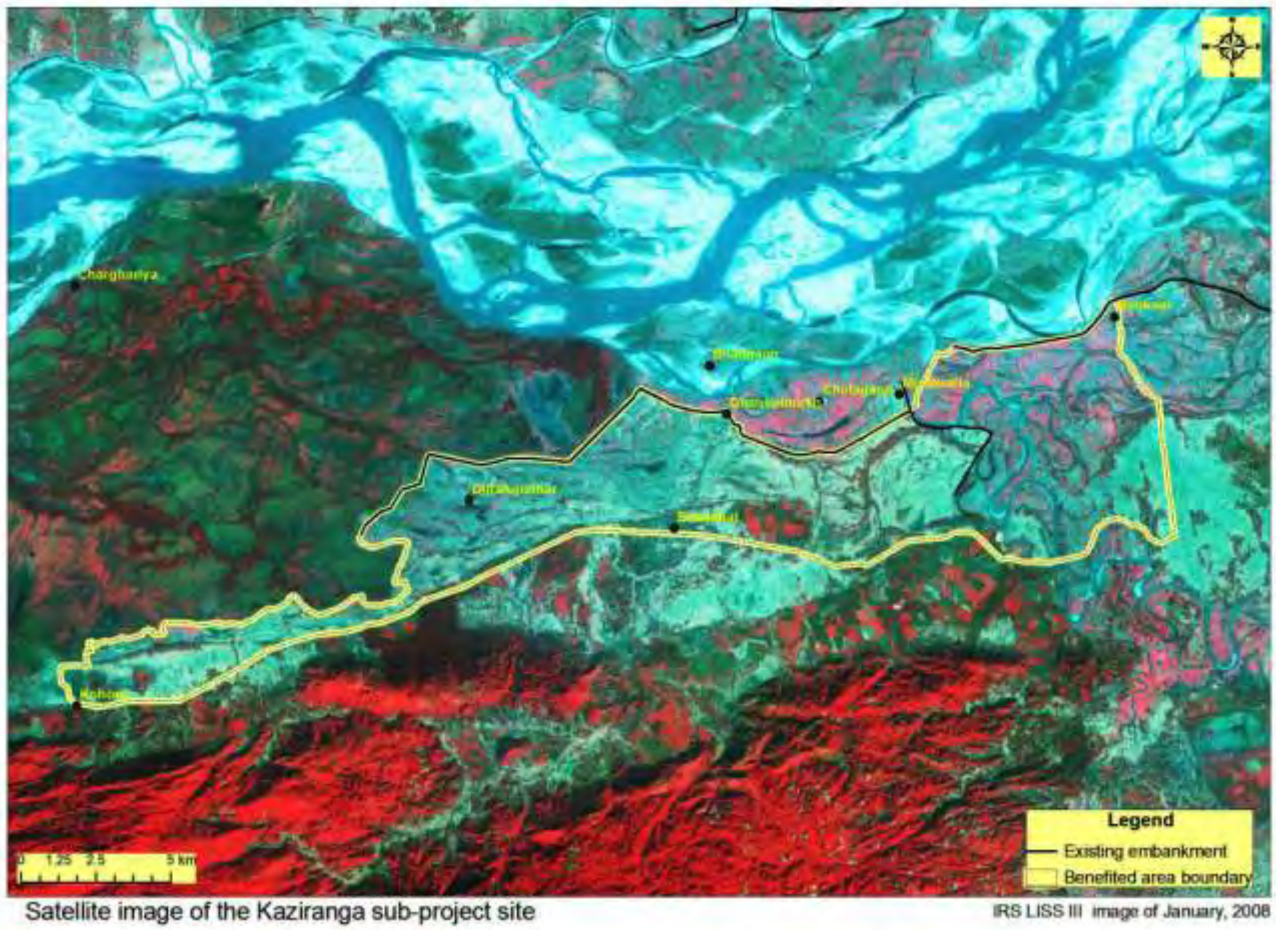


Figure 1.2 Location Map of the Sub-Project (Kaziranga Reach)
(IRS Image 2007)

1.4. Purpose of the Report

6. This report primarily focuses on the environmental impacts of the structural components of the IFRERM-Assam; public consultations conducted and recommended mitigation and monitoring measures.

7. The Subproject focuses on the Kaziranga Reach of the Brahmaputra River located in Jorhat District, about 300 kilometers (kms) away from Guwahati, and 400 kms away from the Bangladesh (Dubri) border. The sub-project area investigated under this study consists of 40,112 hectares of mostly agricultural, homesteads, and tea garden areas confined between elevation 75-85 meters above mean sea level. It is bounded in the southwest by the Kaziranga National Park, a World Heritage Site for in-situ conservation of biological diversity that includes the Great Indian One-Horned Rhinoceros.

8. Currently, breach of the existing embankments or bank overtopping is one of the reasons for high flood hazard. Assessment has been made for hydrological, morphological, climatic, socio-economic factors responsible for such floods. Impacts have been identified of such floods on physical, aquatic and terrestrial ecology. An environmental management and monitoring programmes have been suggested to minimise the impact and sustain the benefits.

1.5. Extent of the EIA Study

9. The environmental assessment was done in tandem with the preparation of the feasibility report. The EIA is based on most up-to-date subproject details/ concept design provided by the Design Team during the preparation of this report. Minor changes may occur in the sub-projects structural component, but these changes are expected to be limited to implementation schedule. References have also been made on the pre feasibility report.

10. The EIA study covered all activities proposed for the integrated flood and riverbank erosion management in Kaziranga Reach. The impact area covers section of river Brahmaputra (complete reach length, its immediate upstream and downstream sections, area within 100 m either side of the reach[1], project benefit area, and beels/wetlands/ tributaries connected with the river in the reach area). The study area has been extended to cover a buffer zone of 8 km wide[2] on either side of the embankment to analyse the land use, identify environmentally sensitive locations, if any, and understand the overall drainage pattern of the area. Geographical Information System (GIS) techniques have been used based on recent satellite data of the project area to analyse the baseline physical, ecological and cultural landscapes and to gather the relevant data for EIA purpose. Impact on aquatic life including Dolphin, their breeding/spawning areas, migratory route of fishes have also been assessed. Assessment of vegetation cover, migratory route of animals, and sourcing of construction material particularly borrow earth and aggregate has also been undertaken.

11. The report has been prepared by:

- **S K Jain**, Environmental Expert, EQMS India Pvt. Ltd.
- **Prof. D C Goswami**, Environmental and Geo Hydrology Expert
- **Naval K Chaudhary**, Environmental Specialist

12. Additional inputs have been provided by:

- **Dr. P K Saikia**, Reader, Department of Zoology, Gauhati University for Terrestrial Ecology
- **Dr. Amalesh Dutta**, Professor, Department of Zoology, Gauhati University for Aquatic Ecology
- **Environmental Science Department**, Gauhati University for Ambient Air Quality, Ambient Noise Monitoring, Soil and Water Quality Testing
- **Dr. Sarat Phukan** & **Ms. Chinmoyee Gogoi**, Gauhati University for Remote Sensing and GIS Related Inputs

1.6. EIA Content

[1] Core zone of the impact was taken as 100m on either side of the reach based on the expert judgement as most of the project activities related to embankment renovation and/or new construction, bank protection will primarily be limited to this zone.

[2] The study area has been selected based on the following two considerations:

(i) The sub-project specific benefit area which is varying up to about 7 km from the embankment in case of Kaziranga reach

(ii) The practice adopted by Ministry of Enviornment and Forests (MoEF), Government of India for delineating environmental assessment of the project, which is 10 km around the project boundary (Though we have followed MoEF guidelines but this project will not require any formal clearance from MoEF as detailed under Section 2.2.1)

13. This EIA report is presented in nine chapters, consistent with he ADB's Environmental Assessment Guidelines (2003). This includes this introduction, and individual chapters describing the subproject, environment, alternatives, anticipated environmental impacts and mitigation measures, economic assessment, environmental management plan, public involvement and disclosure, and conclusion.

1.7. Methodology

14. The EIA study was carried out using reconnaissance survey, review of previous studies, field visits, consultation with stake holders & NGOs, review of existing data, assessment to identify adverse impacts, and the preparation of environmental management plan (EMP). Extensive use of geographic information system establish by the project as part of the engineering and knowledge base component was made. The assessment also builds on the Brahmaputra morphology study using satellite imagery, risk maps, and studies on the influence of spurs and anti-erosion activities of the Water Resources Department (WRD) in Assam. The scope of the EIA extends well beyond the vicinity of the proposed structural measures and covers the entire Brahmaputra River section fronting the existing and proposed measures, and to the extent possible, 8 kilometers radius as the general impact zone. While, the immediate 100-meter corridor centered along the existing and proposed embankment alignments as the primary impact zone where most of the adverse impacts may occur. The decision to expand the environmental assessment impact zone to 8-kilometer radius is based on the following: i) to ensure that environmental impacts attributable to the project are comprehensively identified and assessed, ii) allow flexibility in the detailed design of Tranche II measures, which will adapt to the rapid changes in Brahmaputra River morphology, by providing a comprehensive environmental baseline information, and iii) recognizes that FRERM measures to influence the flow direction and promote siltation in strategic areas may have environmental impacts downstream.

1.7.1. Data Collection

15. The objective of data collection was to provide a database on existing conditions, to be used for predicting the likely changes that are expected and for monitoring such changes. The first step was to undertake a subproject scoping exercise, identify the parameters to be considered, and outline the activities for collecting data on identified parameters. Sources of data were identified and relevant existing data on the physical, biological, and socio-economic aspects of the environment from authentic secondary sources were collected. Data collected, sources, and application are summarized in the succeeding Table.

Table 1.1 Information Collected and Sources

Information Collected	Sources	To be Used in
Project location, project objectives, project designs, and sourcing of construction materials	Pre-feasibility Report; Concept design prepared by TA Consultant team and WRD	Project description and impact assessment
Wildlife, forest areas in project vicinity, flora and fauna details, and possible ecological impacts and mitigative actions	Department of Zoology, Gauhati University; District Forest Office; Department of Environment and Forests, Govt. of Assam	Project description, impact assessment and mitigative actions, alternative analysis, and economic assessment

Information Collected	Sources	To be Used in
Engineering details	TA consultants	Project description, impact assessment, and mitigative actions
Existing quality of the environment, land use, meteorological data, possible impacts because of the project and proposed action plans, identification of ecologically sensitive locations, regulatory compliance	Primary data collection; Department of Environment and Forests; Department of Fisheries; District Forest Office; Census Report, Govt. Of Assam; IMD Regional Office, Guwahati; Gauhati University Library, State Pollution Control Board, Assam	Project description, impact assessment and mitigative actions, management plan, and environmental economic assessment
River geomorphology, hydrology, and flood pattern	Published Research; Govt. Reports; Unpublished Doctoral thesis's, ARSAC reports, Brahmaputra Board, WRD, and GSI Reports	Project and environmental descriptions, and impact assessment

16. Primary data was also collected for noise, water quality, air quality and soil. Since Dolphin is an endangered species, special efforts were made to identify areas where they are frequently sighted including their breeding grounds.

1.7.2. Public Consultation

17. Local knowledge about the ecosystem and problems associated with river behaviour and existing flood protection and erosion control measures were carefully recorded and used in impact assessment and developing mitigation plan. Consultations were held focusing on aquatic and terrestrial flora and fauna to identify sensitive ecosystems that may be affected by the subproject. Formal institutional level public consultation and opportunistic informal meetings involving local villagers, fishermen, and those who are likely to be affected due to the proposed projects were organized to determine potential socio-economic impacts. Finally, interactions were made with various NGOs and concerned government officials.

18. Public consultations were held with the stakeholders during the two state workshops, on December 2007 and June 2008 in Guwahati. Taking into consideration the environmental importance of the project, a number of environmental NGOs were invited during these state workshops, with the advance sharing of the executive summaries of the study findings in each stage, and post-workshop posting of the presentations in the ADB's website on the project information. However, only a few had turned up. A detailed description of the public consultation has been presented in Chapter 8.

2. DESCRIPTION OF THE PROGRAM AND SUBPROJECT

2.1. Rationale

19. India is one of the most disaster-prone countries in the world. Flooding is a major recurrent natural disaster, causing damage of average $450 million annually with increasing incidence in the recent years. The country has a flood prone area of 46 million ha (accounting for some 14% of the geographical area and 25% of cultivable area). A national level policy framework for flood management is promoting short- to long-term programs for both structural and non-structural measures with a basin wide approach with improved catchment management. About 18 million ha in flood prone area has so far been protected with flood embankments and other structures, whereas nation wide flood forecasting and warning system has been set up. However, large gaps still exist between the policy framework and operations at the individual state level.

20. Flooding in the Brahmaputra plain in Assam is a complex phenomenon with different factors often changing roles. These factors are: (i) the Brahmaputra River in high spate has the potential to flood major parts of the plain for extended period of time; (ii) tributaries flood their adjacent plains, but for shorter periods being of short term character in steeper hilly parts with longer-term flooding, influenced by Brahmaputra water levels, in their lower floodplains; and (iii) local rainfall can cause flooding (local floods associated with drainage congestion) even when rivers not over spilling, but commonly drain away after hours or days. Overall, the effective FRERM requires a long-term basin wide approach with a sound planning framework integrating short- to longer-term programs including (i) improved catchment management, (ii) multipurpose reservoirs including flood cushion where feasible, and (iii) balanced combination of structural and non-structural measures to cope with immediate annual risks.

21. Assam remains one of the poorest states in India, with per capita income 45% below the national average in 2005. An inability to minimize the impacts of frequent flooding remains one of the serious development constraints.[3] Flooding and river erosion have devastating impacts each year. The floods are caused by the runoff of extremely heavy rainfall during the monsoon and high sediment loads from upper watersheds that are geologically unstable and degraded because of deforestation and changing land use. Their effective management requires a long-term, basin-wide approach with a sound planning framework integrating short- to longer-term programs, including (i) better catchment management, (ii) multipurpose reservoirs where feasible, and (iii) a balanced combination of structural and nonstructural measures to cope with immediate annual flood and erosion risks.

22. While the state has flood embankment systems protecting 50% of its flood-prone areas, their reliability is constrained by deterioration associated with poor maintenance, failure from river erosion, and local riverbed rising. The improvement of the existing embankments needs to be prioritized, particularly along high-value locations with assured maintenance, supported by riverbank protection where feasible. More cost-effective and flexible options that can adapt to the dynamic river process should be explored. Alternative risk management measures need to be pursued in other areas, such as flood proofing, strategic retirement of embankments, and a range of nonstructural measures including flood and erosion risk prediction and mapping, advance warning, and safety nets for the people threatened and displaced by flooding and river

[3] The Brahmaputra Valley in Assam is one of the most acutely hazard-prone regions of the country, with more than 40% of its land (3.2 million hectares) susceptible to flood damage. This is 9.4% of the country's total flood-prone area. The erosion hazard is also extremely severe in several vulnerable reaches. About 7% of land in the state's 17 riverine districts has been lost because of river erosion over the past 50 years.

erosion. Comprehensive strengthening of the policy, planning, and institutional basis, data, and knowledge base are also required, along with the effective participatory mechanisms to ensure accountable program management.

23. The Government, in its Eleventh Five Year Plan,[4] has prioritized flood management, in line with the paradigm shift of the country's disaster management strategy to focus more on preparedness than responses. This is also in line with a growing concern about the impacts of climate change. The state government has also initiated steps to establish a sound policy, planning, and institutional framework for water resources management, including drafting a state water policy and a vision for holistically managing flood and riverbank erosion from a basin perspective. The Program is designed to support the state government's initiatives by promoting necessary reforms and strengthening key sector organizations, such as the WRD and local participatory disaster management organizations (DMOs). Structural measures will focus on the three existing embankment systems protecting key urban and productive rural areas, which were selected as the priority sites for putting into operation effective FRERM systems. The establishment of a sound data and knowledge base to effectively manage or respond to the dynamic natural river processes will be emphasized.

24. The IFRERM Assam is needed to support the SGOA's initiatives to start taking the specific steps towards more effectively managing the risk of flood and river erosion problems with long-term integrated perspective. Support is to be provided to promote the necessary reforms and capacity strengthening in terms of policy and institutional bases and a sound planning framework placed within a long-term basin context while institutionalizing comprehensive and effective structural and non-structural measures in strategic locations of the state. Structural measures will focus on proper functioning as per the intended design of the existing embankment systems protecting key urban and productive rural areas and requiring upgrading and protection against river erosion exploring alternative (cost effective and sustainable) designs, whereas non-structural measures will extend to the most vulnerable locations to the impacts of chronic flooding. Significant emphasis will also be placed on establishing sound data and knowledge base to effectively manage or respond to the dynamic natural river processes while not disturbing them as much as possible.

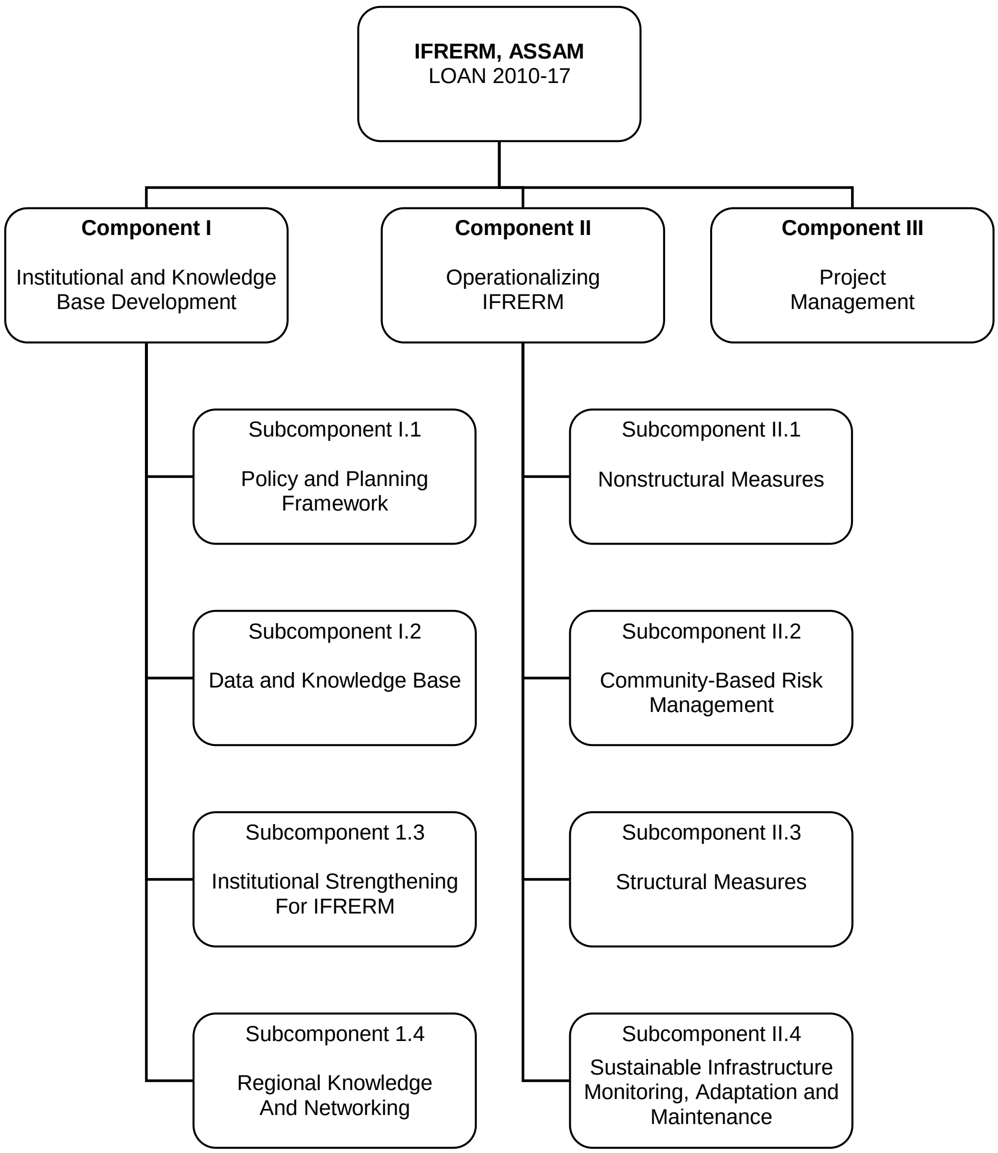
2.2. The Program

25. The Program intends to (i) improve the state's ability to mitigate flood and erosion damage at three priority subprojects that have embankment systems, (ii) increase economic development, and (iii) reduce poverty. Recognizing the need for a holistic approach to FRERM, the Program has several components that mix structural and nonstructural measures, as shown in Figure 1. Component I will address the enabling environment and institutional framework, particularly the policy and planning framework, institutional strengthening, and capacity building. Component II will address the operationalization of integrated FRERM through structural, nonstructural, and community-based risk management measures. Structural measures include the renovation of existing embankments, including their retirements, to maintain their intended design functions; provision of riverbank protection; and associated drainage structures, such as sluice gates along the embankments, to improve local drainage. Component III will address project management and training of project organizations. It is estimated to cost $149 million including financial charges. The Program is described in more detail in Appendix 1.

[4] Government of India. 2007. *Eleventh Five Year Plan (2007-2012). New Delhi*

26. The Program is to be implemented over 7 years, from 2010 to 2016 (including 1 year for maintenance support). Although designed as a project loan having three appraised subprojects, an MFF is adopted for the implementation of the Program to achieve higher quality implementation, progressively improve program design by incorporating lessons, and progressively develop institutional basis and capacities. Within the MFF framework, the implementation philosophy follows an adaptive approach to allow construction at the right place at the right moment. The flexible response largely applies to the implementation of riverbank protection measures. As such, the subproject works are divided into two tranches. The first tranche is more definitive for immediate implementation following local priorities, while the second tranche is indicative at this stage and a more definite scope will be defined at the time of its processing. An updated or revised EIA will be prepared at that time as required.

Figure 1: Program Components



27. A participatory and holistic FRERM will be used to implement the Program. For this purpose, a multidisciplinary project management unit (PMU) will be established under the Assam Integrated Flood and Riverbank Erosion Risk Management Agency, which is being

established with registration under the Societies Registration Act. The PMU will provide stable leadership and strong coordination of technical, nonstructural, and participatory agendas. At the subproject level, multidisciplinary subproject implementation offices will be set up, combining technical, disaster management, and coordination functions. The established system of DMOs, implemented under the United Nations Development Program Disaster Risk Management Project, will be extended to include a wider range of stakeholders and jointly decide on and monitor implementation. The concerned state departments, including the WRD, will be held accountable to DMOs for sound program delivery.

28. The more specific scope of the IFRERM-Assam will include the following:

<u>Component I: Institutional and Knowledge Base Development</u>

(i) Policy and Strategic Planning Framework: (a) consultations towards finalizing State Water Policy and steps for initiating implementation; (b) long term state FRERM plan (building on existing plans, with integration to wider watershed issues)
(ii) Institutional Bases: (a) institutional development actions for WRD and line departments; (b) improved guidelines and manuals including nonstructural measures; (c) FRERM infrastructure asset management information system (MIS); (d) comprehensive capacity development
(iii) Data and Knowledge Base (linking with central and state institutions): (a) data base on hydrology, morphology, sediment transport, topography; (b) tools including flood risk mapping and short-term erosion prediction system; (c) strengthened flood warning system; (d) M&E and R&D system
(iv) Regional Knowledge Sharing and Networking: (a) international networks for FRERM and disaster risk management (DMS); (b) knowledge exchange

<u>Component II: Comprehensive FRERM Systems in Selected Subproject Sites</u>

(i) FRERM Nonstructural Measures: (a) flood and erosion risk mapping; (b) improved warning systems; (c) participatory flood emergency response system; (d) other flood adaptation measures (adaptive cropping, fish culture, etc.)
(ii) Community-based Risk Management: (a) participatory systems integrated with local disaster management committees (DMCs); (b) community FRERM plans; (c) plan implementation such as community awareness, flood shelters, associated flood coping and development programs, e.g., adaptive cropping, fisheries, and livelihoods
(iii) FRERM Structural Measures: (a) upgraded embankments with assured maintenance (with extended platforms as appropriate); (b) systematic riverbank protection exploring cost-effective, adaptive, and sustainable alternatives; (c) associated infrastructure (drainage sluices, canals, etc.)
(iv) Sustainable FRERM Infrastructure Maintenance

<u>Component III: Project Management and Associated Capacity Strengthening</u>

(i) Project management support with community participation (through disaster management systems) with incremental staffs including those hired from the market, implementation consultants, and other operations
(ii) Training for Project-related operations

29. The proposed program will be implemented in two Tranches at three sub-project sites with each Tranche having 3 year duration. Tranche I focus on the development and provision of urgent structural works, knowledge base development to add to the understanding of flood behaviour and riverbank erosion process in the subproject areas, and cost effective structural

flood protection measures specific to Assam. Based on the lessons learned and developments of Tranche I, structural works will be finalized, taking into account the rapid changes of the river environment.

30. Structural measures will renovate and strengthen existing flood embankments as opposed to new construction, with a focus on the systems protecting the vital areas of economic interests. The existing system of flood embankments needs to be supported by riverbank protection measures where feasible, as the Brahmaputra is widening – eroding more and more embankments and posing the risk of large scale avulsion or channel migration in certain locations. Riverbank protection provides the additional benefit of safeguarding the valuable flood plain habitat between existing flood embankments and river. Flood plain land is higher in biodiversity than lower lying often sandy and less valuable amphibian river habitat into which the floodplains turn after erosion. In order to improve the water exchange on the floodplain, especially for drainage but also to allow targeted replenishment of beel areas, a large number of sluice gates will be constructed under this Project.

31. The project implementation philosophy follows an adaptive approach, which means being flexible to respond to unpredictable river changes in future and as such reducing structural work, especially riverbank protection measures, to only those areas immediately threatened. Recognizing the unpredictability of the Brahmaputra River and driven by the objective to minimize cost, the planning framework of structural component incorporates great flexibility in order to allow construction at the right place at the right moment. The flexible response largely affects the implementation of riverbank protection measures, but to a certain degree also the strengthening or rebuilding of embankments. In the case of riverbank protection, the work location might shift upstream or downstream than previously envisaged during planning, in response to the changes in the river channel pattern particularly if previously completed structures are at risk of being outflanked by the river. In case of embankments, this could mean the rebuilding of an embankment that was once envisaged for strengthening if it has already eroded.

32. In implementing the subprojects, IFRERM-Assam will put into operation participatory, effective, and comprehensive FRERM at the community and subproject levels. For this purpose, the SGOA will establish a multidisciplinary project management unit anchored to WRD and Disaster Management Department (DMD), registered under the Societies Registration Act as an autonomous agency, which will provide stable leadership and strong coordination of technical and non-structural agendas including safeguards required for integrated FRERM. At the subproject level, there will also be subproject implementation units (SIUs) comprising technical team (constituting the WRD’s field offices) and disaster management and coordination team (constituting multidisciplinary staff in disaster risk management, social mobilization, and safeguards, who will be engaged locally). Existing disaster management committees at subdistrict and village local government levels will be extended and utilized to jointly decide on and monitor implementation, to which the concerned state departments including WRD will be held accountable.

2.3. The Kaziranga Reach Sub-Project

33. The Kaziranga Reach Subproject area is situated between Brahmaputra and Dhansiri Rivers, and the Kaziranga National Park. The area is subject to inundation and erosion from the Brahmaputra River as well as major local tributaries, such as the Dhansiri River. Direct attacks on the existing embankment occur at numerous locations along the Brahmaputra and Dhansiri Rivers. The existing embankment downstream of the mouth of Dhansiri River is within 350 m of

the riverbank. The succeeding Figure presents the areas undergoing or threatened by accretion, erosion, location of existing Brahmaputra River bank protection, and the area protected against flooding.

34. Discussion with local villagers has recalled erosion experience dating back to 1968. Since then, people of Riri village have moved several times due to erosion by the river. In Bonkwal, bankline erosion began in 1980 and by the year 1985 Bonkwal was completely wiped out by the river. In 1988, the subproject area experienced severe flood as reported by the community members. The small embankment around Bamungaon and Tilia Bari was damaged. About 20 people died of water borne diseases and 1500 families lost their agricultural land. An estimated 3,000 cattle died in one month due to flood and starvation. The same scenario repeated again during the flood of 1998 in which 300 families lost their land in Kaziranga area as a result of erosion. On an average, each family lost about 25 *bigha* of agricultural land. During the flood, 2000 livestock died.

35. During floods, houses either collapse or are flooded with water, due to which people have to leave the house and shift to a new location. They have to carry all their valuables and belongings with them and have accompanying children and elderly to fend for. With no place to stay, and children and elderly to fend for, making arrangement for and finding temporary shelter becomes one of the major challenges. In Kaziranga, Mishing tribe traditionally have a culture of making houses on raised stilts, which is particularly useful during floods as the water does not enter the main house. However, this again is subject to the water level of the flood and is not very useful in case of high floods.

Figure 2.3 Areas Threatened by Erosion and Accretion, Location of Existing Brahmaputra River Embankments, and Protected Areas - Kaziranga Reach Subproject

36. The general trend of the south bank tributaries such as the Dhansiri River, is for significant portions of the channel to run parallel to the Brahmaputra River for many kilometers. This is because the south bank tributaries generally carry very little sediment and is diverted in the downstream direction by the heavy sediment deposition ("natural levee") of the Brahmaputra River. Therefore, when Brahmaputra bank erosion occurs at the mouth of these south bank tributaries, the tributary's channel length can be shortened significantly. This in turn seems to have a destabilizing effect on the platform of the upper portions of the tributaries as they adjust to the new channel slope. Within the Kaziranga sub-project area, the Dhansiri River appears to

be undergoing fairly rapid lateral erosion at the outside of meander bends, which is directly threatening a portion of the embankment.

37. The area upstream of Kaziranga National Park eroded substantially over the last 30 years with the Brahmaputra River moving towards the south. A major tributary, the Dansiri River joins the Brahmaputra upstream of the Kaziranga National Park (KNP). The KNP's unique wildlife of the park normally leaves the plains during the monsoon (due to their inundation from Brahmaputra flood water and local rainfalls) and moves into the southern hills through a depression running parallel to the national highways. However, a breach in the existing Brhamaputra embankment (upstream of the KNR) causes deep flooding in this natural depression cutting the animals off from the safer highlands. Also, longer term flow through the plain could lead to the formation of a channel of Brahmaputra River, cutting off the wildlife permanently from the plain land. The subproject structural component mitigates these potential adverse impacts through the construction of an inner secondary embankment and the protection of the primary embankment with riverbank protection measures.

38. The KNP is a World Heritage Site located at Golaghat and Nagaon Districts with a total area of 430 square kilometers. First declared as a Reserved Forest in 1908, it was declared as a Game Reserve in 1916, Wildlife Sanctuary in 1950, and National Park in 1974, and finally as World Heritage site in 1985. The KNP jurisdiction has been expanding since 1997 with the 43.79 sq.km. first addition in Buraphar, 6.47 sq. km. second addition in Sildubi, 0.69 sq.km. third addition in Panbari, 0.89 sq.km. fourth addition in Kanchanjuri, 1.15 sq.km. fifth addition in Haldibari, and the 376.50 sq.km. in Panfur Reserve Forest Chapories). The KNP land and water use is classified as follow: Eastern Wet Alluvial Grassland, Assam Alluvial Plains Semi-Evergreen Forest, Wastern Dillenia Swamp Forests, Wet Land, Water Bodies, and Sandy Chor. The KNP has not compiled a management plan to date.

39. The existing flood and erosion protection works, mainly by the WRD, in the Kaziranga Subproject has evolved into an elaborate system of riverbank erosion control, flood control embankments, spurs, and pro-siltation porcupine screens. Embankments have been constructed along the Brahmaputra, both upstream and downstream of the Dhansiri River. About 5.5 km of dykes have been constructed along the west bank of Dhansiri River, and from Brahmaputra River extending inland 3.5 km along the border with Kaziranga Park. Upstream of Dhansiri River, 7 km of the Brahmaputra Dyke has been retired multiple times and at present has been replaced by the Krishibundh. Since 2006 approximately 2.2 km of the Krishibundh has been eroded and has been replaced by a low temporary dyke.

40. Some of the portions of these embankments have been recently renovated and widened to provide protection against the risk of Dhansiri River flood. This recent works by the WRD includes sections of the Dhansiri River embankment and 3.5 km section of the Brahmaputra Dyke (Moriaholla- Dhansirimukh 0.0km-3.5km).

41. In other areas the embankments are in poor condition with numerous weak points created by unplanned road crossings and general deterioration of the structure. Five breaches in the embankment bordering Kaziranga Park have been reportedly created by cutting of the dyke by local people to allow more rapid drainage of flood waters. These breaches have not been repaired as yet.

42. Erosion protection efforts have mainly focused on the use of porcupines and porcupine bullheads. Significant installations are present along a reach of Dhansiri River where direct attack on the embankment is imminent. A porcupine screen consisting of three rows of

porcupines has been installed near the 0 km point of the Krishibundh, extending 1.2 km into the Brahmaputra River to link the shoreline with a char. Many portions of this porcupine are now silted over and the main channel has shifted to the north, away from the bank. Demonstrating the successful pro-siltation works in this section.

2.4. Subproject Components and Activities[5]

2.4.1. Structural Measures

43. Works have been proposed to rehabilitate and strengthen significant sections of the existing embankment system. In addition, construction of 3.5 km long inner secondary embankments is proposed within the sub-project area to close the gap between national highway and the existing embankment system to improve the overall protection of the depression along the national highway from inundation and possible channel development. Importantly nine drainage sluices are proposed in order to facilitate drainage and avoid cutting of the embankment by the local population. The project uses the high flood level (HFL) data provided by the WRD for the design of embankment crest levels.[6]

44. There is an urgent need for bank protection works along certain portions of the banks where active erosion is occurring and threatens to undermine additional sections of the embankment. Work in Tranche 1 will consist of 3 km of protection in support of the Krishibundh upstream of the Dhanshiri River and 4 km in the Moriaholla area downstream of the Dhansiri. During Tranche 2 another 2 km of porcupine revetments are suggested to further stabilize the area of the Krishibundh and consequently the Dhansiri mouth.

2.4.1.1 Tranche 1, DPR year 1 to 3:

(i) **Construction of 4.7 km of inner dyke from Diffalupathar to National Highways (NH) 37 (Rs120 million).** The proposed Diffalupathar-NH 37 embankment will enclose the area between Dhansiri River, Kaziranga, and NH 37, providing protection from Brahmaputra flooding (the area is already protected from Dhansiri flooding by an existing embankment). A gated sluice will be provided at the existing opening in the village road near NH 37, allowing drainage of ponded floodwaters following local (rain) floods or an upstream breach. Another gated sluice will be provided at the Diffalu Channel crossing.

(ii) **Construction of three drainage sluices in the Diffalupathar–Moriaholla embankments (Rs120 million).** Three sluices (with three gates) will be constructed on the breaches in Moriaholla–Diffalupathar embankment. It is essential to the functioning of the new embankment that all three sluices be constructed in the same dry season. Together with the subsequent strengthening of the embankment, the work is expected to support reliable flood protection and drainage.

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[5] The area on the west bank of Dhansiri River (a tributary of Brahmaputra River) is protected partly near the mouth by one embankment. This embankment is connected to one PWD road leading to NH 37. But on the eastern side of the said river, there is no embankment. Moreover, there is a branch river of Dhansiri, called Geelabeel river, flowing almost parallel to the Brahmaputra river (East-west direction), though Dhansiri river is flowing North-South originating from Mikir Hills in Karbi-Anglong State. During flood season, spilling occurs on the two sides of these rivers and full area is flooded. Therefore, flood embankments are necessary on the eastern side of Dhansiri river up to NH 37 along with one regulator across Geelabeel river for protecting the land from Dhansiri flooding

[6] Specifically, crest level is fixed at an estimated HFL with 50-year return period plus free board of 1.5-meter free board, following the existing norm.

(iii) **Pro-siltation measures of 3 km in front of Krishibund (Rs15 million).** Pro-siltation measures with systematic placing of porcupine screens will be constructed from 29.7 km post on the Brahmaputra embankment to 2.2 km post on the Krishibund for about 3 km. The bank is on the outside of a sharp bend, and has been eroding for past few years. The screens increase the friction of the channel flow, reduce the slope of energy grade line, and encourage siltation. The placement of the porcupine screens is adaptive over 3 years, with the possibility of placing additional layers of screens over previous ones once they have been silted in.

The total cost of tranche 1 works is Rs255 million.

Tranche 2 (years 4–6, subject to future verification):

(i) **Rehabilitation and strengthening of 18.7 km dyke from Moriaholla to Diffalupathar (Rs130 million).** This dyke protects the area between Dhansiri River and Kaziranga National Park. Part of the embankment is being upgraded, and the remaining length will be upgraded.

(ii) **Porcupine revetment near Moriaholla area 4 km (Rs35 million).** This riverbank protection provides additional safety against erosion of the flood embankment.

(iii) **Additional revetment and pro-siltation measures of 2 km length in front of Krishi bundh (Rs17.5 million).** The work will supplement the work from the first tranche. This dyke protects the area between Dhansiri River and Kaziranga National Park. The Water Resources Department started providing pro-siltation measures in this reach in recent years. Under this initiative, the remaining length will be upgraded.

The total estimated cost of tranche 2 is Rs182.5 million.

The total estimated cost for the subproject is Rs437.5 million. The work distribution over 6 years is estimated in Table 2.2.

Table 2.2 Summary of Tranche-wise Work at Kaziranga Sub-project

Item	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Year 6**
Inner dyke, 4.7 km		50	50			
3 drainage sluices	40	60				
Krishibundh pro-siltation, 3 km	50	30	20			
Moriaholla–Diffalupathar dyke, 18.7 km				50	50	
Porcupine Moriaholla, 4km				50	30	20
Krishibundh pro-siltation, 2 km				50	30	20

Source: Water Resources Department, State Government of Assam.

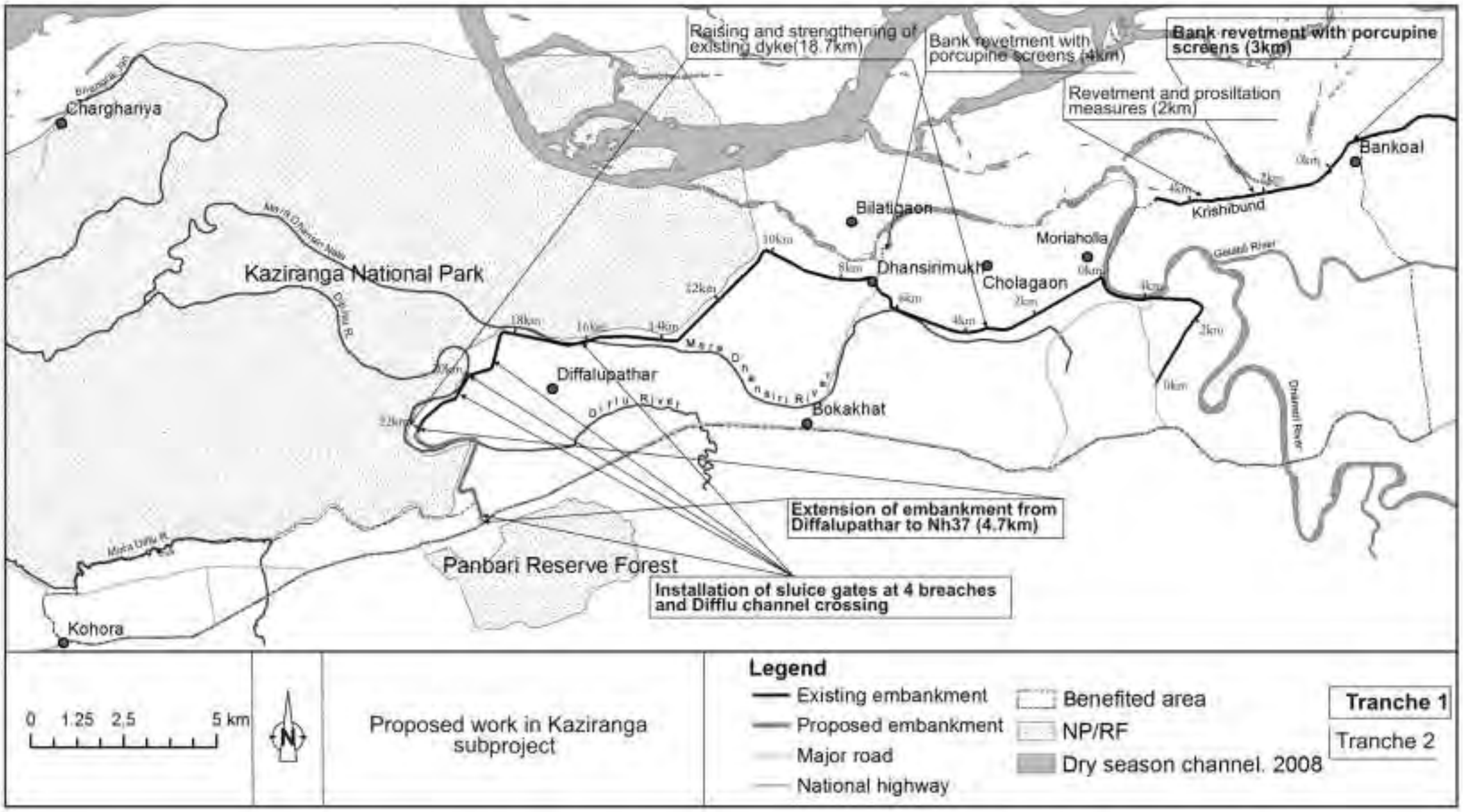


Figure 2.4 Proposed Flood and Bank Erosion Protection Works at Kaziranga Reach Sub-project Site

2.4.2. Non-Structural and CBFRM Measures

45. **Land Use Guidelines**. Land use guidelines are aimed at ensuring that land use across the floodplain is consistent with the likelihood, risk, and hazard of flooding. For this purpose, current and likely future land use in flood-prone areas will be reviewed, especially the expected population growth and its impact on future flood risk and damage in higher-risk areas. In addition, the use of land use zoning to preserve wetlands and protect existing flood storage areas from further development will be assessed.

46. **Building and Development Guidelines*.*** While building and development controls are also not expected to provide a panacea for reducing flood risk and flood impacts in Assam, the flood proofing of public infrastructure is one area where improvements might be possible (to ensure it is ready and effective to return to service after a flood). The Program will assess flood damage to buildings and public infrastructure to identify possible improvements. The United Nations Development Program Disaster Management Project has had work undertaken on the design and construction of flood-resilient buildings, which will be reviewed.

47. **Flood Forecasting and Warning*.*** Flood forecasting is a means to an end—to provide timelier and more accurate flood warnings. It is the warning that is essential, rather than the forecast. While a variety of public agencies participate in the flood forecasting and warning (FFW) process in Assam, most villagers receive no formal flood warnings—they generate their own warning by watching the river during the flood season, taking into account local rainfall. The Program will review the elements of FFW process, paying special attention to warning needs of villages and possible improvements in communities and flood emergency management. An important element of an improved FFW system is anticipated to be the provision of local forecasts by the Water Resources Department, i.e., the translation of regional forecasts by Central Water Commission (CWC) into clear and easily understandable warnings to villages. Local communities will be centrally involved in this process.

48. **Flood Emergency Planning and Management**. Flood emergency planning includes prevention, preparation, response, and recovery activities. Flood emergency planning and management (FEPM) is and will remain a central plank of flood risk management in Assam—flooding is a regular recurring natural event that cannot be prevented or entirely eliminated by structural measures. Flood emergency planning will to be reviewed and probably strengthened at the village, district, and state levels (e.g., through the use of the army for evacuation).

49. **Community-Based Flood Risk Management (CBFRM)*.*** CBFRM is one area where considerable opportunity exists to reduce the impacts of floods on village communities. Under the Program, comprehensive community surveys will be undertaken to address community concerns on flood risk management. Based on the responses, a CBFRM plan will be prepared, including raised platforms and associated facilities (e.g., permanent latrines, a raised tube-well for water supply, and permanent public buildings that are needed during flood emergencies, such as the local school and dispensary, and emergency shelter), along with community non-structure programs, such as flood warning and flood education.

50. **Flood Education*.*** Villagers appear to be very aware of floods and highly flood resilient. The need for further flood education in villages will be assessed in the community surveys. Flood management in Assam is fragmented across many different agencies. The Program will promote cooperation and the exchange of ideas and information between the different agencies through workshops, seminars, etc. (a form of flood education).

51. **Financial Measures*.*** When in emergency accommodation during floods, flood-prone villagers cannot afford kerosene for cooking purposes. Relief payments—whether in cash or kind—are a financial measure (and a form of insurance) aimed at reducing the impacts of flooding. Under the Program, the system of flood relief payments, food, and stock fodder issue and other relief measures will be reviewed and possible improvements will be pursued

2.4.3. Construction Material for Bank Protection

52. Use of inert or natural material is proposed. Geo-textile bags filled with sand shall be the preferred option. It is very stable material and used worldwide. The engineered bags life is considered to be much beyond 30 years, the economic life of the Project. Use of geotextile is considered beneficial even from aquatic fauna aspect. (Refer 3.Appendix 2.1 which provides the extract of the research carried out by Hannes Zellweger on use of geotextile bags for river erosion control in Bangladesh).

2.5. Implementation Schedule and Project Cost

53. The project will be implemented over a period of six years and would seek Multi-tranche Finance Facility (MFF) which may comprise two sub-loans covering year 1-3 and 4-6, respectively. The total estimated cost of the sub-project for structural works is estimated as Rs. 43.8. Crores (i.e. US $ 10.9 Million).

54. The sub-project will provide improved flood and riverbank erosion risk management is to achieve more stable living conditions for the existing population needs to be put into the larger context of land-use zoning to avoid future catastrophes. Understanding the risk of attracting more settlements on the risk prone flood plains, the Project incorporates a strong component of flood plain zoning, which will be the foundation of land-use zoning and building restrictions. There are no plans to reduce the existing embankment system or remove it. The benefit of flood protection can be demonstrated by comparing the inundated areas behind the embankments during the exceptional 2004 flood with a scenario without embankment (Figure 2.5). The Figure illustrates that almost double the area that was inundated in 2004 would have been flooded if there are no embankments in this reach.

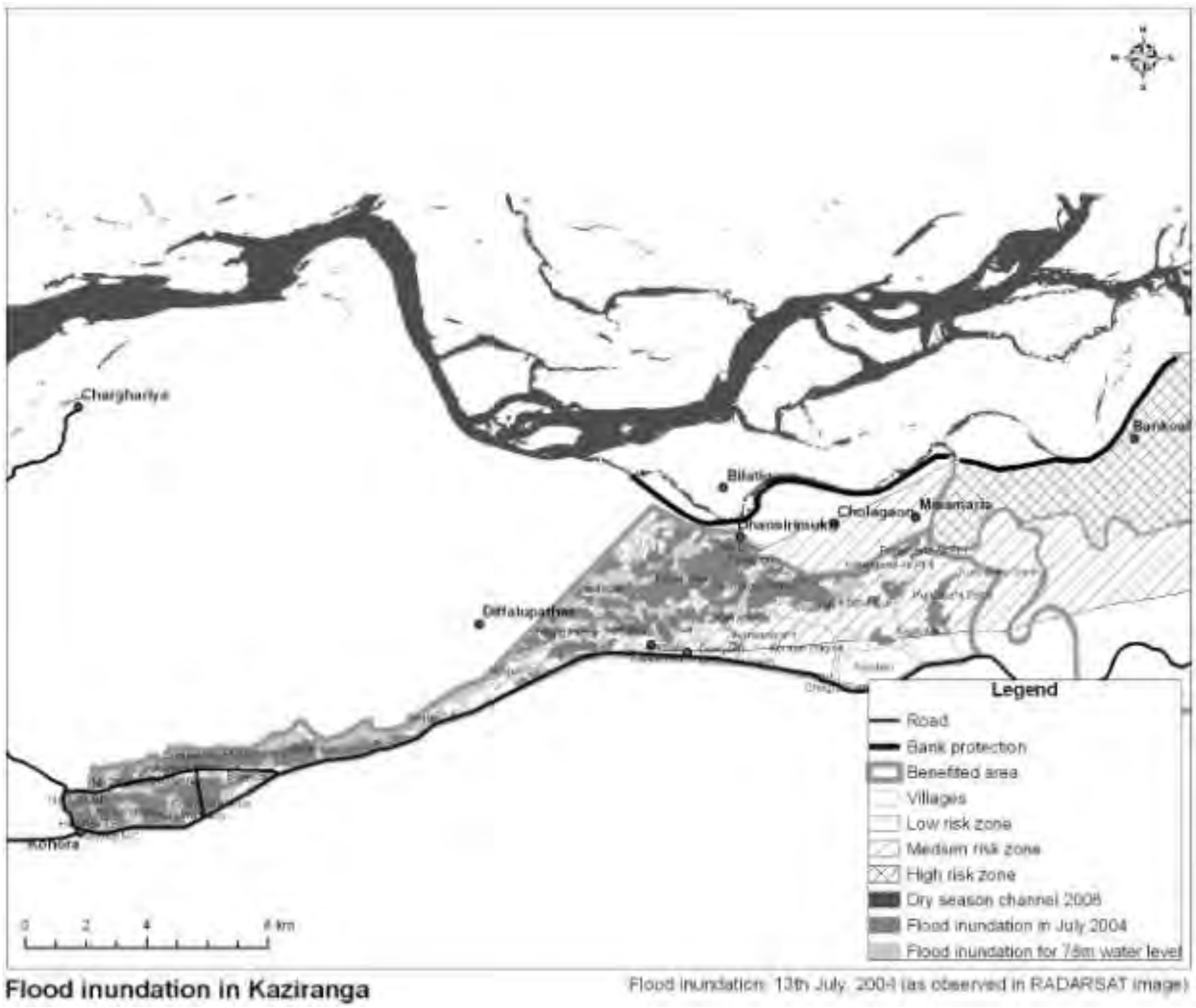


Figure 2.5 Comparison of 2004 flood with Existing Embankments and No Embankment Solution

55. To establish the feasibility of flood and riverbank erosion management measures for certain areas, interventions were planned based on the existing river situation. These measures were prioritized based on urgency, implementation costs, and benefits from reduced risk of flooding and riverbank erosion. Urgently needed work for stabilization is intended to be built over the first three years where the chance of sudden dramatic river changes in river morphology is less, and consequently there is a higher likelihood that the presently outlined work can be implemented without major changes. Lower priority measures previously outlined in this report, are indicative plans and will undergo more detailed planning during the second year of project implementation to adapt to the rapid changes in the river morphology. To cover potential changes in location of future work, this EIA considered a larger area of assessment, beyond the scope of this subproject extending to the full (upstream and downstream) Brahmaputra River section where existing and proposed embankments and pro-siltation works will be installed. The area for which structural interventions are planned together with the benefited area is shown in Figure 2.6. This area is more limited when compared with the area shown in the other maps in this report which cover the total area studied for this EIA.

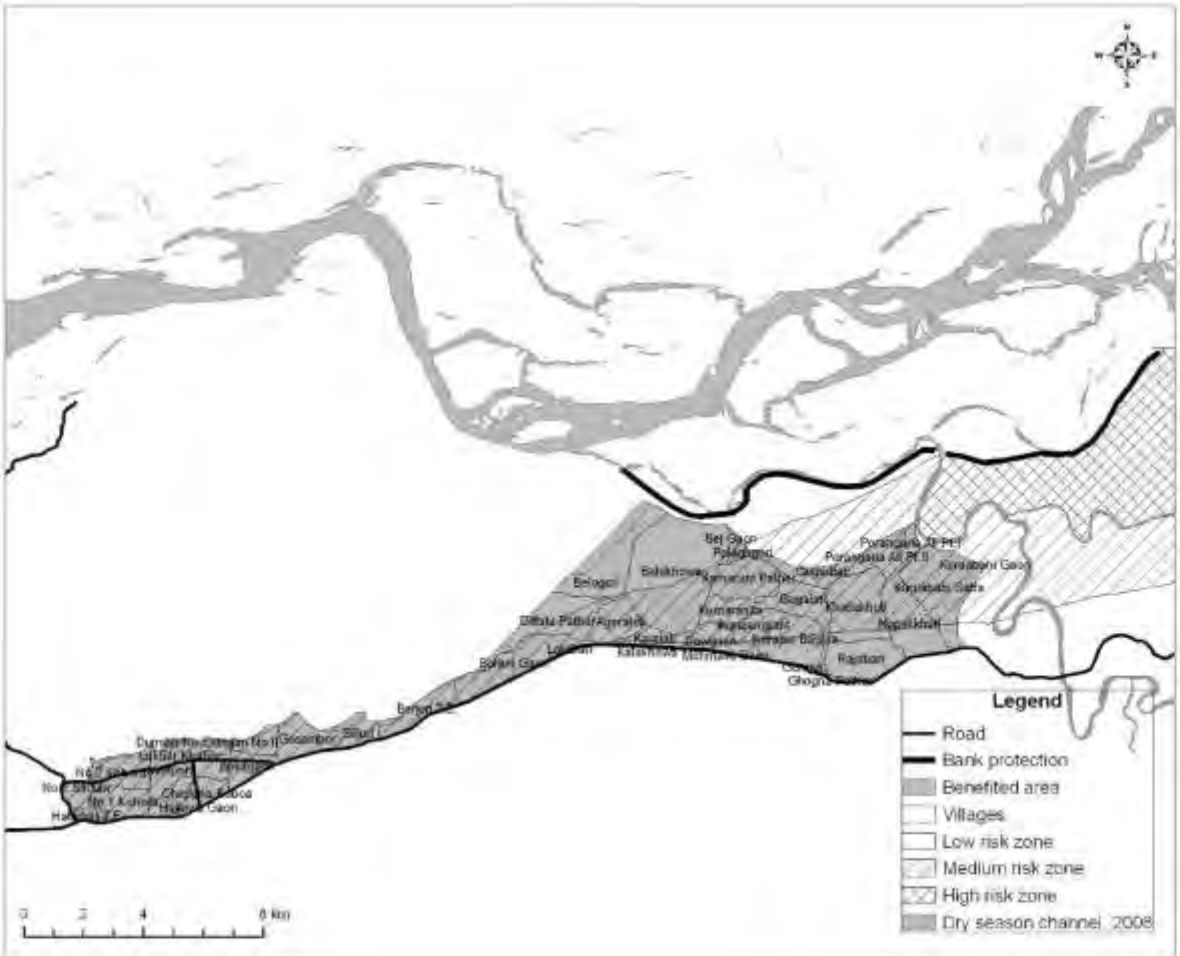


Figure 2.6 Basemap of Kaziranga with Benefited Area

(Note that the Kaziranga National Park is not specifically shown. The wildlife is benefited by reducing the inundation risk of the depression along the NH37, which allows animals to reliably move to higher grounds south of the road during times of high flood peaks.)

56. The Kaziranga Reach has considerable significance from the terrestrial ecological as well as hydrological perspectives. The Kaziranga Reach along the Brahmaputra River is in the immediate vicinity of the Kaziranga National Park, which is the world famous habitat of the one-horned Rhinoceros. The reach is severely being affected by continuous bank erosion and flood inundation caused by the Brahmaputra over the last few decades threatening the existence of the park and survival of its unique wildlife. There appears to be immediate danger from potential avulsion of a spill channel, (viz., Garumara) along an existing depression and string of wetlands within the park thereby isolating the main park area from the surrounding highland. The project activity though will not prevent the desired flow of flood water to the park. The present project will therefore positively contribute towards providing protection to the park, its wildlife and the adjoining villages.

2.6. Regulatory Requirements

2.6.1. ADB's Environmental Categorization

57. The project was initially considered as environmental category A by ADB. With the structural works focusing on the sustaining the functions of the existing flood embankment systems through renovation of deteriorated embankments, provision of inner secondary embankment and sluice gates, and provision of riverbank protection works, the present EIA indicates that the subproject does not have significant adverse environmental impacts that are sensitive, diverse, or unprecedented, and affect an area broader than the sites or facilities subject to physical works. However, in consideration of the proximity of the KNR, and complex and dynamic nature of the natural river conditions and associated natural environment, which calls for careful monitoring and management of environmental and social implications of the subproject interventions, the same categorization is maintained for the Kazuranga subproject.

2.6.2. Regulatory Requirements of the Government of India and Assam State

58. The Government of India has framed various laws and regulation for protection and conservation of natural environment. These legislations with applicability to this project are summarised below in Table 2.3 and approval and monitoring framework is depicted Figure 2.7. Only the Air and Water Acts, and the Eco Sensitive Zone Notification – Numaligarh (East of Kaziranga) are applicable to the Kaziranga Subproject.

Table 2.3 Applicability of Key Environmental Legislations at a Glance[7]

Legislation	Key Requirement	Applicability	Remark	Granting Agency	Reporting Requirement	Monitoring Agency
Air (prevention and control of pollution) Act, 1972 and rules there under	An Act to prevent and control of Air Pollution	Applicable	Applicable during construction stage for the operation of air polluting units like Hot Mix Plant, if used	SPCB	Normally compliance monitoring report is to be submitted once in a year or as indicated in the consent letter	SPCB
Water (prevention and control of pollution) Act, 1972 and rules there under	An Act to Prevent and Control of Water Pollution	Applicable	Applicable during construction stage for discharge of waste from construction camps or maintenance of construction equipment	-do-	-do-	-do-
Environmental (Protection) Act, 1986 and rules there under including EIA Notification, 2006.	Requires prior environmental clearance for all River Valley projects for ≥ 25 MW hydroelectric power generation and ≥ 10,000 ha. of culturable command area	Not Applicable	The proposed project includes only activity related to existing river bank and embankment protection. No hydro power generation or new canal project having large culturable command area.	MoEF/ SEIAA	Once in six months	Regional Office of MoEF
Forest (conservation) Act, 1980 & rules there under	Restriction on the reservation of forests or use of forest land for non-forest purpose	Not Applicable[8]	No diversion of forests land in the whole stretch	MoEF/ State Forest Department	Once in six months	Regional Office of MoEF/ State Forest Department

[7] Time to time amendments is issued to legislations in India. The environmental legislation applicability shall be established at the time of start of project implementation. Necessary clearances, if any becomes applicable shall be obtained from concerned authorities accordingly.

[8] The land revenue records need to be verified again to ascertain if any forest land is require to be diverted. If yes then this ACT shall be applicable and necessary clearance for forest land diversion will have to be obtained. Permission for tree cutting in any case would be required from concerned forests/district authorities.

Legislation	Key Requirement	Applicability	Remark	Granting Agency	Reporting Requirement	Monitoring Agency
Eco Sensitive Zone Notification – Numaligarh (East of Kaziranga) Zone SO 481 5th July 1996	The expansion of industrial area, townships, infrastructure facilities and such other activities which could lead to pollution and congestion shall not be allowed within "No Development Zone" except with the prior approval of the Central Government.	Applicable	To be obtained prior to start of construction	MoEF Central Government	As per NOC conditions	MoEF
Wildlife (protection) Act, 2002 & rules there under	No person shall destroy, exploit or remove any wild life including forest produce from a sanctuary/National park or destroy or damage or divert the habitat of any wild animal by any act whatsoever or divert, stop or enhance the flow of water into or outside the sanctuary, except under and in accordance with a permit granted by the Chief Wild Life Warden	Not Applicable	No wild life sanctuary/ National Park exist in the project area. However portion of project boundary runs adjacent to Kaziranga National Park Boundary.	Chief Wildlife Warden	As per the consent letter	Concerned protected area office/ Chief Wildlife Warden

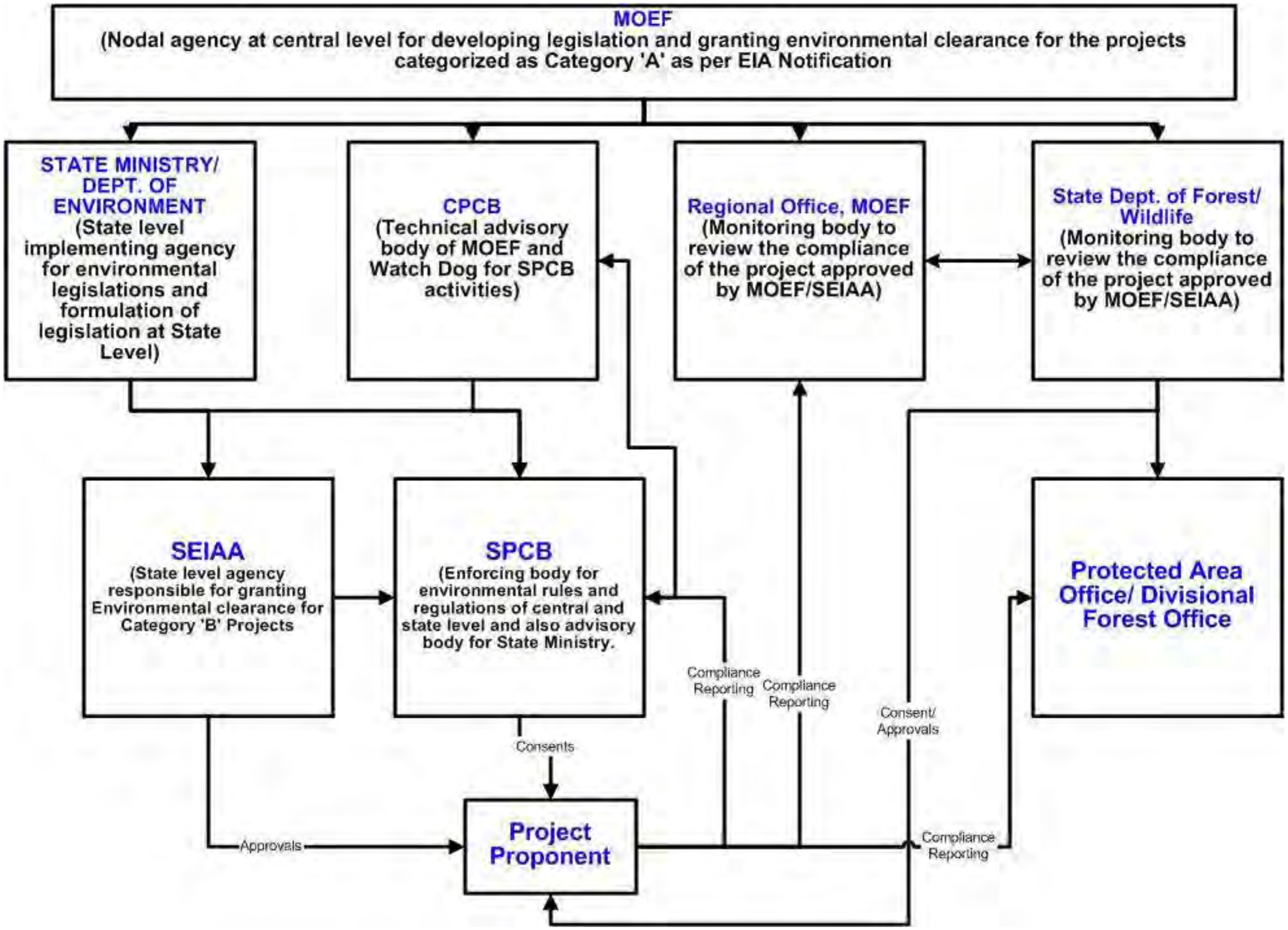


Figure 2.7 Legislative Interface between various Central and State Authorities

3. DESCRIPTION OF THE ENVIRONMENT

3.1. Introduction

59. It is necessary for the environmental assessment studies to establish baseline for valued environmental attributes which are likely to be affected because of the developmental activities. The study of the existing environmental conditions will establish the pre-project physical, biological and socio-economic conditions, and predict associated environmental impacts during the construction and operation phases of the subproject.

60. In this study, emphasis was given to data collection on the physical environment, biological environment, and socio-economic environment of the study area (i.e. 8 km buffer zone around the embankment). These data are considered to be of prime importance considering the nature and location of the proposed subproject focused on the Kaziranga Reach in Golaghat district of Assam.

61. The Kaziranga Reach is located little upstream of the Kaziranga National Park (KNP). The areas close to the KNP boundary represents an ecologically sensitive area being the most significant natural habitat of the one-horned rhinoceros and a host of other precious wildlife. This reach has been experiencing severe erosion and flood inundation caused by the Brahmaputra River that is posing great threat to the numerous villages in the vicinity of the KNP.

3.2. Description of Physical Environment

3.2.1. Climate

62. The climate of the region is sub-tropical with a hot, humid summer season dominated by the southwest monsoons from early-June to mid-September and a cool, dry winter from late October to the end of February. The pre-monsoon season starts in the early part of March until May marked by occasional thunderstorms and rising temperatures during the day. The post (retreating) monsoon season from last part of September to mid October generally represents fair weather conditions with declining rainfall as well as temperature.

63. The Brahmaputra valley in Assam forms an integral part of the subtropical monsoon regime of Eastern Asia receiving a mean annual rainfall of 230 cm with a variability of 15-20%. Distribution of rainfall over different river basins in Assam shows marked spatial variations, e.g. from as low as 175 cm in the Kopili basin located in the central part of the valley to as much as 410 cm in Jiadhol basin close to the Matmara reach in upper Assam. The isohyetal map of the Brahmaputra valley and adjoining highlands (based on IMD data) is shown in the Figure 3.8:

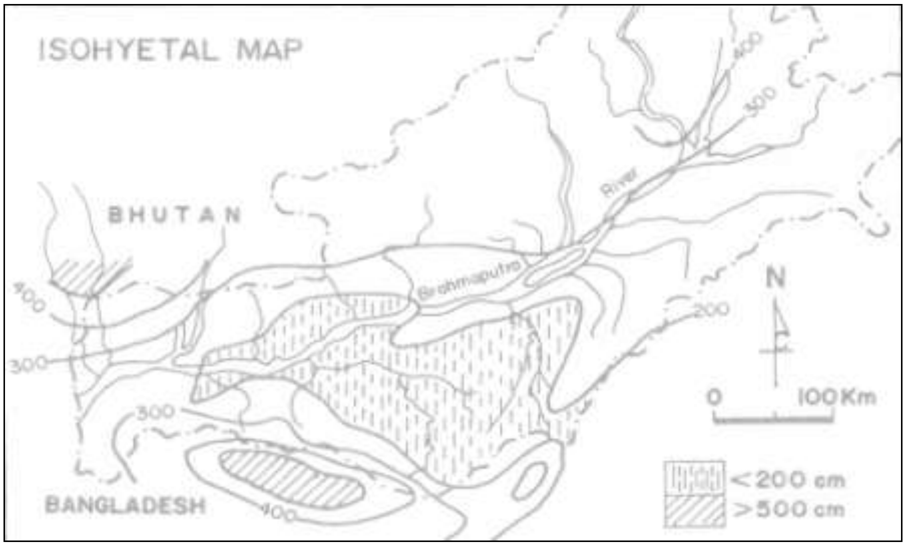


Figure 3.8 Isohyetal Map of the Brahmaputra Valley and Adjoining Highlands[9]

64. Monsoon rain from June to September account for 60-70 % of the annual rainfall in the region, while the pre-monsoon season extending from March through May provides 20-25 % of the rainfall, caused primarily by depressions moving from west and by local conventional storms. The pre-monsoon rains are primarily controlled by the position of a belt of depressions called of monsoon axis extending from North-East India to the head of the Bay of Bengal. In the course of its North-South oscillations in summer, when this axis moves closer to the foothills of the Himalayas, heavy precipitation is caused in Assam and adjoining highlands.

65. The Kaziranga Reach comes under the subtropical monsoon climate regime of North East India. It receives an average annual rainfall of 1850 mm. The pattern of mean monthly rainfall in a station close to the reach where data are available is shown in Figure 3.9. The highest monthly mean rainfall is recorded in the month of July (335 mm) and the lowest monthly mean rainfall is recorded in the month of December (7 mm).

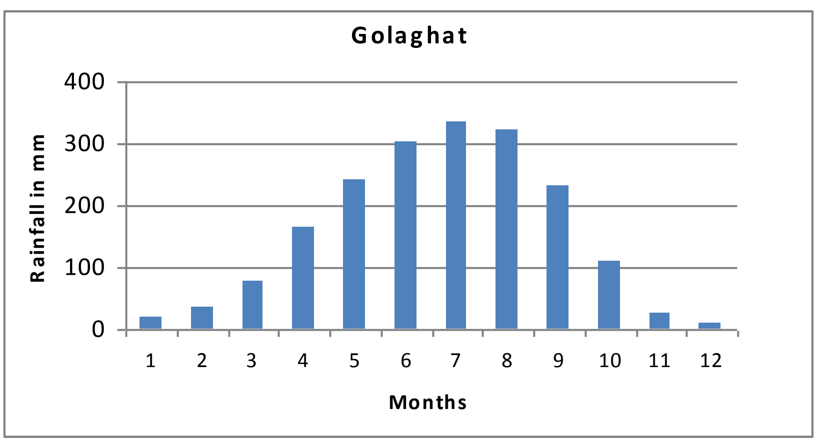


Figure 3.9 Mean Monthly Rainfall in Year 2007 at Golaghat (close to Kaziranga Reach)

66. Powerful atmospheric systems called cloudbursts that trigger intense rainfall in limited areas causing flash floods of great fury, and destruction are being experienced in greater

[9] Goswami, D.C. 1998. Fluvial regime and flood hydrology of the Brahmaputra River, Assam. *Memoir Geological Society of India*, No.41: 53-75.

frequency along the foothill region of and in the immediate downstream areas in the Brahmaputra plains. The situation aggravates further if such extreme climatic events trigger landslide and slope failure in the upper watersheds or temporarily block river courses creating dams that subsequently break sending surging flood waves downstream. During the 1950 Assam earthquake, a massive landslide in Arunachal Himalayas blocked the Subansiri River – a major tributary of the Brahmaputra for days together creating a dam which was eventually released in a deluging flood that greatly devastated the downstream areas in Dhemaji and Lakhimpur districts of Assam. On 10th June 2000, a massive flood occurred in Arunachal Pradesh reportedly as a result of a sudden failure of a landslide induced dam in the neighbouring uplands of Tibet. Cloudburst and landslides related flash floods occurred in 2004 in the Manas and Beki rivers of Assam due to failure of landslide dam upstream of Kurichu hydel project in Bhutan that caused highly destructive flood and channel avulsion. On October 7 of the same year i.e. 2004, a flash flood in Jinari river of Assam was triggered by a cloudburst over Meghalaya that caused great havoc in the downstream areas in Assam.

3.2.2. Physiography and Drainage

67. There is a good measure of homogeneity among the project areas in terms of their riverine locations in active floodplain tract along the bank of the Brahmaputra River, their composition consisting almost entirely of young alluvial soil and vulnerable to flood and erosion during the last few decades. However, in terms of biodiversity, urbanization, socioeconomic base, minerals and industries, and infrastructure, there are considerable variations in each sub-project. The physiography of Assam consists of: (i) Foothill Zone, (ii) Middle Plain of North Bank, (iii) Active Flood Plain, (iv) Middle Plain of South Bank, (v) Sub-mountain Zone, and (vi) Hills. These divisions are shown in Figure 3.10.

68. The Kaziranga reach like the other two reaches under the IFRERM-Assam is located in the active floodplain zone along the bank of the River Brahmaputra. The reach has a variety of landscape elements, *viz.* rivers, floodplains, wetlands, swamps and occasional hillocks.

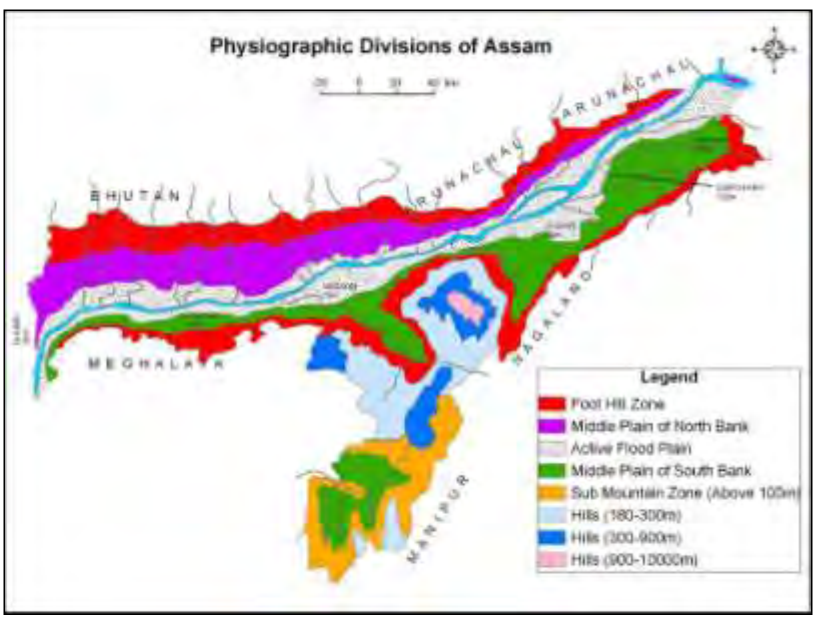


Figure 3.10 Physiographic Divisions in Assam

69. The Dhansiri River (see Figure 2.4), a major south bank tributary of the Brahmaputra and Gelabeel, flow through the reach- the former almost dividing the reach into two sub–reaches near its outfall in the Brahmaputra at Dansirimukh. The Dhansiri River's total drainage area is 10,240 km^2 and carries an average annual discharge of 188.42 m^3/s with a suspended load of 146 ha.m near its confluence with the Brahmaputra. The Dhansiri River used to flow through the Kaziranga National Park area, now the present point of confluence with the Brahmaputra lies about 5 km east of the park boundary.

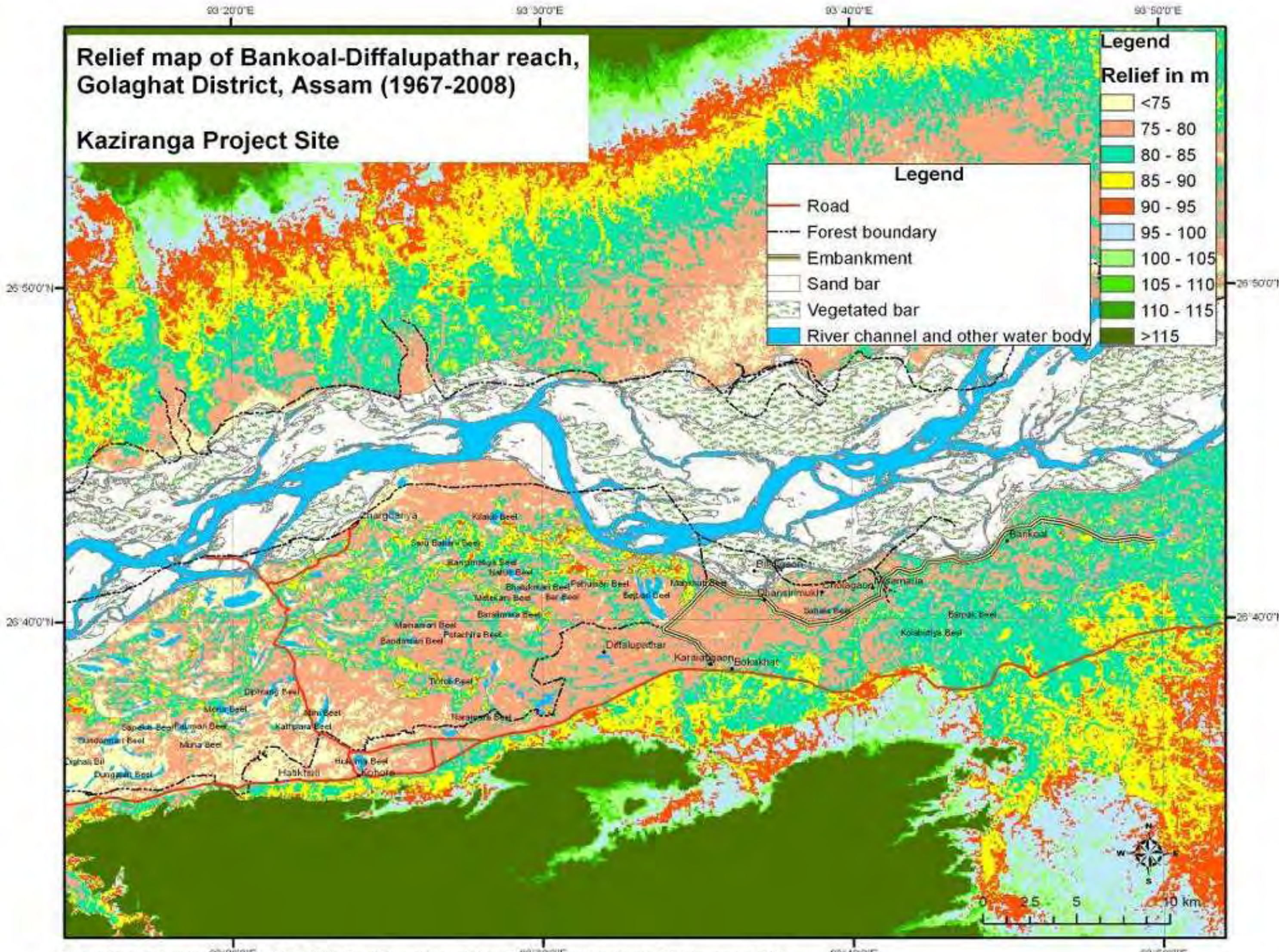
70. The eastern part of the reach extends from Bankoal to Moriaholla for a distance of 7.0 km while the western part extends downstream from Kaziranga National Park to Diffalupathar and further up to the NH-37. The Diffolu River originating from the Karbi – Anglong hills flows through the middle of the park area. Its original course along the southern boundary of Kaziranga now survives as a dead channel of the river known as Mora Difflou. Similarly, there is an abandoned channel of the Dhansiri River flowing through the park which is known as Mora Dhansiri River.

71. Besides, there are a large number of wetlands, marshy and swampy areas meander cut–off channels and ox–bow lakes in the area. Most of these wetlands are in the Kaziranga National Park area, including the Sohola Beel is located outside the embankment in the riverside. Also, there is no wetland in the Moriaholla area, where project activities are likely to be undertaken.

72. An elongated depression with a string of wetlands running along the southern boundary of the park close to the NH-37 that links the Garumarajan with the Mora Diffalu extending close to the currently eroding southern channel of the Brahmaputra appears on satellite imagery as a potential flash point for a major avulsion of the channel, and creating thereby a situation of grave consequence in regard to safety of the park.

3.2.3. Topography

73. The relief map based on analysis of satellite data showing topography of the Kaziranga reach is presented in Figure 3.11. It shows that the relief of the area represents monotonously flat lowland (less than 115 m above MSL) except the adjoining hilly uplands in the south.



Elevation data source: SRTM DEM: Configuration of the Brahmaputra river: IRS image, 2007

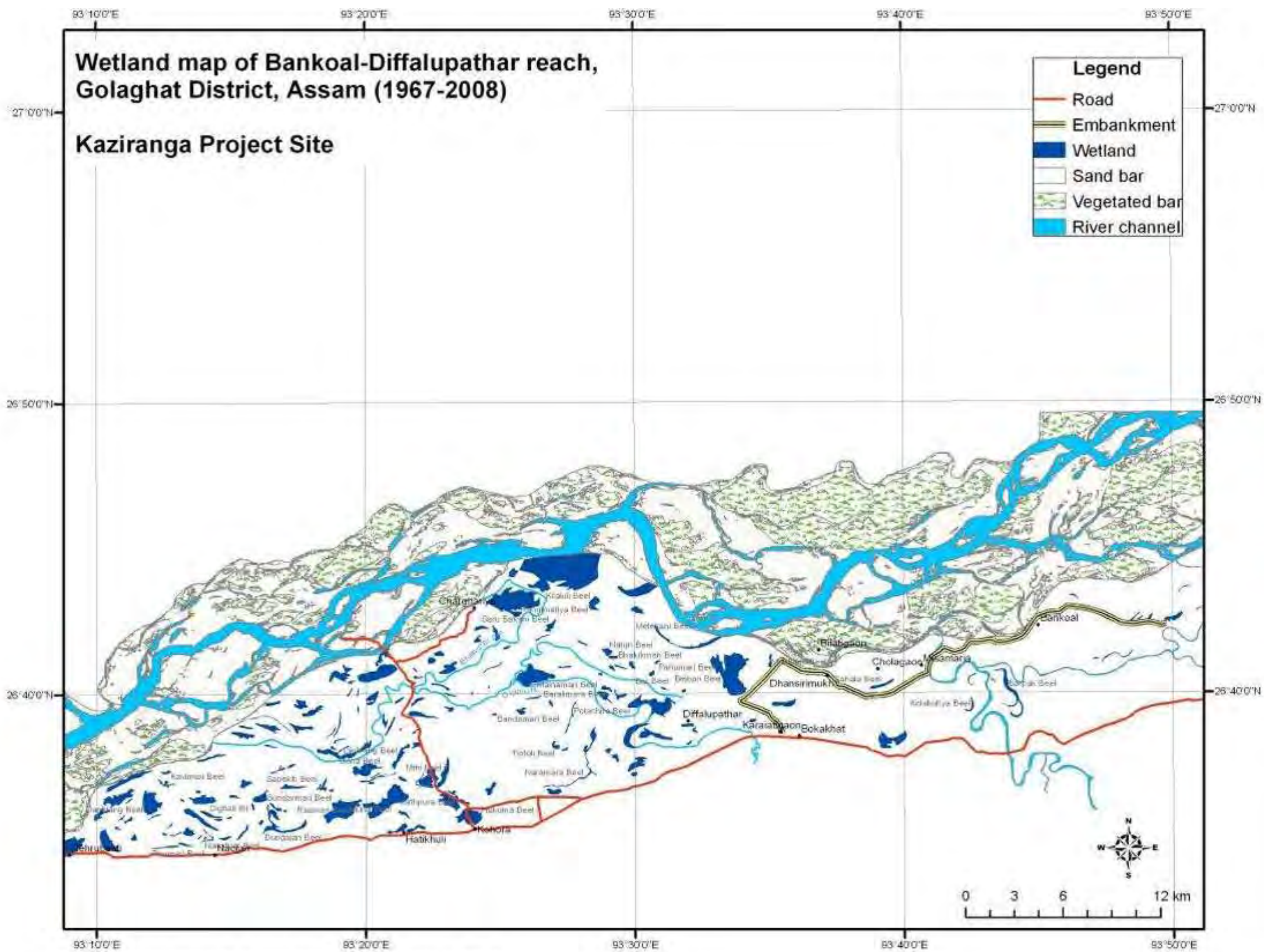
Figure 3.11 Kaziranga Reach: Topography

3.2.4. Water Environment

74. The state of Assam in general and the Brahmaputra valley in particular, is endowed with vast water resources potential. The Brahmaputra River and the 33 major tributaries joining it in Assam including the main trans-Himalayan tributaries of Subansiri, Jia Bharali and Manas carry about 30% of the country's total water resources potential. Surface water bodies covering about 8,251 km^2 account for 10.5% of the total geographical area of the State. Of these, the river systems including waterlogged areas occupy 6,503 km^2. The annual surface water availability is over 53 million ha-m. Besides, there are 3,513 wetlands in the Brahmaputra valley covering 1012.3 km^2 area in Assam. Groundwater is also plentifully available at shallow depth in the valley and the utilizable ground water resources estimated at over 2 million ha m.

3.2.4.1 Surface Water

75. The water environment of the Kaziranga Reach is dominated by the Brahmaputra river, its tributary Dhansiri, distributaries like Diffolu, Geelabeel together with numerous small streams, abandoned channels, wetlands, and marshy areas. The location of major wetlands and other water bodies in the Kaziranga reach is shown in Figure 3.12.



Configuration of the Brahmaputra river: IRS image, 2008.

Figure 3.12 Wetlands and Other Waterbodies of the Kaziranga Reach

76. Water quality monitoring and analysis in regard to phyDRMC-chemical as well as biological parameters was carried out on samples collected from two locations in the project area. The locations of the sampling points are shown in Figure 3.13. The analysis of the results is presented in Table 3.4 and these are compared with the water quality criteria of designated best use given by Central Pollution Control Board (CPCB). (Refer Appendix 3.1)

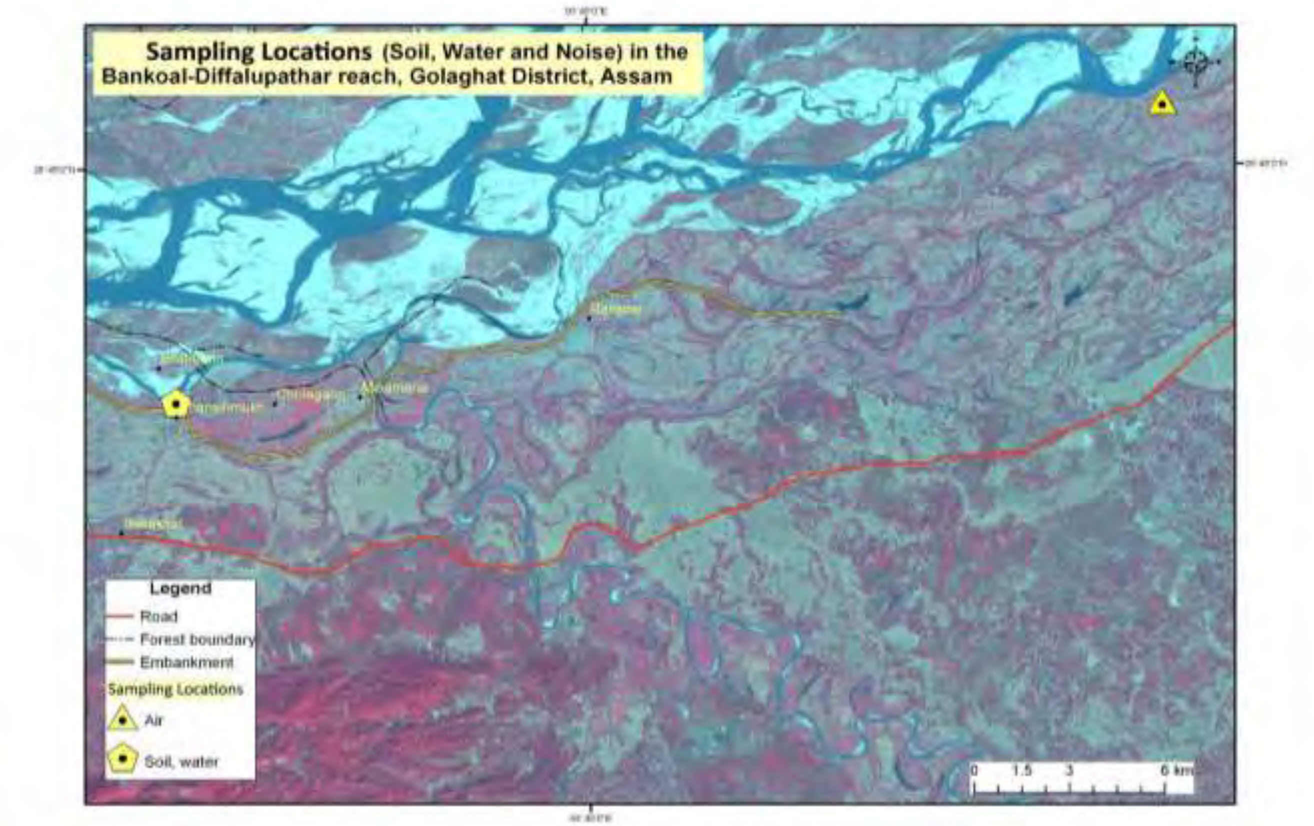


Figure 3.13 Sampling Locations of Water, Soil and Air

Table 3.4 Water Quality at Selected Locations in Kaziranga reach

Parameter	Unit	Dhansirimukh	Sakopara
Colour	Hazen	Colourless	Colourless
Odour	-	Nil	Nil
Temperature	(ºC)	21	22
pH	-	7.1	6.9
Electrical Conductivity	(mS/cm)	2.4	2.6
TSS	mg/L	180	197
TDS	mg/L	14.2	17.1
Total Hardness	mg/L	52	42
DO	mg/L	8.1	9.7
BOD	mg/L	4.2	3.2

Parameter	Unit	Dhansirimukh	Sakopara
COD	mg/L	2.2	2.2
Chloride	mg/L	27.4	24.1
Sulphate	mg/L	6.7	8.4
Nitrate	mg/L	2.3	1.8
phosphorus	mg/L	BDL	BDL
Calcium	mg/L	13.6	14.4
Magnesium	mg/L	38.4	27.6
Ammonical Nitrogen	mg/L	3.1	2.8
Total nitrogen	mg/L	5.2	4.1
Arsenic	Ppb	0.002	0.001
Iron	Ppm	0.76	1.12
Manganese	mg/L	BDL	BDL
Lead	mg/L	BDL	BDL
Fluoride	mg/L	1.4	1.07
Total Coli form	Coliform/100mL	9	11
Focal Coli form	Coliform/100mL	1	0

(Note: BDL – Below Detection Limit)
(Source: Field monitoring and analysis done by Department of Environment Science, Tahiti University)

77. The comparison of the surface water samples analyzed against the water quality criteria for designated best use shows that the water quality of the project area meets the criteria of Class C “Drinking Water Source After Conventional Treatment.”

3.2.4.2 Hydrological and Morphological Aspects

78. The hydrology and morphology of the Kaziranga reach stretching from Bankoal to Diffalupathar for a total length of 28.88 km is dominated by frequent flooding and vigorous erosion hazards of the Brahmaputra, and its tributary rivers originating in the Karbi – Anglong hills that flow through the KNP. The Dhansiri River, a tributary of Brahmaputra River is protected partly near the mouth on the western side (See Figure 2.5). This embankment is connected to one PWD road, which is further connected to NH-37. On the eastern side of Dhansiri River, no embankment or protection is provided. Also, there is a branch river of Dhansiri called Geelabeel River, flowing almost parallel to the Brahmaputra River on an east – west direction. During flood season, spilling occurs on the two sides of these rivers and the area around is flooded. The Krishibundh (the low bund with limited flood protection area) is located on eastern side of Dhansiri River.

79. Regarding the KNP, its location inside a bend of the Brahmaputra buttressed by the Karbi hills on the south helped in the emergence of the low swampy environment with numerous wetlands and extensive grass cover. Floods also help in the formation of different types of soils in different locations of the area. During high floods especially when the beels and grasslands are submerged, the animals from the Park suffer from shortage of fodder and often migrate to the neigh boring hills of Karbi – Anglong across the NH-37. Erosion has been a major threat to the Park as it has already lost considerable area within it.

80. The Brahmaputra River carries more water per unit area of its basin than any other river of the world, and is second only to the Yellow river in China in terms of sediment yield. The pattern of sediment yield in the major tributaries of the Brahmaputra River in Assam is shown in Table 3.5. The high sediment yield in the tributary rivers as well as the mainstream of the Brahmaputra is attributed mainly to the extremely potent rainfall regime, easily erodible rock formations, frequent seismic events causing massive landslides in the hill slopes, and human depredations in the watersheds through harmful land use practices, encroachment of water bodies, forest areas and hill slopes.

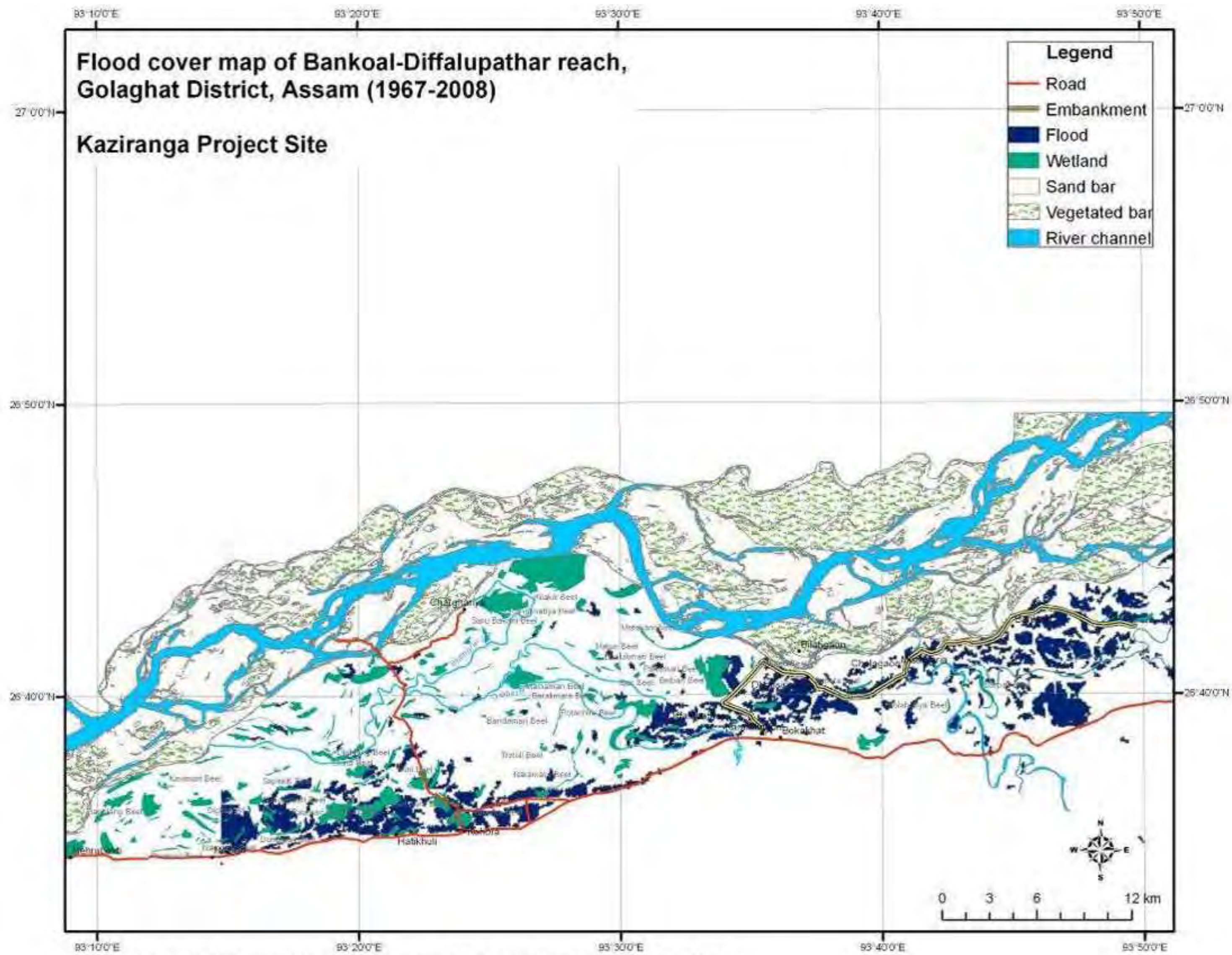
Table 3.5 Water and Sediment Yields of Selected Tributaries of the Brahmaputra River, Assam

River	Drainage area (km^2)	Water yield ($m^3 s^{-1} km^{-2}$)	Sediment yield (tons $km^{-2} yr^{-1}$)
Brahmputra at			
❖ Tsela d' Zang (China)	191222	0.0105	100
❖ Pasighat (India)	244700	0.0231	340
❖ Pandu (India)	500000	0.0306	804
❖ Bahadurabad (Bangladesh)	580000	0.0331	1128
Dibang	12120	0.1066	3765
Lohit	22077	0.0709	1960
Subansiri	27400	0.0756	959
Jia Bharali	11300	0.0858	4721
Puthimmari	1787	0.0403	2887
Pagladia	383	0.1087	1883
Manas	36300	0.0232	1581
Kulsi	750	0.0797	135
Buridhing	4923	0.0788	1129
Desang	3950	0.0382	622
Dhansiri	10240	0.0184	379
Kopili	13556	0.0182	230

(Source: After Goswami, 1985) [10]

81. The flood inundation scenario in the Kaziranga reach based on analysis of satellite data is revealed in the map of an 8 km buffer zone in Figure 3.14. It shows the area affected during the flood of 2004, which is considered to be among the most severe ones to occur in this region. The area covered by inundation was 7,412 ha, which accounts for 10.72% of the geographical area in buffer around the embankment.

[10] Goswami, D.C.1985. Brahmaputra River, Assam, India: Physiography, basin denudation and channel aggradations. *Water Resources Research*. 21: 959-978.



Configuration of the Brahmaputra river: IRS image, 2008; flood inundation:13th July, 2008

Figure 3.14 Flood Inundation Map of Kaziranga reach

Table 3.6 Pattern of Flooding in Buffer Zone of Kaziranga reach (as on July 13, 2004)

Particular	Area (ha)	Area (%)
Flooded Area	7,412	10.72
Total Area in Buffer	69,133	100

82. The morphology of the Brahmaputra River is characterized by intense braiding, bar formation, and extremely dynamic bankline and bed configuration. The morphology and behaviour of the river undergoes drastic changes in response to variation in the flow regime and pattern of sediment transport and deposition in the river following the seasonal rhythm of the monsoon.

83. The Brahmaputra is a classic example of a braided river – a river in which the channel exhibits successive bifurcation and rejoining of flow around sand bars and islands. In case of the Brahmaputra in its Assam Reach, a combination of multiple factors, such as excessive

sediment load, large and variable flow, easily erodible bank materials, aggradations of the channel have been identified as the possible underlying factors.

84. Another striking feature of the river's morphology is the continuous shift of the thalweg (deep channel) from one location to another within the banklines of the river. Bank materials of the Brahmaputra consist mainly of varying proportions of fine sand and silt with only occasional presence of clay. There is a relatively fine grained topstatum and a coarser substratum.

85. The bed regime of the Brahmaputra is characterized by drastic changes in bottom configuration and occurrence of bedforms of greatly varying sizes ranging from small size ripples of few centimeters wavelength to giant size dunes and waves of dozens of meters. The dynamic pattern of the channel configuration and movement of the Brahmaputra in the Kaziranga Reach is demonstrated for different years based on the IRS satellite images for 1973, 1990, 2000, 2007 and 2008 in Figure 3.15. The analysis shows that there has been a continuous shift in the channel towards south causing massive erosion in the area. The movement of the thalweg (deep channel) towards the south bank and its present position hugging the backline where existing protection measures that include embankments are under serious threat is well evidenced in the succession of images presented. The Figure 3.16 shows the pattern of erosion and accretion of the bank during the period 1967 to 2008 based on analysis of satellite as well as conventional data using GIS. The rates of erosion and accretion estimated from this analysis for the period 1967 - 2008 are 7336.42 ha and 3329.46 ha, respectively, giving a net loss of around 4006.96 ha of land.

86. Several water bodies (See Figures 3.13) of permanent nature (beels), marshy and swampy areas and numerous channels, both dead and live, characterize the entire landscape. The Brahmaputra River flowing along the northern boundary of the reach exhibits an intensely braided channel pattern with numerous chars (sandbars) some of which are of considerable size and semi-permanent covered with tall grasses.

Configuration of the Brahmaputra river in the Bankoal-Diffalupathar reach, Golaghat District Assam

Kaziranga Project Site

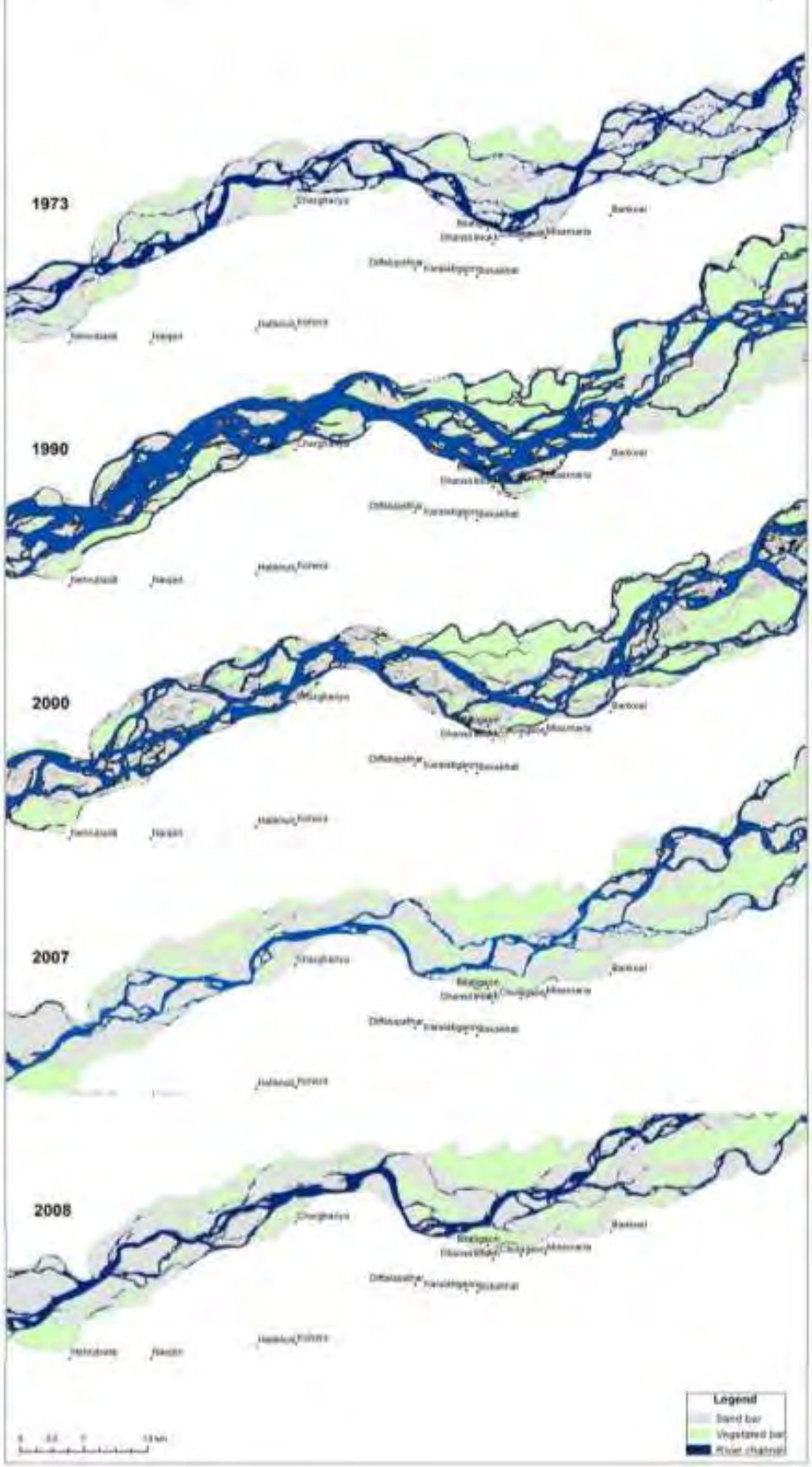


Figure 3.15 Pattern of Channel Configuration and Thalweg Movement of the Brahmputra River in Kaziranga Reach (1973 - 2008)

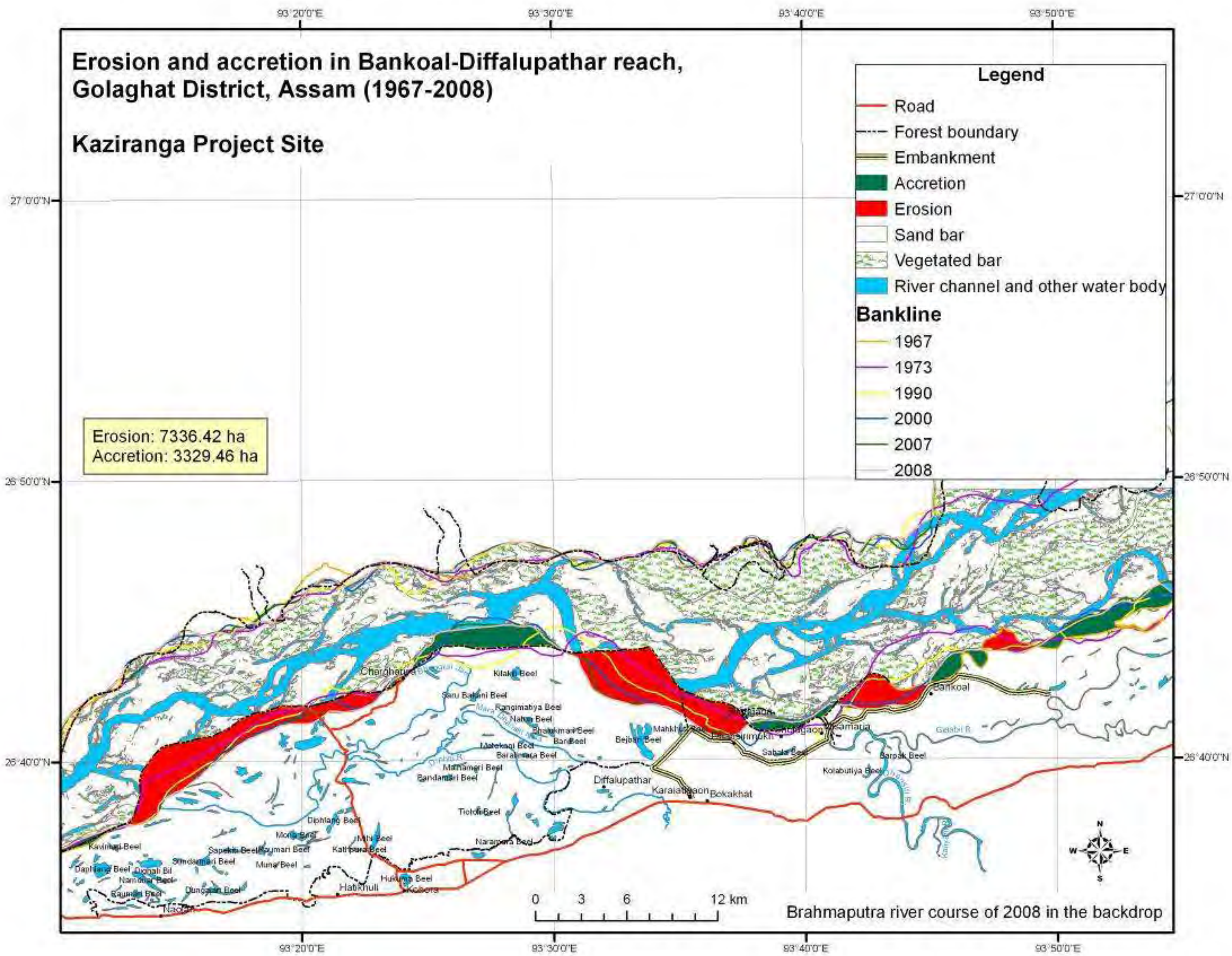


Figure 3.16 Pattern of Erosion and Accretion of the Brahmaputra Bank in the Kaziranga reach (1967 – 2008)

87. The pattern of bankline migration in the reach during different time periods is shown in Figure 3.17. There has been persistent regression of the backline in most of the locations where cross sections are taken although at varying rates. Maximum bankline shifting was observed during 1973 – 1990 period, when it had shifted by more than 4 km. The pattern of shifting of the bankline during the present decade as depicted on the map for the period 2000 - 2007 shows progression in all the sections except a major amount of regression (backward shifting) in one cross-section.

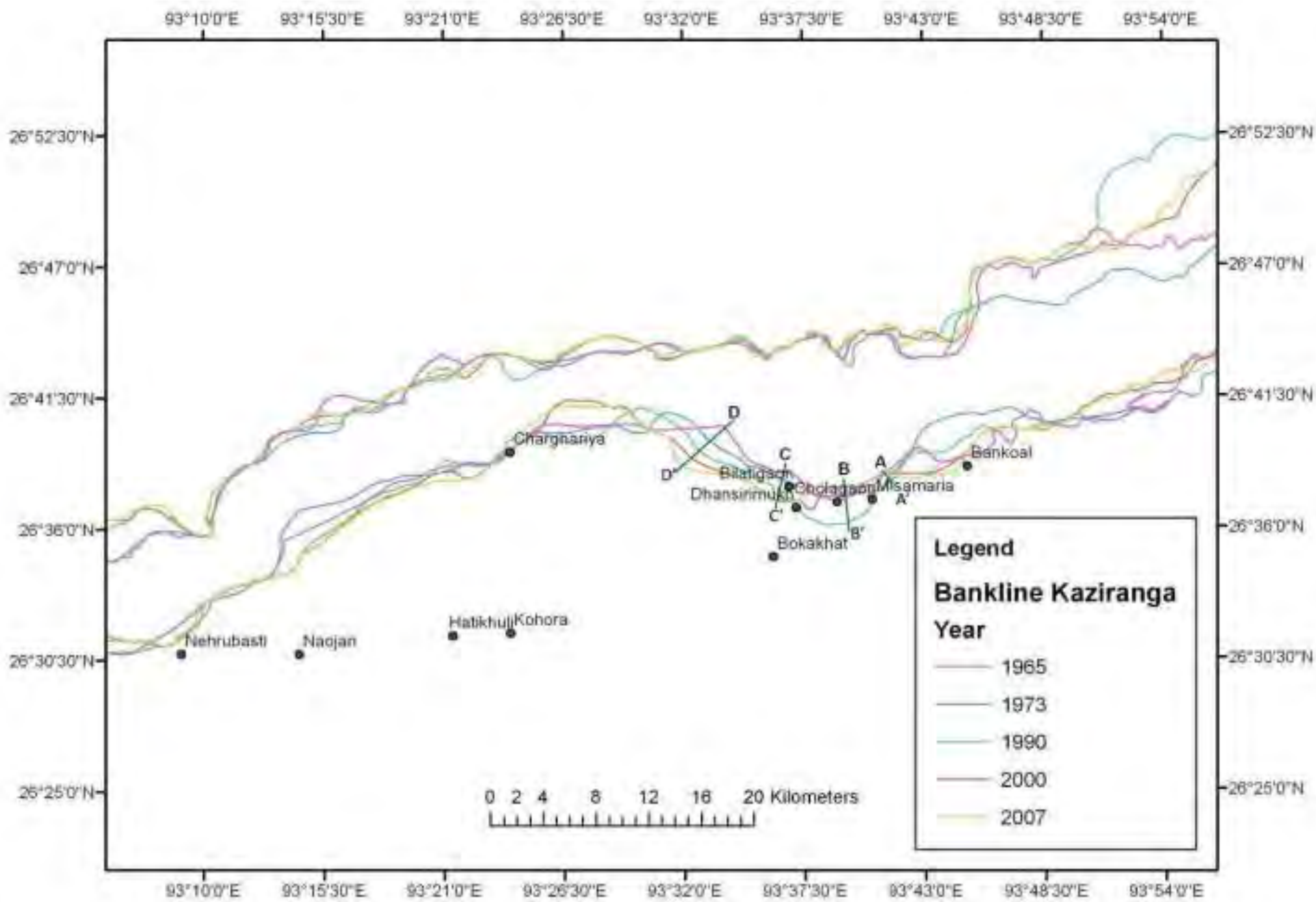


Figure 3.17 Bankline Migration (in m) of the Brahmaputra River in the Kaziranga reach at Selected Cross-sections during different Time Periods

Table 3.7 Rates of Bankline Migration (in m) at Selected Cross-sections in the Kaziranga reach during different Time Periods

Cross-Section	Period			
	1965 - 1973	**1973 - 1990**	**1990 – 2000**	**2000 - 2007**
AA'	-552	-233	717	148
BB'	-393	-1791	2750	79
CC'	-573	-1200	-442	65
DD'	-1500	-1125	-820	-893
Total	**-3018**	**-4349**	**2205**	**-601**

88. The channel cross-section of the Brahmaputra River near Bankoal is shown in Figure 3.18 indicates the morphology and dynamism of the river channel.

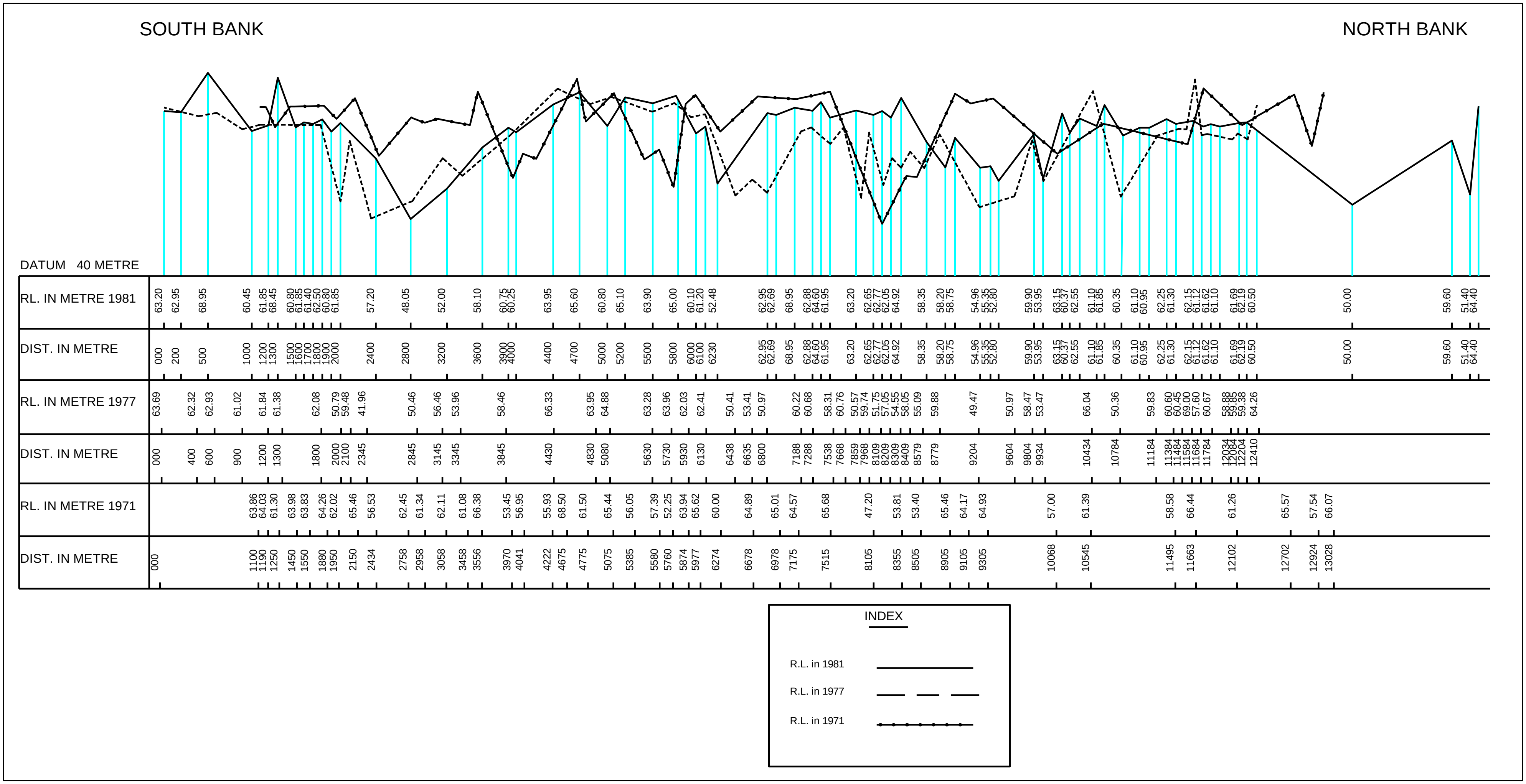


Figure 3.18 Brahmaputra Channel Cross-section near Bankoal

3.2.5. Geology

89. The Brahmaputra valley is formed during the Pleistocene and recent times dating back to approximately 2 million years from sediments derived from the Himalayas in the north and the Assam plateau in the south and brought down by the Brahmaputra River and its tributaries. It is considered to be a tectono-sedimentary basin, 720 km long and 80-90 km wide, underlain by recent alluvium approximately 200-300 m thick consisting of clay, sand and pebble.[11] The basin is underlain for the most part by very young and unweathered sedimentary formations with the result that the river carries mainly fine sand and silt with very little clay. A dominant feature of the riverine landscape of the Brahmaputra is the large number of sandbars of varying shapes and sizes locally known as Chars that develop on the sandy bed of the braided channel. Although mostly transitory in nature, some of these chars are more or less permanent with a veneer of fertile soil on the top that supports vegetation, crops and settlements.

90. The area in and around the Kaziranga Reach is formed by recent alluvium deposited by the Brahmaputra River and a number of tributaries like the Dhansiri, the Diffolu and the Gelabeel. A host of geomorphic features including abandoned river channels, cut-off meanders, meander scars, backswamp deposits are found in the active floodplain belt comprising this reach. The palaechannels occurring in this area belong to the Ifolocene period.

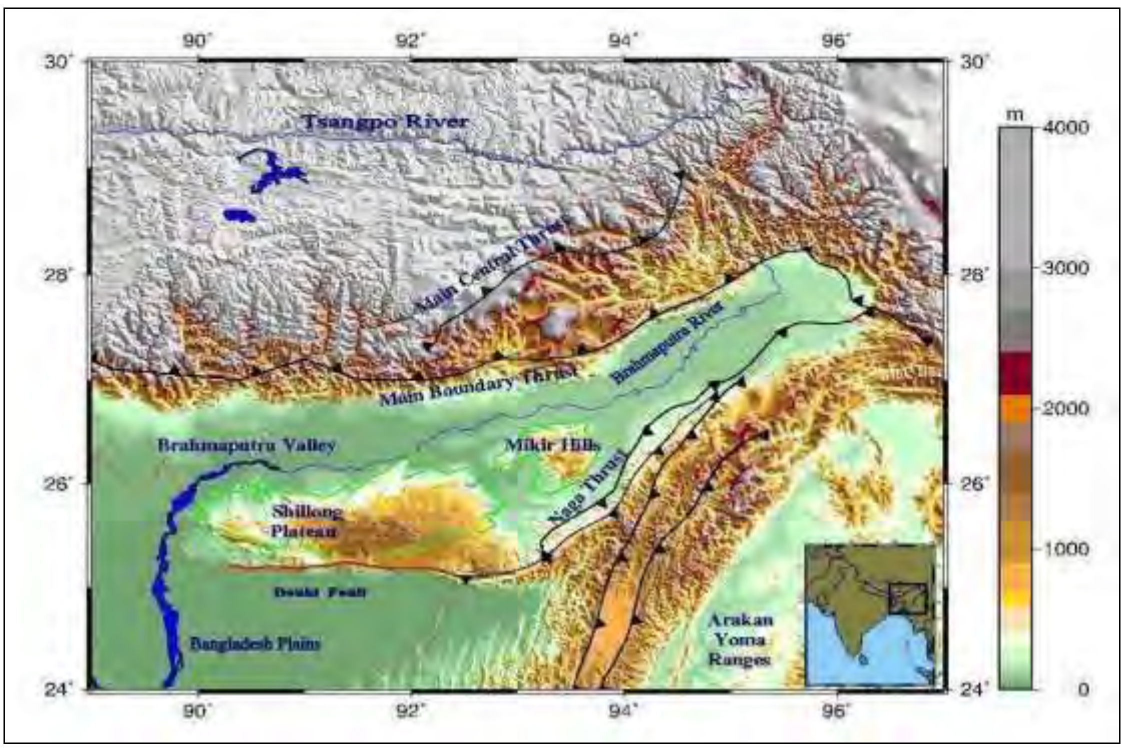


Figure 3.19 Geotectonic Map of Brahmaputra River Valley and its Adjoining Highlands

3.2.6. Seismology

91. Due to their strategic location in regard to colliding Eurasia (Chinese), Indian and Burmese tectonic plate boundaries, the Brahmaputra valley and its adjoining hill ranges are seismically very unstable. The earthquakes have caused extensive landslips and rockfalls on

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[11]GSI. 1977. *Contributions of geomorphology and geohydrology of the Brahmaputra Valley*. Miscellaneous Pub. 32.

the hill slopes, subsidence and fissuring of ground in the valley, and changes in the course and configuration of several tributary rivers as well as the mainstream. The geo-tectonic map of the Brahmaputra valley and its adjoining highlands is presented in Figure 3.19.

92. There appears to be phases of rapid aggradations of the Brahmaputra River associated with earthquakes, mainly as a result of deposition of sediments received from landslides, followed by relatively slower removal of accumulated debris over longer time periods. Active seismicity of the NE region has a very significant impact on the hydrologic regime and morphology of the Brahmaputra River including its host of tributaries and other water bodies (e.g. wetlands) strewn over the floodplains. Occurrence of these episodic events led to intensification of flood hazards, especially in the aftermath of the two great earthquakes of 1897 and 1950.[12]

93. The region coming under the seismically active zone of the North Eastern region has considerable vulnerability in regard to the active seismicity of the region. There appears to have significant impact of earthquakes on the hydrology and morphology of the Brahmaputra River and some of its tributaries. As a result of the 1950 earthquake, when the Brahmaputra channel has been raised due to accelerated rates of sedimentation, the flood and erosion scenario has taken a turn for the worse in this reach. The bankline of the river close to the Kaziranga Reach is considerably steep and highly unstable at several places causing heavy erosion in recent times. In fact a considerable part of the reach including the portion under Kaziranga National Park has already been eroded away by the Brahmaputra.

94. As per the seismic zoning map of India, the entire project area falls in Zone V (most severe seismic intensity zone). The seismic zoning map of India is shown in Figure 3.21. The distribution of major earthquakes (above Richter magnitude 7.0) in the NE region since the 1897 Shillong earthquake is shown in Table 3.8.

Table 3.8 Major Earthquakes in Northeastern India and Adjoining Regions since 1897

Date	Epicentre Area	Lat (^{o}N)	Long. (^{o}E)	Magnitude
12-06-1897	Shilong, Meghalaya	26^{o}00'	91^{o}00'	8.7
31-08-1906	India-Burma Border	27^{o}00'	97^{o}00'	7.0
12-12-1908	Kachim, Burma	26^{o}30'	97^{o}00'	7.0
09-09-1923	Jankaria,Meghalaya	25^{o}12'	91^{o}00'	7.1
02-07-1930	Dhubri,Assam	25^{o}30'	90^{o}00'	7.1
27-01-1931	Kachin,Burma	25^{o}36	96^{o}48'	7.6
04-08-1932	India-Burma Border	26^{o}00'	95^{o}30'	7.0
23-10-1943	Hojai,Assam	26^{o}00'	93^{o}00'	7.2
29-07-1947	Tammu,Arunachal Pradesh	28^{o}30'	94^{o}00'	7.8
15-08-1950	India-Burma-China Border	28^{o}50'	96^{o}30'	8.7
06-08-1988	Manipur-Burma-Border	25^{o}14'	95^{o}12'	7.2

[12] Goswami, D. C. and Das, P J., 2002: Hydrological Impact of Earthquakes on the Brahmaputra River Regime in Assam: A case study in exploring some evidences, Proc. 18th National Convention of Civil Engineers, Nov. 9-10, 2002, pp. 40 -48.

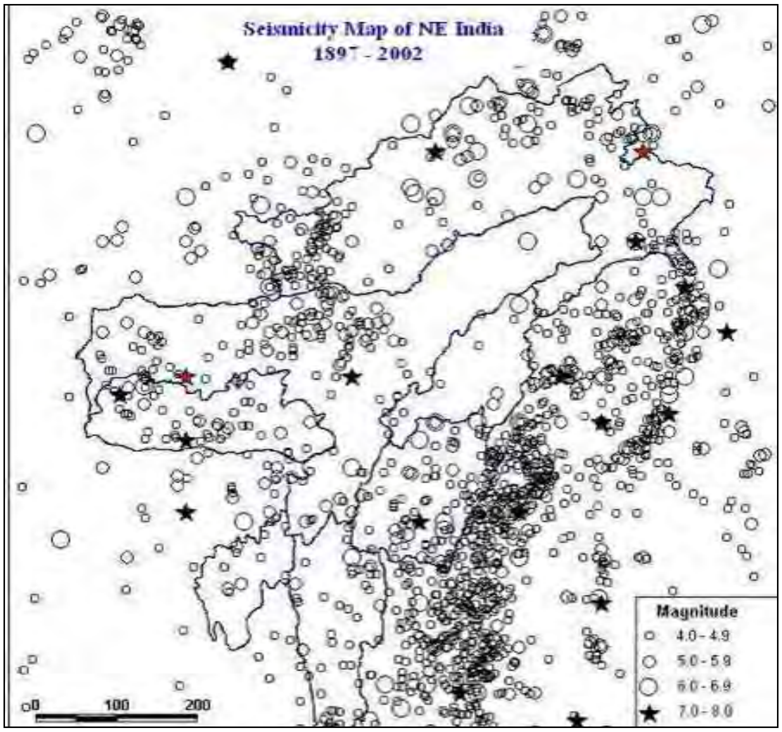

Figure 3.20 Seismicity Map of Northeast India (1897 – 2002)

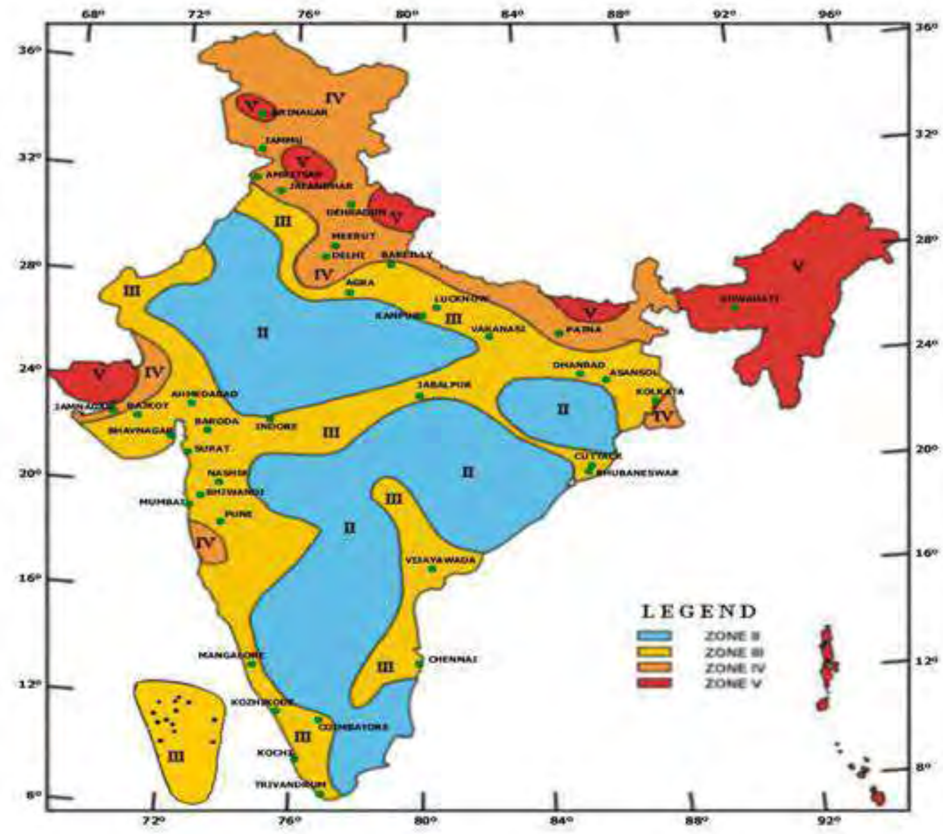

Figure 3.21 Seismic Zoning Map of India

3.2.7. Soil

95. The subproject area, and in fact the entire project area, is almost entirely made up of alluvial soils formed on recent river deposits called new alluvium, which are also termed as Fluvisols or Fluvents. These are mostly composed of sandy to silty loams and are neutral to slightly acidic in reaction. In limited upland areas within the valley and in the foothill region, there are few isolated pockets of deeply weathered Pleistocene deposits of older alluvium. A study of the lithologs of the Quarternary sediments of the Brahmaputra valley extending down to more than 100 m reveals repeated sequence of clay, pebbles, and boulders.[13] In the hill areas, especially to the south of the reach, laterites and red loams are found. The distribution of soil types in Assam is shown in Figure 3.22.

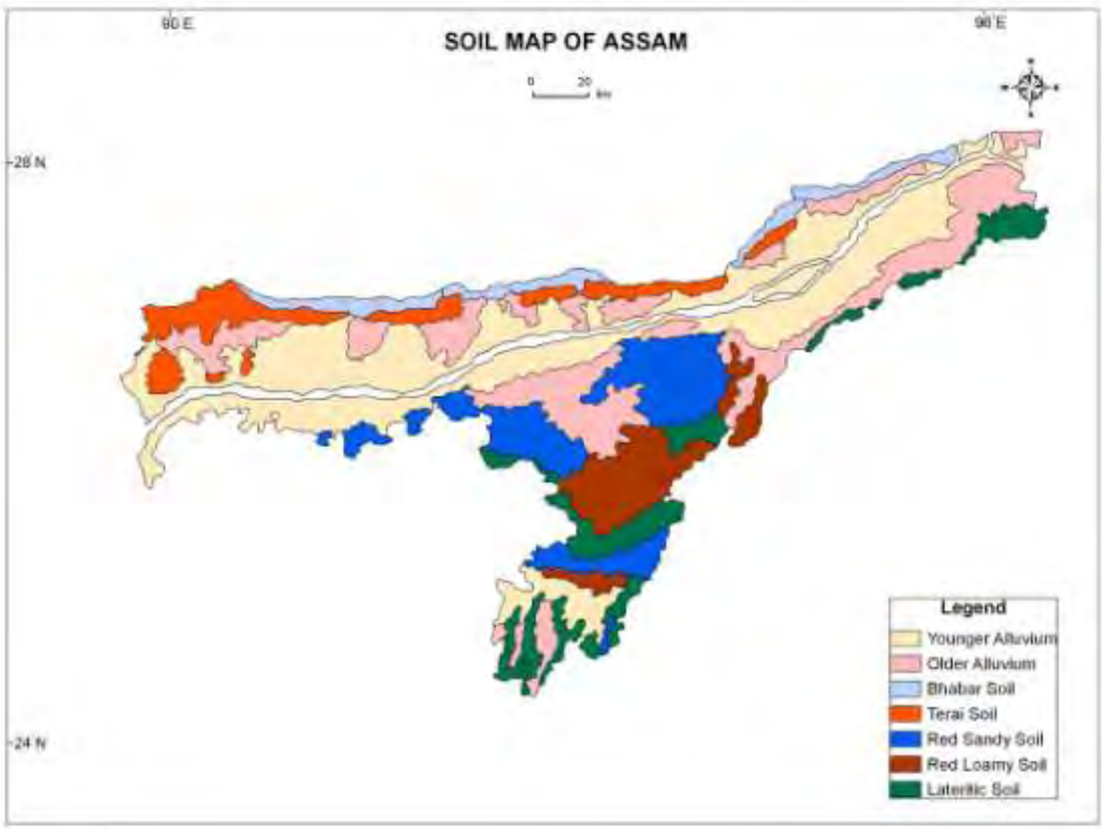

Figure 3.22 Soil Types in Assam

96. The soil quality of the project area was sampled and analyzed for two locations, namely Dhansirimukh and Sakopara. The sampling locations are shown in Figure 3.13 and soil quality at selected locations in Kaziranga reach is given in Table 3.9. The soil quality in the Kaziranga Reach shows medium organic carbon, medium available nitrogen, and low available phosphorous and low available potassium.

[13] GSI. 1977. *Contributions of geomorphology and geohydrology of the Brahmaputra Valley*. Miscellaneous Pub. 32.

Table 3.9 Soil Quality

Parameters	Unit	Dhansirimukh	Sakopara
Organic carbon	%	0.67	0.59
Organic matter	%	1.74	4.65
Available nitrogen	Ppm	27.8	31.5
Available phosphorus	Ppm	0.003	0.005
Iron	Ppm	0.106	0.042
Copper	Ppm	0.017	0.005
Manganese	Ppm	BDL	BDL
Lead	Ppm	BDL	BDL
Chromium	Ppm	BDL	BDL
Zinc	Ppm	0.025	0.02
Mercury	Ppm	BDL	BDL
Arsenic	Ppm	0.001	0.002
Potasium	Ppm	39	42
CEC		0.85	0.77
Textural Classes		Clay	Clay
Clay	%	47	32
Silt	%	28	37
Sand	%	25	31
Bulk Density	g/cc	4.2	3.0
Water Holding Capacity	%	30.3	31.3
Pore Space	%	41.3	39.0
Specific Gravity	%	1.36	1.22
Electrical Conductivity	dS/m	2.2	2.4

(Source: Field Monitoring and Analysis by Environmental Science Department, Gauhati University)

3.2.8. Land Use

97. The current land use pattern in the area is examined in three different scale and space dimensions keeping in view the nature and intensity of the potential impact of the different project elements. On a broader scale, an 8 km buffer around the embankment is chosen and the land use pattern within the zone is delineated from satellite images using GIS. The size of the buffer is decided based on the consideration of topography and the location of the major wetlands or tributaries of the area. The land use map of the 8 km buffer zone around the embankment is presented in Figure 3.23 and the areas covered by different categories of land use are given in Table 3.10.

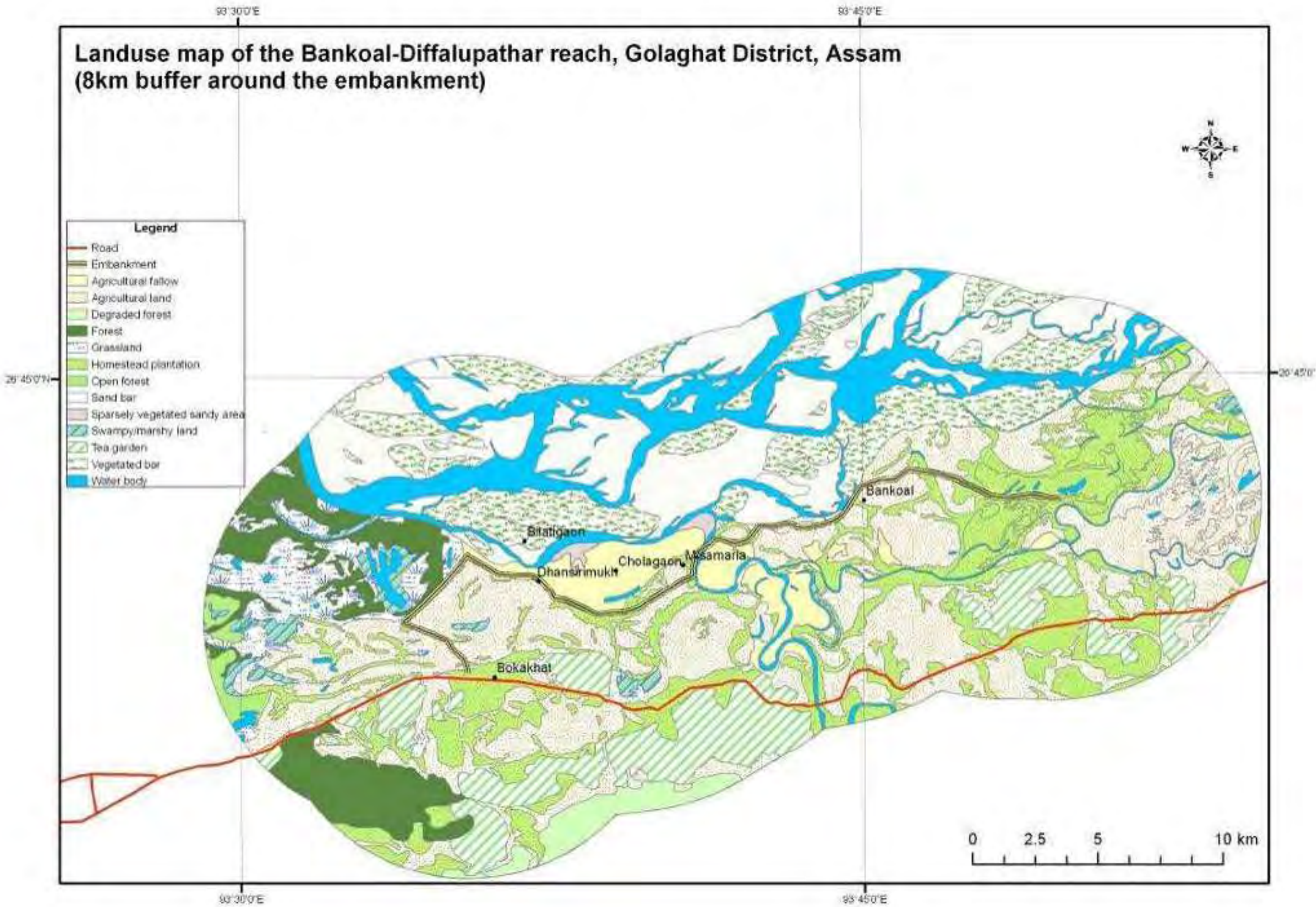

Figure 3.23 Landuse Map of Kaziranga Reach (8 km buffer around embankment)

Table 3.10 Landuse in the Study Area (8 km buffer around embankment)

Category	Area (ha)	Area (%)
Agricultural fallow	2454.9	3.6
Agricultural land	18137.8	26.2
Degraded forest	1035.0	1.5
Forest	3779.1	5.5
Grassland	2119.3	3.1
Homestead plantation	11542.8	16.7
Open forest	446.9	0.6
River channel	6806.6	9.8
Sand bar	9318.5	13.5
Sparsely vegetated sandy area	165.2	0.2
Swampy/marshy land	813.6	1.2
Tea garden	5565.1	8.1
Vegetated bar	6391.9	9.2
Water bodies	556.3	0.8
Total	**69133**	**100**

(Source: IRS-P6 data for Year 2008)

98. Out of the total study area of 69,133 ha within the study area, agricultural land occupy 18,137.8 ha accounting for 26.2% of the total geographical area, followed by homestead plantation (16.7%), sand bars (13.5%). River channel occupy about 9.8% area of the buffer, whereas other water bodies occupy 0.8% area. Vegetated chars are also present in the area occupying about 9.2% of the total buffer area.

99. Land use pattern is also examined in a 100 m direct impact zone on either side of the embankment using satellite remote sensing and GIS. The dimension of the direct impact zone is decided based on field observations as well as discussions with technical and administrative officials of the Government. The 100 m direct impact zone for the entire reach is shown in Figure 3.24. The land use data for the direct impact zone is presented in Table 3.11. It indicates that the agricultural lands occupy the largest portion of the area (38.7%) followed by homestead plantation (28.2%) and agriculture fallow land (20.7%).

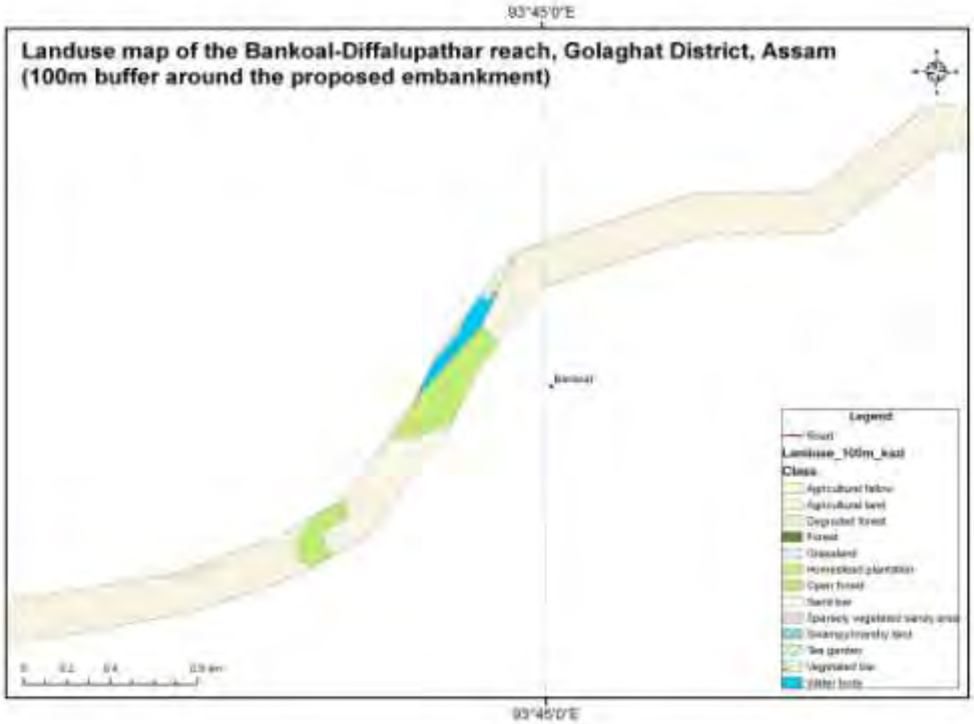

Figure 3.24 Landuse Map of Kaziranga Reach (100 m Buffer Around Embankment)

Table 3.11 Landuse of Kaziranga reach (100 m buffer around the embankment)

Category	Area (ha)	Area (%)
Agricultural fallow	144.1	20.7
Agricultural land	269.9	38.7
Forest	21.1	3.0
Grassland	47.3	6.8
Homestead plantation	196.1	28.2
River channel	15.3	2.2
Sand bar	1.3	0.2
Vegetated bar	1.4	0.2
Total	**696.5**	**100**

100. The land use pattern in the zone lying between the bank and the embankment was also mapped using satellite data and GIS (Figure 3.25). The result of this analysis is shown in Table 3.12. It shows that agricultural land dominates the land use accounting for 31.0% of the total area followed by agricultural fallow land (29.2%) and homestead plantation (19.8%).

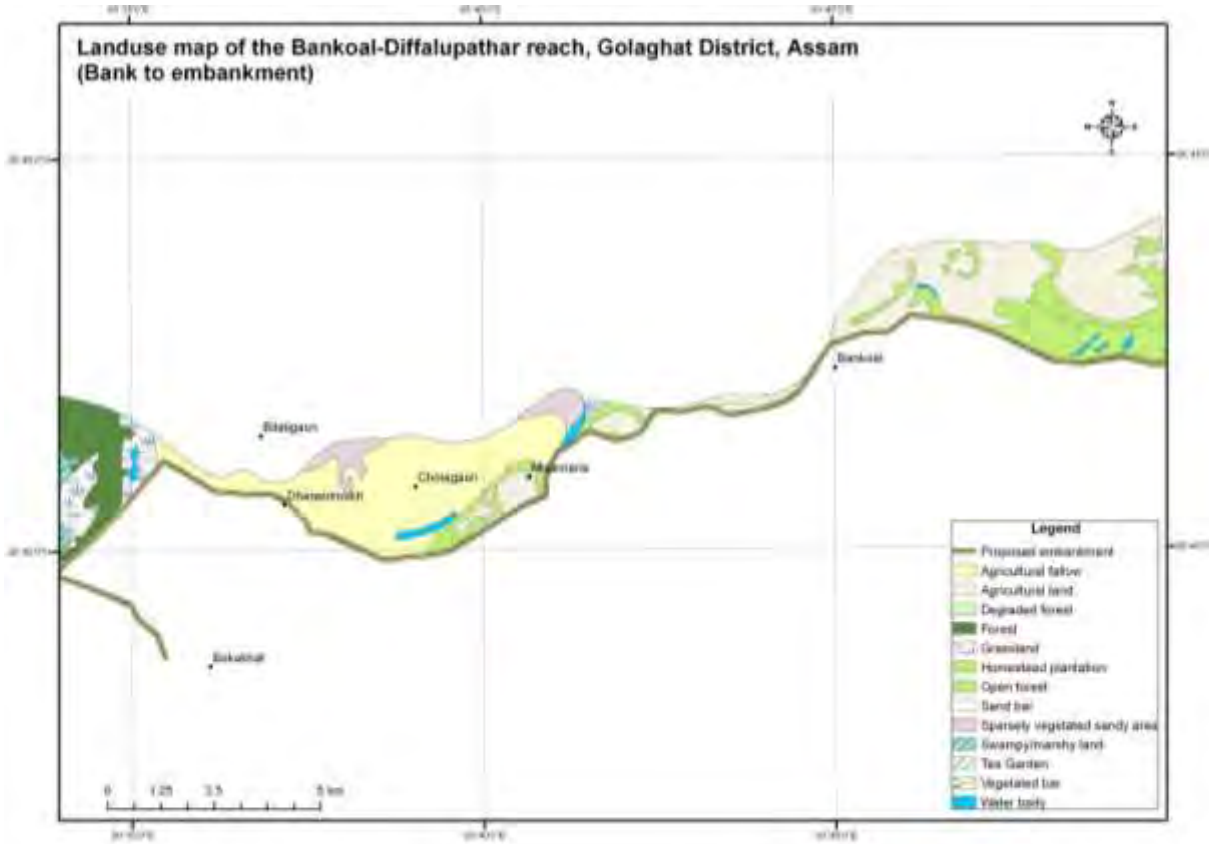

Figure 3.25 Land use Map of Kaziranga reach (Bank to Embankment)

Table 3.12 Land use of Kaziranga Reach (Bank to Embankment)

Category	Area (ha)	Area (%)
Agricultural fallow	1216.8	29.2
Agricultural land	1290.2	31.0
Forest	326.3	7.8
Grassland	240.6	5.8
Homestead plantation	823.2	19.8
River channel	18.0	0.4
Sparsely vegetated sandy area	159.6	3.8
Swampy/marshy land	32.7	0.8
Water body	57.5	1.4
Total	**4164.9**	**100**

3.2.9. Air Quality

101. The Kaziranga Reach being rural in character with limited economic development and infrastructure has a relatively undisturbed ambient air quality. There are no major sources of air pollution in this reach except for unpaved road travel. However, in order to scientifically establish the baseline air quality status as required for the purpose of environmental impact assessment, and in view of its future relevance, ambient air quality was monitored at Bankoal as indicated in Figure 3.13. The results of ambient air quality monitoring in the reach are

presented in Table 3.13. The ambient air quality results have also been compared with the National Ambient Air Quality Standards (NAAQS) for Residential and Rural Areas in India.

Table 3.13 Ambient Air Quality

S. No.	Parameter	Unit	NAAQS for Residential and Rural Areas	Bankoal
1.	Suspended Particulate Matter (SPM)	µg/m^3	200	78
2.	Respirable Suspended Particulate Matter (RSPM)	µg/m^3	100	32
3.	Oxides of Nitrogen (NOx)	µg/m^3	80	3.8
4.	Sulphur Dioxide (SO2)	µg/m^3	80	3.7
5.	Lead (Pb)	µg/m^3	1.0	0.056
6.	Carbon Monoxide (CO)	µg/m^3	2000	150
7.	Hydrocarbons (HC)	µg/m^3	-	750

(Source: Field Monitoring done by Dept. of Environmental Science, Gauhati University)

102. It is evident from the comparison that all the air quality parameters are found well within the permissible limits as per the NAAQS for residential and rural areas. The National Ambient Air Quality Standards in India are shown as Appendix 3.2.

3.2.10. Noise Environment

103. Ambient noise levels along the Kaziranga Reach have been monitored at Dhansari, Sakopara and Road Side (Kaziranga) during day and nighttimes. In the absence of any major source of noise pollution in the immediate vicinity of the impact corridor, the noise levels observed were well within the standards for residential areas. The ambient noise levels during day and night time are presented in Table 3.14. The National Ambient Air Quality Standards in respect of noise are shown as Appendix 3.3.

Table 3.14 Ambient Noise Levels in the Study Area

Location	AAQS in respect of Noise for Residential Area		Day Time [dB(A)]			Night Time [dB(A)]		
	$L_{eq(day)}$	$L_{eq(night)}$	L_{max}	L_{min}	$L_{eq(day)}$	L_{max}	L_{min}	$L_{eq(night)}$
Dhansiri	55	45	58	41	51	47	36	44
Sakopara			49	33	42	51	32	41
Kaziranga (Road Side)			62	48	52	57	48	51

(Source: Field Monitoring, Dept. of Environmental Science, Gauhati University, March 2008)

3.3. Terrestrial Ecology

104. Assam is one of the most important biodiversity 'hotspot' in northeastern region of India. The area harbours great varieties of wildlife species in its diverse and mosaic natural habitats. The wilderness habitat of Assam supports 689 species of bird[14], 194 species of mammals[15], 185

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14 Saikia, P. K. and M. Kakati 2000. Diversity of Bird Fauna in North East India.Jour. Assam Sci. Soc. Vol: 41(4): Pp 379-396.

15 Chaudhury, A. U. 1997.Checklist of the Mammals of Assam. Gibbon books with Assam Science Technology and Environment Council. PP 1-103.

species of fish[16], 115 species of reptiles, 54 species of amphibians[17], more than 900 species of butterflies[18] and immense varieties of moths. In floral diversity, Assam has documented 6,027 species of plants, of which 3,010 are flowering plants along[19]. The area sustained 33 endangered mammalian fauna, above 20 endangered avian fauna under Wildlife Protection Act, 1972 and 45 globally threatened avian fauna and 17 endemic birds. Apart from that the state supports above 15 endangered reptilian and amphibian fauna each, 43 endangered insets fauna[20].

105. The Bankoal – Diffalupathar reach along the Brahmaputra River is in the immediate vicinity of the Kaziranga National Park. The reach is severely being affected by continuous bank erosion and flood inundation caused by the Brahmaputra over last few decades threatening the existence of the park and survival of its unique wildlife. There appears to be immediate danger from potential avulsion of a spill - channel along existing depression and wetlands within the park thereby isolating the main park area from the surrounding highland.

3.3.1. Methods for Baseline Data Collection

106. The tree samples in the project site have been taken from Bankoal Bali Sapori (ch.1.0 km to ch. 5.0 km); Krishibund in Bankoal (ch. 0.0 km to ch. 5.5 km); Moriaholla to KRF boundary (ch.0.0 km - ch 10.25 km); KRF boundary to Diffalupathar (ch 10.25 km to 23.38 km); extension of Brahmaputra dyke from Diffalupathar to NH 37 (ch 23.38 km to 26.88 km); and Tamul pathar (chain 31.0) etc. The data were collected based on departmental demarcation of the Brahmaputra dyke. The assessment was carried out from 11 February 2008 and continuing till April, 2008**.** The published materials were collected to gather the additional data.

107. The identification of tree species was made as per the books on plant taxonomy. The plant species sampling was done with the help of Plant taxonomist from the Department of Botany, Gauhati University. The animal species data were collected in study sites through direct sighting methods, indirect evidences and as well as the information of local inhabitants (through displaying the animal's colour plates). Identification of Mammalian, Avian and Reptilian species were made as per the available Books and published materials. For data analysis, the SPSS Software Version 11.0.1 and Species Diversity & Richness Software Version 3.0 were used.

3.3.2. Identification of Terrestrial Flora

108. The area falling from Mohkhuti Camp to Agoratali area is under Kaziranga National Park and others are situated outside the Park boundary. The vegetation compositions of the terrestrial zones comprise, viz., Ajar-*Lagerstroemia flosrganae,* Areca catechu, Terminalia arjuna, Erythrine indica, Am-Mengifera indica, *Kash Kol*-Musa paradisiacal, *Narikol*-Cocos nucifera, Sajina-Moringa oleifera, Elaeocarpus floribundus, Siris-Albizzia lebek, Kolajamun-Syzygium cumini, Bogori-Zizipha zuzuba, Kadam-Anthocephalus cadamba, Atlas-Annona squamosa, Segun-Tectona grandis, Ahot-Ficus religiosa, Dimoru-Ficus lipidosa, Krishna sura-Delonix regia, Morapat-Corchorus capsularis, Palas-Butea monosperma, Kathal-Artocarpus heterophylus, *Sunaru*-Cassia fistula, *Bholukabanh*-B. balcooa, Mokal Banh-B. nutans, Jati

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[16] Das, S. K. 2000. Fish Genetic Resources of North East India and their status of Conservation. Jour. Ass. Soc. Vol: 41(4): PP.355-362.

[17] Hattar, S. J. S. 2000. Overview of Faunal Diversity of Northeast India. Jour.Assam Sci. Soc. Vol: 41(4): Pp 352-354

[18] Evans, W. H. 1932. Identification of Indian Butterflies. Croom Helm Ltd., Kent. (BI).

[19] Mao, A. A. and T. M. Hynniewta 2000. Floristic diversity of North East India. Jour. Assam Sci. Soc. Vol: 41(4): Pp 255-266.

[20] Saikia, P. K. and M. Kakati 2000b. Endangered fauna of Northeast India withspecial reference to Conservation. Jour. My Green Earth. Vol: 1(3). Pp.8-16.

banh- Bambusa tulda, *Chenikol*-M. champa, BhimKol-Musa balbiciana, *Pakori*-F. rumphii, Khongal Dimoru-Ficus tinctoria, Bijuli banh-Bambusa pallida, Karas-Pungamia pinnata, Owtenga-Dillenia indica, Veleo-Tetramelos nudiflora, *Satiana*-Alstonia scolaris, Gamari-Gmelina arborea, Simul-Bombax ceiba, Kutoha banh-Bambusa arundinacea, Sisoo-Delbergia sisso (Appendix 3.4).

109. Other plants available in the project sites are Amita-Carica papaya, *Phulkabi*-Brassica oleracea var, *Ghehu*-Triticum aestivum, Jati Bet- *Calamus erectus,* Dubari Ban- *Cynodon dactylon,* Locosa Ghanh- *Hemarthia compressa,* Birina- *Vetiveria zizanoides,* Ekora-*Saccharum ravanae,* Khagori- *Phragmites karka,* Ulukher- *Imperata cylindrica,* Hankher-*Pollinia ciliata,* Kahua- *Saccharum sponteneum* and Borota Kher- *Saccharum elephantinus etc .*The most other important plant species of the area has been eliminated due to regular flood and changing scenario of soil characters. The major climber species comprises *Stephania harnondifolia* (Tubuki lata), *Zanthoxylum hamiltonianum* (Tej-muri), *Cuscuta reflexa* (Akashi Lata), *Illegeria khasiana* (Kerkeri lata), *Dioscorea hamilttoni* (Bonoria alu), *Smilax macrophylla* (Tikoni boral), *Calamus erectus* (Jati bet), *C. gracilis* (Wahing bet). C. *latifolius* (Motha bet), *Pinaga gracitis* (Raidang Bet), *Pothos cathcartii* (Hati-poita) and *P. scandens* (Kawri Lata) etc (Appendix 3.4).

3.3.3. Identification of Areas of Eco-sensitivity, Protectect and Restricted Areas

110. The Kaziranga National Park attached with certain parts of embankment harbours more than 478 bird species[21], including 24 globally threatened species. While it would not be possible to describe status and distribution of each threatened species. Out of the 478 bird species listed, 197 are residents, 165 are migrants, 46 are local migrants, and the status of the remaining species is uncertain. Notable resident species with significant populations are: spot billed Pelican *Pelecanus philipensis*, Lesser Adjutant *Leptoptios javanicus*, Swamp Francolin *Francolinus gularis*, Bengal Florican *Houbaropsis bengalensis*, Pallas's fish eagle Haliaeetus leucoryphus, Greater Grey headed fish eagle *Icthyophaga ichthyaetus*, white bellied heron *Ardea insignis*, Black necked stork *Ephippiorhynchus asiaticus*, Bristled Grass warbler *Chaetornis striatus*, Marsh Babbler *Pellorneum palustre*, Black breasted parrotbill *Paradoxornis flavirostris* and finn's Weaver *Ploceus megarhynchus*.

111. Some of the uncommon residents are Oriental white baked vulture Gyps bengalensis, slender billed vulture G.tenuirostris, Red vented vulture Sarcogyps calvus, Black bellied tern *Sterna acuticauda*, Pied falconet *Microhierax melanoleucos*, Greater adjutant *Leptoptilos dubius*, Jerdon's Bushchat *Sexicola jerdoni*, Rufous vented prinia *Prinia burnesii*, Jerdon's Babbler *Chrysomma altirostre* and slender billed Babbler *Turoides longirostris*. Some of the species especially of the tall grasslands and thick shrubs may not be as rare as thought because finding them is rather difficult, especially on brief bird watching surveys. Possibly, the globally threatened pale-capped pigeon Columba punicea breeds in the park is considered as a summer visitor.

3.3.4. Important Terrestrial Mammals

112. Kaziranga National park is an internationally famed wilderness, mainly known for the Indian one horned rhinoceros *Rhinoceros unicornis*. However Kaziranga has large populations of many others endangered species, notably the tiger *Panthera Tigris*, wild buffalo *Bubaius arnee*, Asian elephant *Elephas maximus*, swamp deer *Cervus duvaucelli* and many more. However it is equally rich in avian diversity with more than 490 bird species. Situated in the

[21] Baruah, M., and P. Sharma. 1999. Birds of Kaziranga National Park, India. Forktail 15: 47-60.

flood plains of the Brahmaputra River, it covers parts of Nagaon, Golaghat and Sonitpur districts of central Assam. Panbari and Kukurakata reserve forest, small but important areas of many forest bird species, lie just outside the park, but are included in the IBA (Appendix 3.6).

3.3.5. River Interface

113. Although no migratory route of wildlife species was found there, an interface was seen near Dhansirimukh. In this site River Dolphin was seen and the endangered herpitofaunas pass through the river's mouth (ch.25.0 km; co-ordinates: 26°40′19″N-93°37′39″E).

3.3.6. Dolphin and its Behaviour Pattern

114. River Dolphins are found along the tract of river Brahmaputra and Dhansiri river mouth near embankment site. They are the common wildlife during monsoon, but returned back to the deeper channel during winter season when water depth reduced.

3.3.7. Forests

115. There are four main types of vegetations in the area: (i) Alluvial inundated grasslands, (ii) Tropical wet evergreen forest, (iii) Tropical semi evergreen forest, and (iv) Tropical semi evergreen forests. Grasslands predominate in the west, with tall elephant grass on the higher ground and short grasses on the lower ground surrounding the beels. *Erianthus ravennae*, Phragmites *karka, Arundo donax, Imperata cylindrica* and *saccharum* species are the main grass species. The herbaceous *Alpina allughas* grows abundantly all over the grassland, especially in the damp areas. Amidst the grasses are numerous forbs and the scattered trees of *Bombax ceiba, Dillenia indica, Careya arborea* and *Emblica officinalis*. Tropical wet evergreen forest near Kanchajuri, Panbari and Tamulipathar blocks are dominated by trees such as *Aphanamixis polystachya*, *Talauma hodgsonii, Dillenia indica, Garcinia tinctoria, Ficus sp*., *Cinnamomomum bejolghota* and *Syzygium sp*. Tropical semi evergreen forests occur near Baguri, Bimali and Haldibari.Barringtonia acutangula grows in the waterlogged area.

3.3.8. Economically Important Plants

116. Limited abundance of economically important tree species was found in the proposed sub-project site. Altogether 15 economically important tree species were recorded of which 6 have timber value, 4 have fuel wood value, 3 are economically valuable fruit tree species and 2 are economically important seed producing trees.

Table 3.15 Economically Important Tree Species in 100 m around the Embankment

Plant Species	Used type	Outside	Inside
Sisoo-Delbergia sisso	Timber	19	0
Gamari-Gmelina arborea	Timber	60	35
Veleo-Tetramelos nudiflora	Fuelwood	25	112
Bijuli banh-Bambusa pallida	Fuelwood	0	0
Jati banh- Bambusa tulda	Timber	152	35
Mokal Banh-B. nutans	Fuelwood	73	0
Bholukabanh-B. balcooa	Timber	108	0
Kathal-Artocarpus heterophylus	Economically Important Fruit	43	38
Segun-Tectona grandis	Timber	20	11

Plant Species	Used type	Outside	Inside
Kadam-Anthocephalus cadamba	Fuelwood	25	0
Sajina-Moringa oleifera	Economically Important Seed	12	10
Narikol-Cocos nucifera	Economically Important Fruit	10	0
Am-Mengifera indica	Economically Important Fruit	52	0
Terminalia arjuna	Timber	2	0
Areca catechu	Economically Important Seed	58	0

3.3.9. Identification of Endemic, Threatened and Endangered Species within Kaziranga National Park

3.3.9.1 Avian Fauna

117. Kaziranga supports 40 globally threatened avian species, of which 2 are categorized as endemic, 2 critically endangered, 4 endangered and 18 vulnerable.

Table 3.16 Globally Endangered, and Endemic Avian Fauna in Kaziranga National Park

Common Name	***Scientific Name***	Status		
Oriental white baked vulture	*Gyps bengalensis*	CR	Within 100 mtr.	Beyond 100 mtr
Slender billed vulture	*Gyps tenuirostris*	CR	Y	Y
White bellied heron	Ardea insignis	En	Y	Y
Greater adjutant	*Leptoptilos dubius*	En	Y	Y
Bengal Florican	*Houbaropsis bengalensis*	En	Y	Y
Spotted greenshank	*Tringa guttifer*	En	Y	Y
Spot billed pelican	*Pelecanus philipensis*	V	Y	Y
Lesser adjutant	*Leptoptilos javanicus*	V	Y	Y
Lesser white fronted goose	*Anser erythropus*	V	Y	Y
Marbled teal	*Marmaronetta angustirostris*	V	Y	Y
Baer's Poachard	*Aythya baeri*	V	Y	Y
Pallas's sea eagle	*Haliaeetus leucoryphus*	V	Y	Y
Greater spotted eagle	*Aquila clanga*	V	Y	Y
Eastern imperial eagle	*Aquila heliacal*	V	Y	Y
Lesser kestrel	*Falco naumanni*	V	Y	Y
Swamp francolin	*Francolinus gularis*	V	Y	Y
Indian skimmer	*Rynchops albicollis*	V	Y	Y
Purple wood pigeon	*Columba punicea*	V	Y	Y
Hodgson's Bushchat	*Saxicola insignis*	V	Y	Y
Marsh babbler	*Pellorneumpalustre*	V	Y	Y
Jerdon's babbler	*Chrysomma altirostre*	V	Y	Y
Slender billed babbler	*Turdoides longirostris*	V	Y	Y
Black breasted parrotbill	*Paradoxornis flavirostris*	V	Y	Y
Finn's weaver	*Ploceus megarhynchus*	V	Y	Y
Darter	*Anhinga melanogaster*	NT	Y	Y
Black necked stork	*Ephippiorhynchus asiaticus*	NT	Y	Y
Oriental white ibis	*Threskiornis*	NT	Y	Y

Common Name	*Scientific Name*	Status		
	melanocephalus			
Ferruginous Poachard	*Aythya nyroca*	NT	Y	Y
White tailed sea eagle	*Haliaeetus albicilla*	NT	Y	Y
Greater Grey headed fish eagle	*Ichthyophaga ichthyaetus*	NT	Y	Y
Cinereous vulture	*Aegypius monachus*	NT	Y	Y
Red headed vulture	*Sarcogyps calvus*	NT	Y	Y
White cheeked hill Patridge	*Arborophila atrogularis*	NT	Y	Y
Black bellied tern	*Sterna acuticauda*	NT	Y	Y
Blyth's kingfisher	*Alcedo herculis*	NT	Y	Y
Great pied hornbill	*Buceros bicornis*	NT	Y	Y
Long tailed Prinia	*Prinia burnesii*	NT	Y	Y
Rufous rumped grass warbler	*Graminicola bengalensis*	NT	Y	Y
Marsh babbler	*Pellorneum palustre*	Endemic	Y	Y
Black breasted Parrotbill	*Paradoxornis flavirostris*	Endemic	Y	Y

(En: Endangered; CR: Critically endangered; V: vulnerable; NT: Near threatened)

3.3.9.2 Mammals:

118. Altogether 8 IUCN endangered, 11 vulnerable, 2 data deficient and 10 less concerned species of mammalian faunas are found in Kaziranga National Park (0).

Table 3.17 Endangered Mammalian Fauna

Scientific Name	Common Name	IUCN Status	Within 100 mtr	Beyond 100 mtr.
Nycticebus bengalensis	Slow Loris	DD	N	Y
Pletinista gengeticus	River Dolphin	En	Y	Y
Bunopithecus hoolock	Hoolock gibbon	En.	N	Y
Macaca mulata	Rhesus macaque	LR	Y	Y
Macaca assamensis	Assamese macaque	V	Y	Y
Trachypithecus pileatus	Capped langur	En.	N	Y
Cervus unicolor	Sambar	LR	N	Y
Cervus duvaucelii	Swamp deer	V	N	Y
Muntiacus muntjak	Indian Muntjac	LR	N	Y
Axis porcinus	Hog deer	LR	N	Y
Bubalus arnee	Asiatic wild buffalo	En.	Y	Y
Bos gaurus	Gaur	V	N	Y
Sus scrofa	Wild pig	LR	Y	Y
Elephas maximus	Asian elephant	En.	Y	Y
Rhinoceros unicornis	Greater one-horned rhinoceros	En	Y	Y
Ursus thibetanus	Asiatic black bear	V	N	Y
Helarctos malayanus	Sun bear	DD	N	Y
Melursus ursinus	Sloth bear	V	N	Y
Canis aureus	Jackal	LR	Y	Y

Scientific Name	Common Name	IUCN Status	Within 100 mtr	Beyond 100 mtr.
Cuon alpinus	Wild dog	V	N	Y
Vulpes bengalensis	Indian fox	LR	Y	Y
Panthera tigris	Tiger	En.	Y	Y
Panthera pardus	Common leopard	LR	Y	Y
Neofelis nebulosa	Clouded leopard	V	N	Y
Pardofelis marmorata	Marbled cat	V	Y	Y
Catopuma temmincki	Golden cat	V	Y	Y
Felis chaus	Jungle cat	LR	Y	Y
Prionailurus bengalensis	Leopard cat	LR	Y	Y
Prionailurus viverrinus	Fishing cat	V	Y	Y
Melogale moschata	Small-toothed ferret bad-ger	En.	Y	Y
Melogale personata	Large-toothed ferret bad-ger	V	Y	Y

(DD: data deficient; En: endangered; LR: less concern; V: vulnerable)

3.3.10. Identification of Endemic, Threatened and Endangered Species within the Subproject area

119. Outside the 100m buffer zone from the embankment, 2 endemic, 2 endangered, and 11 vulnerable avian fauna are spotted, as well as 2 endemic, 6 IUCN endangered and 7 vulnerable mammalian fauna. None of these species has its habitat around the Kaziranga reach area.

3.3.11. Peoples Dependence on Flora and Fauna

120. Various indigenous communities, represented by mishing people inhabit the Bankoal-Difalupathar sub-project site. The local people primarily depend on the native biodiversity resources viz., natural fishes, fuel wood, timber wood, horticultural plants as well as paddy cultivation. The mishing people also collect ground dwelling insects, red ant and some of other wild animal (name not disclosed) species for consumption. Hence, the proposed flood embankment and erosion management project will help them by protecting existing livelihood resources in long term basis.

3.3.12. Wetlands

121. The Shohola beel is an important wetland of Kaziranga National Park situated near Agoratali on the river side of the embankment. A few other wetlands inside the embankment are Barpak Beel and Kolabutiya Beel. However all these beels are not connected with Brahamaputra River and mostly fed by rainwater and flood water. It shall be noted that most of the wetlands in the study area fall in the Kaziranga National Park, which will not be affected due to the project intervention. Various terrestrial and aquatic wildlife species depend on the wetlands for their sustenance.

3.3.13. Bio-Diversity Index

122. The analysis of Shannon diversity indices of tree species diversity at 'total inside' the embankment and 'total outside' the embankment shows that, the tree species diversity index of outside the embankment was H= 2.945 (variance: 0.0005), whereas, it was H=1.988 (variance:

0.001491) in ‘total inside’ the embankment in Bonkual- Diffalupathar proposed project site. Comparing the diversity between two sample sites (‘total inside’ and ‘total outside’ the embankment) shows that the diversity was significantly higher outside the embankment than inside at 5% level (pair wise randomized test based on 10,000 re-samples.

Table 3.18 Diversity Index of Tree Species

Sample	H	Variance H	Lower 95%	Upper 95%
Total Number	2.931	0.0003186	2.888	2.958
Total Outside	2.945	0.0005	2.89	2.98
Total Inside	1.988	0.001491	1.904	2.051

3.3.14. Tree Counting

123. Altogether 1997 tree species has been counted in the project sites that are likely to be loss due to project intervention, of which 604 were from outside the embankments and 1393 from inside the embankment (Appendix 3.5).

3.4. Aquatic Biology

124. The Dhansiri river, a major tributary of the Brahmaputra River and Gelabeel River, a sub-tributary of it, flow through the sub-project area, the former bisecting the area into two sub-reaches near its outfall in the Brahmaputra (area called Dhansirimukh). Two separate embankment systems protect these sub-reaches along the river on the south bank extending from Bankoal on upstream to Diffalupathar on downstream. The embankment systems are affected almost every flood season due to breaching as a result of river erosion and overtopping by flood water causing immense damage to the National Park and jeopardizing its unique and invaluable wild life resources including the legendary one-horn rhinoceros.

3.4.1. Identification of Aquatic Fauna

125. The Bankoal- Diffalupathar project site is situated within the coordinates of Latitude 26°38' N - 26°43' N, Longitude 93°33' E - 93°50' E. All the data on aquatic fauna were collected from 12 different study zones. The whole stretch of river bandh was surveyed these 12 different points *viz.* Alami, Afola (0 pt.), Bholukaguri, Bongkuwal, Bongkuwal Bali-chapari, Ririgaon, Dhansirimukh, Kurabahi, Nikorihat, Jugonia, Jugonia Ati, Dhansirimukh, Kharugaon, Mohkhuti camp, Aageratoli and Tamulipathar were selected randomly for detail observation. Some of the points were adjacent to fishing communities. Secondary data was collected from fishermen and published literatures. The variability and number of each species in all study zones vary per ecological variations in these areas. As these areas are flood prone, so there is tremendous scope of diversity of aquatic fauna. The major fisheries of these areas are Garrta, *Gudusia chapra, Salmophasia bacaila, Barilius spp etc.* Migratory fish *Anguilla bengalensis*, an endangered species is also encountered in that projected sites (Appendix 3.11).

126. In these areas (Bholukaguri, Bankoal, Bankoal Bali-chapari, Ririgaon) some of the benthos like *Tubifex, Chironomus* etc. are also found. Presence of turtle like *Kachuga sylhetensis*, *Aspideretes gangeticus* are also seen in the site. Dolphins are reported to be frequently seen by the local villagers and fishers. Besides that, Dolphins were frequently

encountered at several points along Ririgaon, Dhansirimukh, Kurabahi, Nikorihat, and Jugonia. Surfacing of Dolphins was observed in the main channel of the river.

127. The river mouth is found to be very important for fish richness and local migration of fish for breeding in these areas. Because of fish richness the river Dolphin come to forage or breed.

3.4.1.1 Aquatic or Macro-invertebrates Ecology:

128. The aquatic fauna under macro-invertebrates such as crabs, molluscs, snails, lizards, amphibians and other aquatic mammals (river Dolphin & Otter) gives a rich diversity in the project area. Besides these phytoplankton as well as zooplankton were also found in abundance.

3.4.1.2 Fish Species Diversity :

129. Total 65 species of fishes belonging to 23 families has been identified in the study area. Diversity of fishes in different sites gives different results. *Salmostoma, Garra,* and Gadusia species are predominant in all project sites. Hilsa is found to be more dominant in the flood seasons because it migrates through main channel of the Brahmaputra River. In winter season also Hilsa is found to migrate in a lesser number. Other fish species like minnows are found to be less in diversity in some points. There are some species like Channa, Clarius, Heteropneustus, Anabas etc. are found to be predominant only in adjoining wetlands.

3.4.1.3 Faunal Behaviour Pattern

130. These areas support large number of fish and amphibian species which breed during pre-monsoon and monsoon season. The river Dolphins also breed and play in the river water adjacent to all sites. Dolphins come to the connecting channels for feeding where fish are found in plenty. Other species like turtles and tortoises prefer to breed only in sandy ground near the bank of the river having land river interface.

3.4.2. Migratory Route of Aquatic Fauna

131. The migratory fish species like Tor and Anguilla which have been encountered show anadromus and catadromous migratory behaviour respectively migrate through the main channel of the river i.e. through the deeper zones of the river. So migratory route will not have any negative effect owing to the construction of the dyke. Other fish species like *Crossocheilius, Tor* show only local migration from upper to lower reaches of the river.

3.4.3. Areas of Eco-sensitivity/ Protected area/ Restricted area/ Legislative and Others

132. Notwithstanding the aquatic environments in Kaziranga National Park adjacent to the western edge of the project area there are no other eco-sensitive areas, protected areas, restricted areas, legislative areas and others related to aquatic founa within the project site.

3.4.4. Identification of Endemic/ Threatened and Endangered Species

133. Two fish species are found under endangered category (*garra gotyla stenorhynchus,* and *laguvia shawi*). Beside fish, turtles, some amphibians and Dolphin are also under Schedule-I endangered species (Appendix 3.11).

3.5. Socio-Economic Environment

3.5.1. Demography

134. The Kaziranga Reach falls in 3 Development Blocks as per the land records, namely, Golaghat West, Golaghat North and Kakodonga. The general details of demography of the Kaziranga reach are given in Table 3.19.

Table 3.19 Kaziranga Reach: General Details

Block	Area (ha)	Total No. of Households	Total Population	Male	Female	Sex Ratio	SC	ST
Golaghat West	34729	21946	117655	60608	57047	941	12592	26124
Golaghat North	6139	3382	19312	10018	9294	928	4497	4221
Kakodonga	2549	2026	11888	6128	5760	940	1601	4694
Totals	43417	27354	148855	76754	72101	939	18690	35039

(Source: Census of India, 2001)

3.5.2. Education

135. The education facilities in the project area are distributed mainly in the form of Primary, Middle, Secondary and Senior Secondary Schools. A total of 115 villages in the area have some sort of education facility. The details of education facilities in the Blocks have been presented in Table 3.20.

Table 3.20 Education Facilities in the Kaziranga reach

Block	Village with any form of education facility	Primary Schools	Middle Schools	Secondary Schools	Senior Secondary Schools	Colleges
Golaghat West	85	151	44	22	0	1
Golaghat North	20	42	18	6	3	0
Kakodonga	10	22	6	2	0	1
Totals	115	215	68	30	3	2

Source: Census of India 2001

3.5.3. Peoples Dependence on Flora and Fauna

136. Various indigenous communities, represented by Mishing people inhabit the Bankoal – Diffalupathar sub-project site. The local people primarily depend on the native biodiversity resources viz., natural fishes, fuel wood, timber wood, horticultural plants and as well as paddy cultivation. The mishing people also collect ground dwelling insects, red ant and some of other wild animals (name not disclosed) species for consumption. But owing to regular detrimental flood from Brahmaputra, they have suffered loss of their livelihood resources for a long time. Hence, the present proposed flood embankment and erosion management project will help them by protecting existing livelihood resources in long term basis.

137. Almost 55% people depends on fishing in the surrounding areas of the Kurabahi, Nikorihat, Jugonia, Jugonia Ati, Dhansirimukh, Kharugaon, Mohkhuti camp, Aageratoli and Tamulipathar. They depend solely on fishing in the river. Besides fishing, most people are dependent upon the river Brahmaputra for bathing, irrigation in paddy field etc. Therefore, there

should be a provision for people's movement to these points for their livelihood, agricultural purposes (People move to Char areas using boats for different purposes).

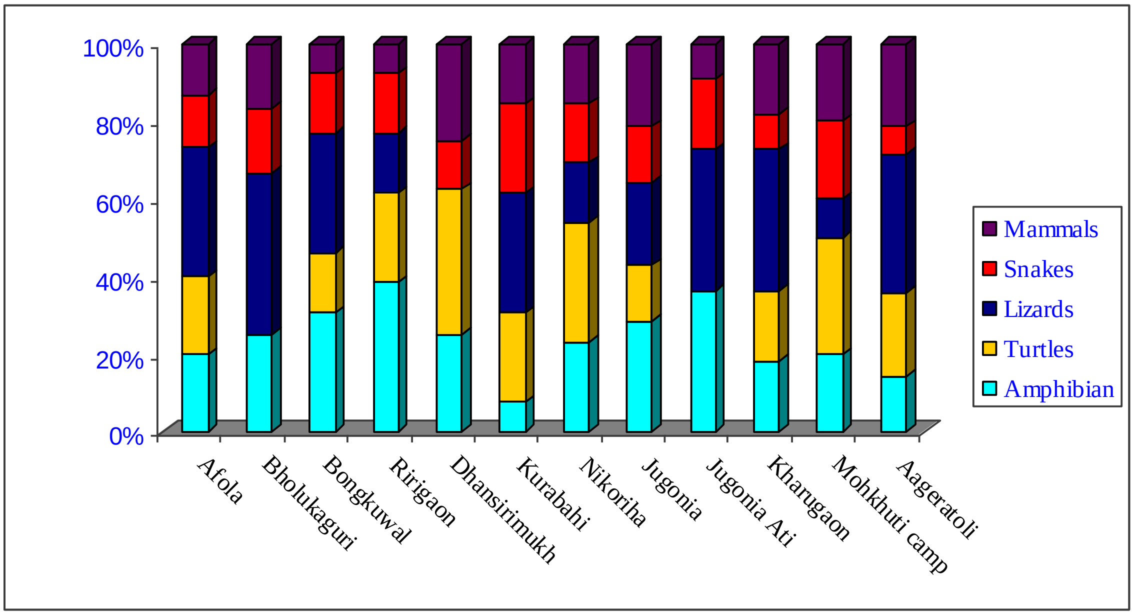

Figure 3.26 Abundance of Different Aquatic Vertebrates Other than Fish

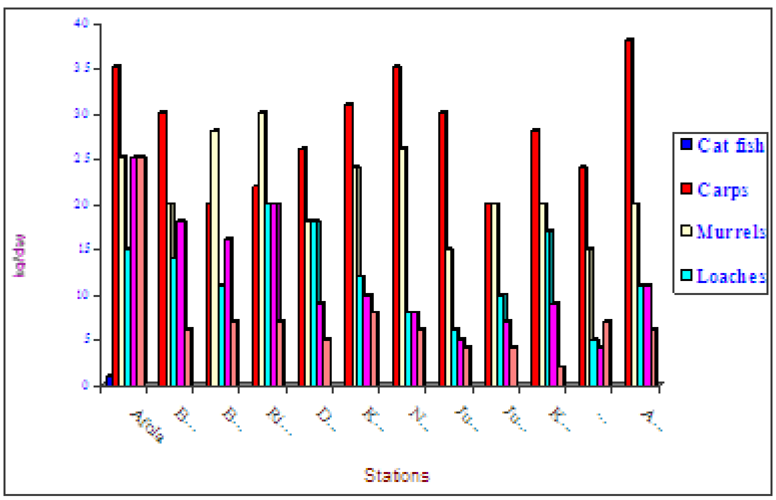

Figure 3.27 Average Fish Landing in Different Stations

3.5.4. Manufacturing Activities

138. The manufacturing of cane goods, furniture, and tea are the main activities in the entire area along the Kaziranga Reach. As of 2001, the distribution of these industries in various development blocks along the Kaziranga Reach are given in Table 3.21:

Table 3.21 Kaziranga reach: Manufacturing Activity Profile

Block	No. of Villages with Stated Industries

	Cane Goods and Furniture	Tea	Bricks
Golaghat West	8	7	5
Golaghat North	2	0	0
Kakodonga	0	1	0
Total	**10**	**8**	**5**

(Source: Census of India, 2001)

3.5.5. Commuting Facilities

139. The villages in the 3 Development Blocks are mostly connected through unpaved roads. As of 2001, only 73 villages have paved road connectivity. The details of the connectivity has been shown in Table 3.22:

Table 3.22 Kaziranga Reach: Connectivity

Block	Paved Road	Mud Road	Footpath	Navigable River	Navigable Canal	Navigable Waterway
Golaghat West	51	91	3	6	0	0
Golaghat North	16	20	8	0	0	0
Kakodonga	6	10	8	0	0	0
Total	**73**	**121**	**19**	**6**	**0**	**0**

Source: Census of India, 2001

3.5.6. Power Facilities

140. Power facility in the Kaziranga reach area is available in most of the villages. Mostly, power is available only for domestic usage. As of 2001, only in 31 villages, power is also available for other activities.

Table 3.23 Kaziranga reach: Power Facilities

Block	Villages Connected to Grid	Domestic	Agriculture	Other Purposes
Golaghat West	71	71	0	31
Golaghat North	14	14	0	0
Kakodonga	4	4	0	0
Total	**89**	**89**	**0**	**31**

Source: Census of India 2001

3.5.7. Drinking Water Supply

141. Main source of drinking water in the entire Kaziranga Reach is mainly groundwater. Water is available through wells, tube wells, hand pumps, and river. The drinking water facilities throughout the year in the villages of Kaziranga Reach are given in Table 3.24 (2001 data).

Table 3.24 Drinking Water Facility

Block	Villages with Drinking Water Facility	TAP	WELL	TANK	Tube well	Hand pump	River	Canal	Other sources
Golaghat West	95	21	52	12	93	41	41	3	1
Golaghat North	20	2	6	6	19	0	11	0	0
Kakodonga	10	1	7	1	10	1	2	0	0
Total	**125**	**24**	**65**	**19**	**122**	**42**	**54**	**3**	**1**

Source: Census of India 2001

142. During summer season, drinking water is available from tapped water, wells and tube wells in 24, 2 and 78 villages, respectively, as of 2001. The distribution of drinking water sources in different blocks is illustrated in Table 3.25:

Table 3.25 Sources of Drinking Water during Summer Season in Kaziranga reach

Block	Tapped Water	Tube Well	Hand Pump	Wells	Tanks	River
Golaghat West	21	56	9	2	1	6
Golaghat North	2	13	0	0	0	5
Kakodonga	1	9	0	0	0	0
Totals	24	78	9	2	1	11

Source: Census of India 2001

3.5.8. Medical Facilities

143. Medical facilities are not satisfactory in most of the villages in the Kaziranga reach. As of 2001, the details of the health care facilities are given in Table 3.26:

Table 3.26 Medical Facilities

Block	Villages with any Health Facility	No. of Allopathic Hospitals	No. of Allopathic Dispensary	Health Centres	Public Health Centre	No of Pub. Health Subsidiary Centres
Golaghat West	15	4	1	2	4	6
Golaghat North	1	0	0	0	1	0
Kakodonga	2	1	0	0	1	0
Total	**18**	**5**	**1**	**2**	**6**	**6**

Source: Census of India 2001

3.5.9. Land use

144. As per the revenue records, the areas under different land use categories in the villages falling under the core/ buffer zone of Kaziranga reach are given in Table 3.27:

Table 3.27 Landuse

Development Block	Forest Land (ha)	Culturable Waste Land (ha)	Area not available for Cultivation (ha)	Total Irrigated land (ha)	Land without Irrigation (ha)
Golaghat West	0	4335	7632	4447	18315
Golaghat North	0	1174	1224	0	3741
Kakodonga	0	228	666	0	1656
Total	**0**	**5737**	**9523**	**4447**	**23711**

Source: Census of India 2001

3.5.10. Occupational Pattern

145. The details of working population are presented in Table 3.28 and distribution is illustrated as bar diagram in Figure 3.28.

Table 3.28 Distribution of Working Population

Category	Male	Female
Main worker	33974	12160
Main Casual Labor	15770	5901
Main Approved Labor	1035	563
Main Other	16674	5297
Main Worker House hold	495	399
Marginal Worker	8967	14769
Marginal Casual Labor	3346	7183
Marginal Approved Labor	1125	1926
Marginal Worker House hold	150	794
Marginal Other	4346	4866
Non Worker	39599	50177

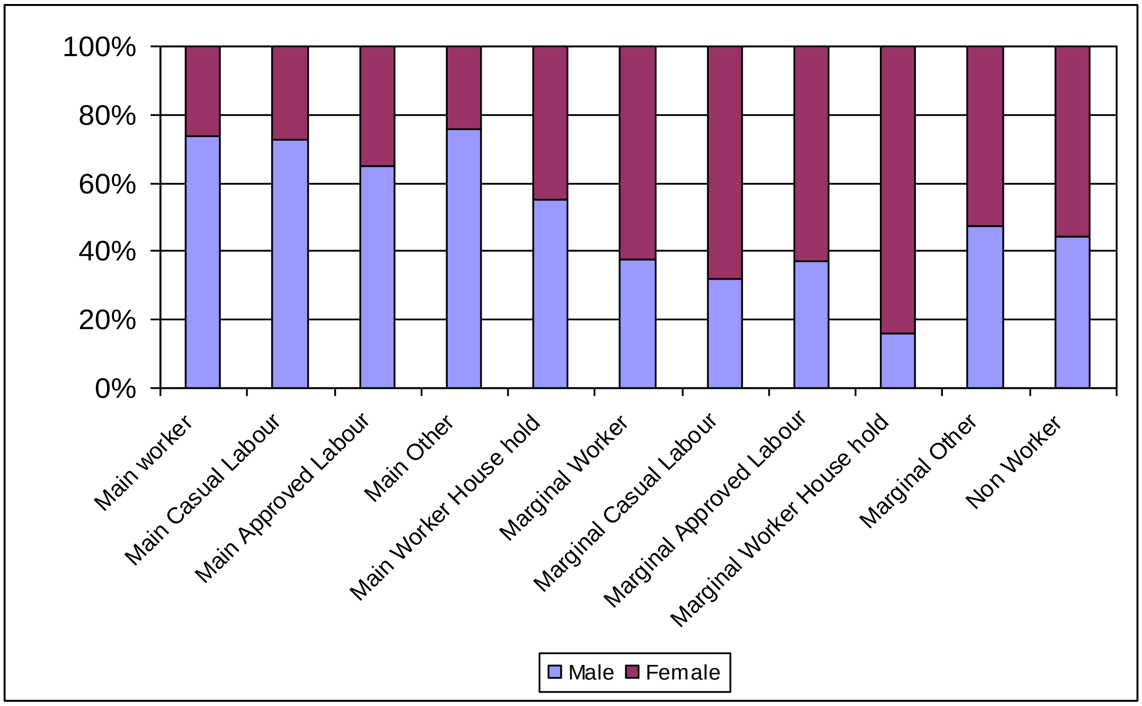

Figure 3.28 Distribution of Working Population

4. ALTERNATIVE ANALYSIS

146. The analysis of alternative is an effective tool to examine the number of options (locational & technological) and establishing most environmentally favourable alternative or which cause minimum environmental loss to the natural and social environment. However, since the Program aims to sustain the functions of the existing flood embankment systems protecting a large number of people and landmass from frequent devastating flooding and riverbank erosion of the Brahmaputra River, the scope for assessing alternatives to the project is limited. This project in general, and specifically the Kaziranga Reach, is site specific and involves protecting the riverbank from erosion and renovation or reconstruction of flood embankments in specific sections of the Brahmaputra River and its major tributaries. The designs involve rehabilitation and strengthening of existing embankments of Brahmaputra dyke, Dhansiri dyke, and construction of 4.7 km of inner dyke from Diffalupathar to NH-37, along with revetment/ prosiltation measures in front of Krishibundh.

147. Under the circumstance, the "without project" option was considered and compared against the "with project" option as an alternative analysis. In addition, an intermediate option of continuous or repeated embankment retirement in response to the progress of riverbank erosion was considered as another alternative, as opposed to providing riverbank protection works under the "with project" scenario. Within the "with project" option, various revetment options, such as cement slabs, geo-textiles, sand bags, and porcupines, were assessed from its environmental suitability perspective and the most cost-effective option suitable for the river environment was adopted.

4.1. Alternatives to the Sub-Project

148. Since, the proposed project aims to provide protection to large number of people and landmass from frequent devastating flood of the Brahmaputra river, the scope of assessing alternatives to the project is limited to the “with” and “without sub-project” (means do nothing or status quo) options, along with "repeated embankment" option.

4.1.1. ‘Without Project’ Option

149. **Physical Environment.** In the ‘without project’ scenario, loss of precious land at the rate of about 34 ha/year (reaching 1,000ha in 30 years) will continue due to riverbank erosion. Siltation of land due to flood will also happen resulting in reduced productivity or loss of single crop. There is also a risk that the present depression along NH-37 may develop into a permanent river course through Brahmaputra avulsion, leading to further land loss and isolation of the KNP from the adjoining southern hills. The floodplains and wetlands will be flooded annually, reverting to their former function supporting aquatic life during the flood season. No effect is anticipated on ambient air and noise quality.

150. **Biological Environment.** In the ‘without the project’ scenario, the eroded land will turn into a river channel turning into an aquatic environment. Floodplain and wetlands will eventually revert to their former function supporting aquatic life during the flood season. However, there will be a loss of vegetation and productivity in agriculture and culture fishery. For other seasons, no change is anticipated in fish productivity of wetlands, or productivity of agricultural land. On the other hand, under this scenario, there is a risk of Brahmaputra avulsion into the natural depression and isolation of KNP from the southern hills, which would affect the seasonal migration pattern of wildlife in the KNP.

151. **Socioeconomic Environment.** Without the project, large number of population will remain vulnerable to flood effect. Specifically, there will be displacement of people associated with 1,000ha of land in 30 years to be lost due to river erosion, many of whom may have to be resettled to the flood embankment as landless squatters. Due to more frequent flooding, the agriculture productivity of the presently protected area by the embankment will be reduced, affecting the livelihoods of the population in the subproject areas, although this may be slightly offset by the increased capture fish production during the flood season. Flood also causes many linked socio-economic and health problems.

4.1.2. 'With Project' Option

152. **Physical Environment.** In the "with project" scenario, no change is expected in air, soil and water media. The air pollution and noise level are likely to increase during construction phase but that will be confined within the close vicinity of construction sites and will be temporary in nature. The bank protection measures will prevent loss of about 22 ha/year of productive land (out of 37 ha/year to be lost without project), which in turn would reduce the sedimentation load of the Brahmaputra River.

153. **Biological Environment.** In the 'with project' scenario, there is likelihood of improved fish productivity from wetland. No significant impact is expected in terms of increase in sedimentation level or fish productivity during construction stage. With the implementation of mitigative measures the overall impact of the project is likely to be positive on the biological environment except in terms of loss of trees which will be minimised and also regenerate over a period of time due to proposed tree plantation. In this option, there will be no change in the biological environment in the KNP. The impact of sudden water intrusion into the KNP through the natural depression originated from the breach of the Brahmaputra embankment will be avoided.

154. **Socioeconomic Environment.** The 'with project' scenario is also likely to bring stability to the economy of the area. It will facilitate conservation of large area from erosion (34 ha/year). With more reliable and effective functioning of the existing flood embankments, agricultural produce would increase where farmers can increase the number of crops in a year with better yields facilitated by investments under more flood secure environment. Wetland fisheries productivity would improve due to reduced siltation load and improved fishery practices. The project will also provide better commuting opportunities to the people of the area through the paved road on the embankment and protected land inside, which means reduced commuting time to reach the markets and education, health, and other facilities. The flood protected environment may also promote agro based industries in the area. The post project scenario will enhance the overall economy of the area.

4.1.3. 'Repeated Embankment Retirement' Option

155. **Physical Environment.** This option involves the retirement of flood embankments in response to the riverbank erosion process, with the acquisition of land and compensation to the affected people. In this scenario, loss of land at the rate of about 34 ha/year (reaching 1,000ha in 30 years) will continue due to riverbank erosion. There is also a possibility of frequent flood inundation in the subproject area, unless the retired embankment can be constructed before the existing embankment is breached due to the river bank erosion.

156. **Biological Environment.** In this option, the eroded land will turn into a river channel turning into an aquatic environment. The environment of floodplain and wetlands during the monsoon season will depend on the timing of constructing the retired embankment against the breach of existing embankment due to erosion. For other seasons, no change is anticipated in fish productivity of wetlands, or productivity of agricultural land.

157. **Socioeconomic Environment.** Since this option involves continuous river erosion, there will be displacement of people associated with 1,000ha of land in 30 years to be lost due to river erosion, of which agriculture productivity will be lost. The similar economic benefits may be delivered in case of timely construction of retired embankment prior to the breach of existing embankment due to river erosion. However, there is a risk of failure given the lengthy procedures for land acquisition and opposition from the concerned population in the subproject areas (when compared with the ‘with-project’ option), in which case there will be repeated flood damages, affecting the confidence of local population on the reliability and effectiveness of FRERM systems leading to much less positive socio-economic impacts as compared with the ‘with-project’ option.

4.1.4. Conclusion

158. During the EIA, a number of public consultations have also been carried out with the local communities and stakeholders. The overall findings of the meetings are that most of the people consider riverbank erosion as the major threat to their livelihoods causing severe social and economic hardships let alone environmental disbenefits. They are strongly in favour of the ‘with-project’ option with riverbank protection measures against ‘without-project’ option. As to the comparison of ‘with-project’ and ‘embankment retirement’ options, local people are opposing the latter option, in view of the severe displacement impacts of the affected people in the riverine areas at large, saying that there is not enough land within the project area to resettle people displaced by the riverbank erosion.

159. Under the circumstance, and in light of the assessment of the available alternatives as shown above, the ‘with-project’ option is deemed as the optimal solution, as far as its feasibility and sustainability during its project life and beyond can be ascertained. It will generate overall positive social, environmental, and economic impacts and their negative impacts can be mitigated through appropriate safeguard measures as defined under the EIA and the social safeguards assessments. Strong ownership was also shown by the concerned local stakeholders in terms of their willingness to participate in the planning, implementation, and post-implementation stages of the suggested interventions. These will be pursued with the necessary participatory and institutional strengthening arrangements included in the design of the IFRERM-Assam.

5. ANTICIPATED ENVIRONMENTAL IMPACTS AND MITIGATION MEASURES

160. Based on the compiled information, attempts have been made to assess the present environmental status of the Kaziranga reach and identification of Valued Ecosystem Components (VECs). Preliminary environmental surveys along the Kaziranga reach was conducted coupled with detail study of flood patterns, erosion, study of topographic maps, satellite imageries, collection of baseline data from primary and secondary sources, etc. During the survey, a number of discussions were held with the people in the localities including those presently living along the various stretches of the Kaziranga reach. Some NGOs working in the areas were also consulted. The details of public consultation are furnished in Chapter 8. The ADB's Rapid Environmental Assessment (REA) checklist for irrigation projects[22] (Refer: 3.Appendix 2.3) was used for identifying the valuable ecosystem components in the region.

5.1. Valuable Ecosystem Components (VECs)

161. The VECs identified in the Kaziranga reach are as follows:

- Land
    - Soil erosion
    - Change in land use
    - Soil compaction & Soil Contamination
- Hydrology & Morphology
    - Upstream & Down stream Effect
    - Flood Effect
    - Effect on river water levels/flow velocity/discharge intensities
    - Effect on drainage system
    - Silt Disposition and Bed level Changes
    - Effect on Wetland & Beels
    - Water Quality
- Climate
- Air
    - Change in air quality
- Noise
    - Change in ambient sound pressure levels
- Terrestrial Ecology:
    - Disturbance to Vegetation
    - Habitat fragmentation and destruction
    - Animal distribution & Migratory routes
    - Endangered species
- Aquatic Ecology
    - Effect on fish Activity & Productivity

[22] Under ADB Environmental Assessment Guidelines 2003, only following 16 REIA checklists have been defined: (i) Irrigation, (ii) Fisheries, (iii) Forestry, (iv) Hydropower, (v) Thermal Power Plants, (vi) Power Transmission, (vii) Agro Industrial Projects, (viii) Chemical-based Industrial Projects, (ix) Petrochemical Industrial Projects, (x) Urban Development, (xi) Water Supply, (xii) Solid Waste Management, (xiii) Sewage Treatment, (xiv) Airports, (xv) Ports and Harbors, (xvi) Roads and Highways, (xvii) Governance and Finance. Taking into consideration all the REA checklists, "Irrigation REA checklist" was found the most closer to the nature of IFRERM project activities.

-
    - Effect on spawning and breeding ground
    - Effect on pond fisheries
- Socio-economic
    - Effect on Establishments
    - Effect on Archaeological sites
    - Water Supply & Sanitation
    - Socio economic Impacts
    - Accident & Safety
    - Navigation

5.2. Potential Environmental Impacts

162. Potential environmental impacts associated with the proposed project at Kaziranga Reach are classified as: (i) impacts during design and construction phase and ii) impacts during operation phase. Qualitative and quantitative techniques have been applied for direct and indirect impact identification. Impacts are classified as being insignificant, minor, moderate and major. The mitigation measures have been presented along with the impacts required.

5.2.1. Land use

5.2.1.1 Land Use Change due to Project Activities and Borrow Area

Design and Construction Phase

163. **Impacts.** The project activity involves rehabilitation and strengthening of the existing Brahmaputra and Dhansiri dykes and construction of 4.7 km long inner embankment to close the gap between NH-37 and the existing embankment system to protect the depression along the NH-37 from sudden inundation. Five drainage sluices are also proposed in order to facilitate drainage and avoid cutting of the embankment by the local people. Since only 4.7 km long new dyke is to be constructed, the land use change would be equivalent to the area of about 20.6 ha.

164. For construction of river embankment of about 5 m height above the ground level with a top width of 7.5 m and a side slope of 1:2 to 1:3 that is estimated to provide protection against 50-year floods, substantial quantity of earth is required. The demands for earth will be fulfilled by excavating borrow pits in the vicinity of the river embankment. No land within the Kaziranga National Park will be used for borrow areas. The unplanned selection of borrow areas/ no rehabilitation of the borrow areas may cause loss of productive use of the land and shall be avoided. The transportation of borrow earth may also cause air pollution, if transported in uncovered trucks.

165. Due to such construction activities along the river bank, the land use of up to 100 m buffer is likely to be affected or changed. Based on satellite imagery and GIS interpretations, in the Kaziranga Reach currently about 269.9 ha land (38.7%) of this buffer area is used as agricultural land and about 196.1 ha (28.2%) area is used as homestead plantation (Refer Figure 3.24). Under the project, however, no land within the KNR shall be used for any temporary or permanent works.

166. The access to the embankment construction site is mainly through single lane rural roads as well as PWD roads, which are connected with NH-37 (Guwahati – Dibrugarh) in the

southern side. These roads would require strengthening to sustain the heavy trucking load. In addition 2-3 construction camps throughout the 37.0 km long Kaziranga reach are likely to be located at a distance of about 10-15 km apart, close to the embankment. This will also temporarily change the land use of the area.

167. Due to the proposed interventions, most of the agricultural land and homestead plantation around the embankment site and construction camp areas may be affected adversely. Loss of topsoil is one of the most potential impacts with respect to borrowing of earth. Besides this compaction of soil along the haulage route may also take place, if proper mitigation measures are not employed.

168. **Mitigation Measures.** Since the impact zone around the embankment covers productive land, which is used by the villagers for cultivation, diversion of land for project purposes shall be minimised to the extent possible. Adjacent cultivable lands, shall not be occupied for storage and/or handling of construction materials. Construction camps shall preferably be located on uncultivated areas. All requisite facilities (drinking water supply, sanitation, domestic solid waste collection & disposal, fuel supply) shall be provided at these camps. The land used for construction camp shall be made reusable/cultivable after closure of construction camp. No construction debris shall be deposited on agricultural land. Loss of crops for construction camp area shall be compensated to the landowners in accordance with the RAP. In addition, along where the construction activities are located near the Kaziranga National Park no land use impacts will be attributable to the subproject. In addition to strict implementation of the WRD borrow area location, no borrow pit, workers camp, quarrying, an discharge of any wastes along the side of the parks boundary and the embankment. These restrictions shall form part of the contract documents for construction.

169. **Borrow Area Location and Rehabilitation:** The borrow pits shall be on river side since borrow pits on the river-side get silted up in the course of time whereas on the country-side remains a permanent disfiguration. Further the borrow pits next to embankment on the countryside can induce seepage to the foundations. In case borrow earth has to be sourced from the country side, the borrow pits should be away from embankment even at the expense of comparatively long hauls. In the scenario that sourcing earth from country side is unavoidable, the preference to be given for the following options:

- Land which farmers want to either convert into a fishpond or lowering the agriculture field level to increase its water retention capacity.
- Exploring the option of using combination of soil and sand in embankment construction i.e. using soil as outer cover and sand as filler in between.
- Exploring technical feasibility of using soil from sandbars existing away from the bank.
- No land acquisition shall be made for borrow areas.

170. Follow the WRD guidelines for locating borrow pits near the embankment. All efforts shall be made to avoid or minimize tree loss due to borrowing. The trucks shall be covered while transporting the earth.

171. While borrowing the earth top soil shall be preserved. The borrow pits shall be rehabilitated after borrowing the earth. The WRD guidelines for rehabilitation of the pits shall be strictly followed. The Indian Road Congress (IRC):10-1961 guideline will govern the selection of borrow pits. In all cases good engineering and construction practices shall be followed. The

construction contractor or DPR consultant shall submit the borrow area identification details along with borrow area rehabilitation plan in advance.

172. WRD Guidelines with respect to borrow area location and rehabilitation:

- For high embankments no excavation shall be done within 45 m of the riverside toe of the embankment. From 45 m to 60 m the borrow pits must not be more than 1.8 m deep and from 60 m to 90 m not more than 2.4 m deep and beyond 90 m they can be of any depth.
- If earth is to be taken from land-side of the embankment, no borrow pits shall be excavated within 24 m of the land–side toe of the embankment. The depth of excavation in 24 m to 36 m shall not be more than 0.6 m.
- For low embankments the borrow pits on the river-side and on the land-side shall not be located at less than 24 m from the toe.
- The borrow pits shall be staggered and on undisturbed ground 6 m wide left at regular intervals to prevent the velocity of flow through the river-side borrow pits. The staggering will also help in inducing silting and filling up of these borrow pits.
- On the country-side the water logged areas (bandhis) shall be cut and interconnected to permit ordinary drainage. These shall be connected to the nearest drainage channel so as to carry away the drainage water.
- The borrow areas selected for taking earth shall be cleared of all trees, shrubs, grass and vegetation mounds.
- No borrow pits shall be made on roads, village tracks, graveyards, canals or embankments.

173. The Indian Road Congress (IRC):10-1961 guidelines for selection of borrow pits and amount that can be borrowed.

- Borrow areas shall not be located on cultivable lands. However, if it becomes necessary to borrow earth from temporarily acquired cultivated lands, their depth shall not exceed 45 cm. The topsoil to a depth of 15cm shall be stripped and set aside for its later use for the purpose of turfing on slopes of the embankments. Thereafter, soil may be dug out to a further depth not exceeding 30 cm and used in forming the embankment.
- Borrow pit shall be selected from wasteland;
- Priority shall be given to the borrowing from humps above the general ground level within the road land;
- Priority shall be given to the borrowing by excavating/enlarging existing tanks;
- Borrowing shall be from land acquired temporarily and located at least 500m away from the road;
- Borrowing shall be from mounds resulting from the digging of well and lowering of agricultural fields in vicinity of the road;
- In case of settlements, borrow pits shall not be selected within a distance 800 m from towns or villages. If unavoidable, earth excavation shall not exceed 30cm in depth;
- The haulage distance from site shall not be too far.

Operation Phase[23]

[23] Operation phase in this section means post-construction use period.

174. **Impacts.** Encroachment on embankment for habitation and cultivation purpose may affect embankment stability. Villagers also cut the embankment to create approach to river side for their movement for toileting, cattle grazing, farming etc. Borrow areas if not rehabilitated may have landscape and accidental hazards. Also if the borrow areas are not rehabilitated as per the intended end use of the owner, some social impacts like loss of income may occur.

175. **Mitigation Measures.** Provision shall be made in the embankment design for providing access to the river bank close to the settlement areas. Where possible, platforms will be attached to the embankments to provide space for the possible squatter, with regular monitoring and guidance by the executing agency so that encroachers will not affect the integrity of the embankment structure. Provision of nine drainage sluices has already been made in the project design to reduce the possibility of cutting of embankment by the villagers. The construction contractor shall ensure rehabilitation of borrow area before handing over the project.

5.2.1.2 Land use Change due to Construction Material Sourcing (Quarrying)

Design and Construction Phase

176. **Impacts.** A project of this magnitude would require significant amount of construction material. Illegal quarrying may lead to land use change, unstable rock formation, air and noise pollution. The aggregate demand for construction of river embankment with paved road on the top in Kaziranga Reach will be met through approved quarries such as Bihori, Lakhojan, and Kakochang, which are located between 20 km to 40 km from the reach. The environmental aspects and control of pollution due to quarrying operation of these approved quarries are controlled and monitored by SPCB. Thus, adverse impacts as a result of quarrying operations are not envisaged in the proposed project.

177. **Mitigation Measures.** Aggregates required for construction of embankment and roads shall be procured from quarries approved by State Pollution Control Board. Air and noise emissions from quarry shall be well within the prescribed limits. Setting up of stone crushers, if required, shall be done only after obtaining consent from State Pollution Control Board and taking adequate measures for air pollution control. While finalising the site, proper land use assessment shall be done. The land to be earmarked for dumping construction waste if any shall be free from any social or R & R issue.

5.2.2. Soil

5.2.2.1 Soil Erosion

Design and Construction Phase

178. **Impacts.** Soil erosion potential of an area depends on its topography, geological structure, rainfall, soil type and land use/land cover. In the Kaziranga Reach, the topography of the terrain covering the alluvial plain is monotonously flat lowland except the adjoining hilly uplands in the south. The Dhansiri and Gelabeel Rivers, which are tributaries of Brahmaputra River in the south bank, also contribute in sedimentation and erosion.

179. **Mitigation Measures.** Following mitigation measures can prevent the soil erosion:

- Construction shall be scheduled such that large areas of soil particularly at borrow areas near the embankment are not laid bare during the monsoon.

- Exposed surface shall be resurfaced and stabilized as soon as possible. This shall also be covered by straw or mulch to avoid soil loss in the intervening period.
- Ground disturbances shall be phased so that it is limited to workable size.
- Stabilizations of soil around approach roads/slopes shall be done by turfing and tree plantation in ROW.
- Other slope stabilization measures like selection of less eroding materials around water bodies/water streams shall be adopted.
- The embankment and road design shall incorporate adequate engineering measures so that the construction could withstand the earthquake magnitude of more than 6 Mb.
- Soil erosion shall be visually checked on potential erosion zones during construction phase. In case soils erosion is found, suitable measures shall be taken to control the same.

Operation Phase

180. **Impacts.** Due to bank erosion, the bank line at various sections through out the reach has shifted up to maximum of 4.3 km during the study period of 1973-1990. A total of 7,336.42 ha land was eroded between year 1967-2008 in the Kaziranga sub-project and KNP areas. However, the proposed subproject will have net benefits in terms of soil erosion and preventing progression of land loss estimated at 34 ha/year at present.

181. **Mitigation Measures.** Soil erosion may still occur during the operation phase and early detection and remedial measures shall need to be taken for safety of the embankment and roads. There is also an attempt under the project to promote holistic management of catchment through state-wide planning and implementation coordination from a (sub-) basin perspective.

5.2.2.2 Soil Compaction and Contamination

Design and Construction Phase

182. **Impacts.** Soil around construction site, haulage road, construction camp, and workshop, will get compacted due to transportation of man, machine and materials. Since about 38.7% of land in the closed vicinity of river embankment is used for agricultural purposes in Kaziranga Reach. Apart from this about 20.7% land is used as agricultural fallow land. Hence, taking into consideration of 6 years of construction period agricultural yield will reduce substantially due to soil compaction. Soil may also get contaminated around construction site, machine maintenance area, fuelling station, construction camp, and hot mix plant site, and haulage road.

183. **Mitigation Measures.** The movement of construction vehicles, machinery and equipment shall be restricted to the embankment site and pre defined haulage road. Adequate provision for approach roads capable of handling movement and haulage of heavy vehicles and machineries shall be made to avoid damage to existing village roads, crop lands and settlement areas. The non usable, non saleable, non hazardous construction waste shall be dispose of in the properly delineated places. Usable or saleable waste shall not be disposed of to landfill.

184. All efforts shall be made to prevent soil contaminations. Following measures shall be taken to prevent the same:

- The construction vehicle shall be fuelled or repaired/serviced at the designated place with proper arrangement of waste collection and disposal. The arrangement shall include, cemented floor with dyke around for fuel storage and filling as well repairing of construction equipments.

- To avoid the soil contamination at the wash down and re-fuelling areas, “oil interceptors” shall be provided.
- The demolition waste if any shall also be used to the extent feasible for construction.
- Oil and grease spill and oil soaked materials shall be sold off to State Pollution Control Board (SPCB)/ MoEF authorized vendors.

Operation Phase

185. During the operation phase, contamination of soil is not likely to happen other than due to accidental spillage from vehicle movement. As to the mitigation measures, depending on the nature and magnitude of spill, appropriate land remediation measures shall be employed by the concerned authorities.

5.2.3. Hydrology and Morphology

Design and Construction Phase

186. No impact is envisaged during this phase. The aspects associated with design and construction of various project components associated with hydrology and morphology have been addressed under land use, soil, flora and fauna, air and noise and water quality section. The impacts associated with the post-construction (operation) stage are presented under various sub-sections below:

5.2.3.1 Flood

Operation Phase

187. **Impacts.** The project activities include structural flood and riverbank erosion protection measures, which could negatively impact on the river morphology. The impact of both measures is different. While flood protection embankments could increase water levels, riverbank protection measures could impact on the river characteristics and the sediment transport. The impact of the planned flood protection measures along the Brahmaputra as compared with the present flooding behaviour is considered negligible or insignificant, since they only focus on the existing embankment systems that will be rehabilitated or strengthened to perform its regular intended functions (including the reconstruction of new embankments behind the existing embankments that are too much exposed to riverbank erosion).

188. The embankment system will prevent inundation of country side by the flood waters during the monsoon season. As per the analysis an area of 7,412 ha was inundated during 2004 flood, which was one of the largest in recent years. This project will facilitate in preventing inundation of this large area from flood. This will have net positive benefits in terms of protection of households, land and population. However because of the low lying nature of the floodplain and low gradient of the tributary rivers there will be considerable drainage congestion in the country side especially in the southern part of the reach.

189. Flood protection embankments will be used for the structural management of flood risk. There are two components to this management measure: the raising and strengthening of existing embankments to the original design levels and the extension in a southerly direction of the western limit of the Brahmaputra Dyke to NH-37. While the detailed design is limited to the area west of the Dhansiri, this EIA considers a total length of 22.5 km for the renovation of existing embankments, which include:

- The ‘East’ Brahmaputra Bund, which is located to the east of the Dhansiri River and runs upstream for 7.0 km from the existing Krishi Bund (4.07 km in length) around Bonkuwal to the Nikori-PWD road (which connects to NH-37);
- The ‘West’ Brahmaputra Bund, which is located to the west of the Dhansiri River and runs westward for 12.0 km from the ‘West’ Dhansiri Bund (west bank of the Dhansiri River) to a location along the eastern boundary of Kaziranga National Park.
- The ‘West’ Dhansiri Bund, which is located on the western bank of the Dhansiri River, and runs in a southerly direction for 3.5 km from the eastern end of the West Brahmaputra Bund.

190. This EIA considers constructing the 3.5 km southwards extension to NH-37 of the West Brahmaputra Bund.

191. It is expected that the proposed structural works will have minimal effect on the current flooding situation outside of the subproject area, the order of which will be confirmed by flood studies during the Project. The renovation of existing embankments will merely formalize existing flooding behaviour that has persisted since these embankments were first constructed. The construction of the extension embankment will prevent any back flooding from the Brahmaputra around the western end of the West Brahmaputra Bund into the area ‘protected’ by this bund. The construction of the extension bund will also prevent the movement of floodwaters into KNP along the drainage path that runs parallel to NH-37.

192. **Effect of the proposed works on flooding behaviour across the KNP**: The area upstream of KNP eroded substantially over the last 30 years with the Brahmaputra moving towards the south. A major tributary, the Dansiri River joins the Brahmaputra just upstream of the park. The unique wildlife of the park normally leaves the plains during the monsoon and moves into the southern hills through a depression running parallel to the national highways. With the Brahmaputra embankment construction additional problems have emerged: while the lower lying plain remains dry keeping the wildlife in a sense of security, a sudden upstream breach leads to deep flooding cutting the animals off from the safe higher lands. In addition longer term flow through this plain could lead to the formation of a permanent channel of the Brahmaputra River, cutting the wildlife permanently of from the plain land. The project mitigates this risk through the construction of the extension embankment and the protection of the primary embankment with riverbank protection measures.

193. An overview of likely flooding behaviour in KNP indicates that most–and probably nearly all–floodwaters flowing across the eastern area of the Park originate from the Brahmaputra proper and flow in a southwest direction around the western end of the West Brahmaputra Bund. The only time this may not be the case is when the West Brahmaputra Bund is breached, the area protected by this bund is flooded, and the incoming floodwaters drain into KNP via the drainage channel that runs parallel to NH-37. The construction of the extension embankment will prevent these floodwaters passing into KNP and ensure that the Brahmaputra does not avulse into the drainage channel.

194. The drainage of floodwaters from the area protected by the West Brahmaputra Bund is currently impeded by the lack of sluices through the embankment. The proposed construction/repair nine drainage sluices will improve post-flood drainage. The location, size and effectiveness of these sluices will be confirmed in ‘drainage studies’ to be undertaken in the Project. It is believed that appropriate drainage works can cost-effectively relieve current and any future drainage problems.

195. Given the nature of the subproject to restore the functions of the existing embankments systems, the impact of the proposed works on the flooding of beels and wetlands located within the areas is deemed insignificant, the specific magnitude of which will be assessed in the said drainage studies. Flooding and drainage behavior in the area protected by the West Brahmaputra Bund and across KNP will be investigated for all types of floods–mainstem, tributary and local (rainfall) floods. The presence of sluices will allow the controlled flooding of beels and wetlands in the protected area.

196. **Mitigation Measures.** The principal mitigation measures include the conducting of flood and drainage studies in the Project to assess, review and confirm that the resultant flooding and drainage behaviour is acceptable and to install appropriate drainage improvements. It is noted that the construction of raised earth platforms for emergency refuge purposes, as proposed under the CBFRM Program, will relieve the social component of flood impacts. Note, that in improving drainage behaviour, special attention will be paid to potential adverse impacts on the wetting and drying behaviour of beels and wetlands and to the environmental significance of these areas.

197. Natural drainage systems shall be left undisturbed as far as possible. Adequate provisions shall be made in designing to withstand extreme meteorological and other geophysical events.

5.2.3.2 Changes in Water Levels

Operation Phase

198. **Impacts.** The proposed works will have no significant affect on flood levels in the Brahmaputra River, but this will be quantitatively assessed and confirmed by modelling studies undertaken during the Project. The total width of river channels plus chars near Bokunwal is some 12 km; the hydraulic conveyance of this section is so great that the loss of additional flood storage associated with the proposed works, if any, will have only an insignificant effect on flood levels. The renovation of existing embankments will merely formalize existing flooding behaviour that has persisted since these embankments were first constructed.

199. **Mitigation Measures.** The Project scope has included the flood and drainage studies in the Project and close monitoring of the hydrological behaviour of the Brahmaputra and its tributaries in the subproject areas and its interface with the internal rainfalls. The flooding behaviour and wetting and drying behaviour of beels and wetlands will also be carefully assessed, along with their environmental significance, before drainage improvements are constructed. Again, it is noted that the construction of raised earth platforms for emergency refuge purposes, as proposed under the CBFRM Program, will relieve the social component of any residual flood impacts around beels and wetlands incorporated for environmental purposes.

200. In chronically inundated low lying areas, which may still have potential risk of getting affected by high floods, will be identified in the Project and option of providing raised platforms in appropriate locations may be explored. These platforms may be designed for multiple purposes like flood shelter, rural stadium/ playground, public meeting ground etc.

5.2.3.3 Effect on Flow Velocity/Discharge Intensities

Operation Phase

201. **Impacts.** Recognizing instability and unpredictability of the Brahmaputra River, clearly two different scales need to be distinguished for studying effects of flow velocity and discharge

changes: (i) the total river cross section, many kilometres in width, and (ii) the cross section of the near bank channel, typically below one kilometre in width. Limited interventions along the bank do not change the cross section average flow velocities in alluvial rivers. Areas of faster flow are compensated through areas of slower flow and lower discharges, which on average even out. The average flow velocity and discharge is affected by different river stages with increasing discharges resulting in increasing flow velocities. The lack of systematic measurements limits the present ability of quantifying this satisfactorily.

202. The picture is different when concentrating on the channel along the protected bank. Here two cases can be distinguished: protection through (i) revetments, and (ii) pro-siltation measures. The protection through spurs is not considered as they are not suggested under this project, apart from limited rehabilitation work of existing spurs. Revetments lead to a moderate local increase in near bank flow velocities, as the river is guided along a fixed boundary. This is commonly reflected in local scouring along the bank and deepening of the channel after construction of riverbank protection. The present level of understanding does not allow quantifying this increase in general terms. Experience with the lower Brahmaputra indicates that there is no significant increase and flow velocities are in general well below the depth averaged design velocity of 3 m/s, even though in some cases spikes surpassing 4m/s at the surface could be measured. As the same order of magnitude of flow velocities also occurs at natural nodal points, no negative effects on wildlife, especially fish are expected. Locally, in the immediate vicinity of the bank, riverbank protection provides a more favourable environment to fish than unprotected banks. While the smooth eroding underwater slopes do not provide any shelter, voids between the larger riverbank protection elements have a demonstrated positive effect on the number of fish.

203. In case of porcupines the flow velocities are retarded and sedimentation is encouraged. Slow flow velocities do not have a negative effect, as the areas of low velocity are comparable to areas of active creation of in-stream channel bars (chars or chaporis). This happens regularly all over the river.

204. **Impacts from Upstream Development Works.** Large numbers of hydroelectric projects (57 Nos. till February 2008 with a total generation capacity of 15,114 MW) are under implementation in the Brahmaputra Basin in Arunachal Pradesh. It is likely that these dams will have a significant effect on mainstream flood behaviour in the Kaziranga Reach. Any affect of upstream dams will be to reduce flood peaks. The dams will act as sediment traps on the tributaries and lessen the inflow of sediments to the main stem Brahmaputra River. The impact of this reduction in sediment inflows on main stream channel cross-sections and flood behaviour in the Kaziranga Reach is difficult to predict, but any effects are likely to lead to a reduction (probably small to insignificant) in flood levels.

205. **Mitigation Measures.** Flow velocity changes along the bankline will be systematically monitored as part of the near-bank surveys. This includes establishing systematic records of discharges and flow velocities during the hydrological cycle. It is expected that this monitoring will contribute to a better understanding and a gradual optimization of the layout of structural flood and erosion countermeasures.

206. Revetment which consist of dumped stone (rip-rap) shall be preferred to be laid on geo-textiles, jute textile or sand bags (as a bedding) to protect under-washing. Impermeable bituminous or interlocked revetments shall not be preferred as they have impact on the natural environment by interrupting exchange between flowing water and ground water. Any of the eco-

friendly local resource based methods may be used in preference to the impermeable surfaces like bituminous or cement slab.

5.2.3.4 Effects on River Morphology

Post- Construction / Operation Phase

207. **Impacts.** The construction of riverbank protection leads to a river response to the implemented work, commonly deepening of the channel alongside the protection work. This is a consequence of flow concentration and/or a reduction of sediment entrainment from eroding bank. It is commonly believed that the Brahmaputra instability is largely associated with excessive sediment transport. The proposed interventions, revetments and anti-erosion measures, commonly referred to as "porcupines", reduce the intrusion of additional sediment from local bankline erosion. In addition, porcupines tend to store sediment, which is parts can be mobilized during higher discharges. This storage and release follows the normal river regime where sediment gets mobilized mainly during the higher discharges of the flood season, with little transport during the drier months. Both measures further reduce turbulences and the impact on the currents as opposed to spurs, which actively deflect the currents, and as a consequence minimize negative effects. The reduced sediment entrainment alongside the protected reach has the tendency of encouraging more pronounced and stable channels without affecting the opposite bank or the upstream area. In order to avoid downstream riverbank erosion the project places the downstream termination with a slight curvature away from the existing bank, which results in passive protection of a certain downstream length. This does not alter the unstable pattern of constantly changing in-stream channel bars, locally called, chars or chaporis. Fluent and adaptive land use patterns of char land will continue in future.

208. Certain impacts would be expected from the construction of dams upstream, which will act as sediment traps on the tributaries and lessen the inflow of sediments to the main stem Brahmaputra River. The impact of this reduction in sediment inflows on main stream channel cross-sections and flood behaviour in the Kaziranga Reach is difficult to predict, but any effects are likely to lead to a reduction (probably small to insignificant) in silt deposition in the riverbed.

209. **Mitigation Measures.** The Project envisages systematic annual platform analysis and prediction, which includes the analysis of the structural response to riverbank protection work. The analytical tools consist of (i) low-water satellite imagery based large-scale morphological analysis of Brahmaputra reaches, supported with (ii) large-scale bathymetric surveys covering the near bank channel pattern starting from several kilometres upstream of locations of interventions and typically ending around 10 km downstream, and (iii) near-bank surveys, providing a detailed picture of the river response and structural performance.

210. In case unexpected downstream effects are observed, the Project concept allows later rectification within the concept of adaptive approach. To this end, the project has substantial contingencies.

5.2.3.5 Impact on Silt Deposition

Post construction/Operation Phase

211. **Impacts.** Brahmaputra river is one of the most heavily sediment charged river carrying average annual suspended load of 400 million metric tons. During the flood the inundated area gets heavily silted due to this high sedimentation load in the river. In the past flooding scenarios, such as in 2004, it was observed that there were sand depositions on good agricultural lands associated with embankment breaches. The deposition of sand with low organic content leads

to reduction in soil productivity. Breaches in embankments during flood constitute the major factor in large-scale deposition of sand-sized coarse sediments i.e. sand-casting in the riverine tracts of Assam. The bank stabilization and strengthening of the embankment system in the Kaziranga Reach would prevent deposition of silt over the land which used to get flooded, leading to improvement in productivity of soils. This will help in supporting the agriculture land as about 26.2% of land in 8 km buffer around the embankment is used for agricultural activities. In the absence any breach in the embankment system after the commissioning of the project, the danger of sudden onrush of water and deposition of coarse sediments in the floodplain making the soil unproductive could be avoided and safety provided to the subproject area.

212. On the other hand, there will be induced silt deposition along the riverbanks induced by pro-siltation measures such as porcupines in selected areas depending on the local flow and channel conditions. However, this does not alter the unstable pattern of constantly changing in-stream channel bars within the river area.

213. **Mitigation Measures.** The pattern of silt deposition in the river and areas adjacent to the bank especially in the vicinity of anti-erosion and river training works will be monitored at regular intervals and necessary changes regarding the mitigation measures taken accordingly.

5.2.3.6 Effect on Drainage System

<u>Post construction/Operation Phase</u>

214. **Impacts.** Effect on the natural drainage system can not be totally avoided in the case of a structural intervention such as embankment built along a natural river like the Brahmaputra, but the impact can be minimized if adequate mitigation measures are taken.

215. **Mitigation Measures.** Provision shall be made to the extent possible not to obstruct the natural drainage lines from discharging into the Brahmaputra. The strengthening of the existing embankment structure and provision of necessary cross-drainage facilities like sluice gates, and additionally providing bank protection and river training works at different locations will help improve the drainage system in the reach. A comprehensive analysis of the existing natural drainage system will be undertaken in the next phase of the Project to identify drainage behaviour and problems, key drainage channels/ systems and drainage congestion areas. The cost-effectiveness of various remedial measures will be assessed with the object of improving drainage conditions. As part of this investigation, the effectiveness of deepening and extending existing wetlands and water bodies will be assessed.

5.2.3.7 Effect on Wetlands/ Beels

<u>Post construction/ Operation Phase</u>

216. **Impacts.** The Shohola beel is one of the important wetlands of Kaziranga Subproject area located between Moriaholla and Dhansirimukh. This beel is located towards the riverside of the embankment. No direct impact is anticipated on this beel due to the Kaziranga sub-project activities. There are many other wetlands in the study area, but most of them are on the riverside or in Kaziranga National Park area and are not likely to be affected by the project activities.

217. **Mitigation Measures.** Since various terrestrial and aquatic wildlife species depend on these wetlands, due care should be taken to insure that no direct or indirect impact like siltation or flow of construction waste is caused to any wetland located in the closed vicinity of project construction activities.

5.2.3.8 Water Quality

Design and Construction Phase

218. **Impacts.** The major source of surface water pollution during project construction phase will be sewage and wastewater generated from labor camp/ colonies as well as workshop areas. The project construction is likely to last for a period of 6 years. Most of the labourers would come from nearby areas. About 50-60 labour families (total population 250 to 300) are likely to stay in each construction camp. The domestic water requirements in each construction camp will be about 45 m^3/day. It is assumed that about 80% of the water supplied will be generated as sewage. Thus, total quantum of sewage generated is expected to be of the order of 36 m^3/day. However, it may pollute land and other nearby water bodies if discharged untreated, especially during the low flow season.

219. No arsenic pollution is noticed either in river water or ground water in this area. Hence no impact of arsenic is anticipated in this area which is otherwise prevalent problem in West Bengal and adjoining areas and reportedly in some locations in Assam.

220. As significant quantity of groundwater is not likely to be extracted as part of this project, any appreciable quantitative impact on ground water because of the construction activities is also ruled out. In addition to that ground water is easily available in 5 m BGL even during the lean periods. Impact on ground water quality is not likely due to the project activities as the wastewater generated from the project will be trapped for treatment before it will discharge/ percolate from the project sites.

221. **Mitigation Measures.** To minimize the need for construction camps, preference shall be made to local communities and workers to work on specific section of the embankment, or specific tasks like the construction and installation of porcupine screens. Septic tanks shall be provided in each camp to treat the domestic sewage. Provision of mobile toilets may also be considered with the provision of channelling the sewage to septic tank in closed loop system. Discharge of untreated domestic sewage to the Brahmaputra River or to any natural waters will not be permitted. No debris shall be dumped in the water bodies.

Post Construction/ Operation Phase

222. No impact is anticipated due to the project in this phase.

5.2.4. Climate

Design and Construction Phase

223. **Impacts.** Short term impact on temperature may happen in the immediate vicinity of the embankment due to the construction activities and cutting of trees falling in the project intervention zone. As per field assessment, there are about 2,000 trees of various varieties, which are likely to be affected/ cut due to the project. These trees are however of fast growing species like Simul, Bogori, Bhimkol etc.

224. **Mitigation Measures.** The maximum possible efforts have to be made for minimizing cutting of the trees while designing the embankments. Compensatory tree plantation to be undertaken preferably on the basis of 3 trees plantation against each tree cut.[24]

Operation Phase

225. **Impacts.** No direct impact is anticipated on the climate of the area due to the proposed project. However changes in the catchments area of the river and extreme events due to possible climate change (global warming) can have indirect impacts on project and project area.

226. With respect to the proposed project, climate change can play a major role due to its implications on water resources, water availability, and inland/ fresh water wetlands .The climate change impacts on water resources for throughout the country were studied as part of India's Initial National Communication (Natcom 1) Project[25]. The study revealed that climate change impacts on the inland wetlands would be a complex issue dependent on several variables, including temperature increase, rate of evaporation, changes in precipitation on the catchment, changes in nutrient cycling and the responses of a variety of aquatic species. Although tropical lakes are less likely to be impacted by climate change as compared to temperate lakes, an increase in temperature would alter the thermal cycles of lakes, oxygen solubility and other compounds, and affect the ecosystem. Shallow-water marshes and swamps would be even more vulnerable to increased temperatures and lower precipitation. The increased evaporation of water and reduced inflow from rainfall could desiccate the marshes, swamps and shallow lakes.

227. GCM model projections (by HadCM2) for India indicate an increase in precipitation by up to 30% for the north-eastern region in addition to a relatively moderate increase in temperature of about 2°C by the period 2041-2060. This could increase the incidence of flooding in the Brahmaputra basin. Since, there are divergent views on the above findings; these can not be taken into consideration for any design change at this stage till more specific and dependable information related to climate change effect on river hydrology in this region is available.

228. **Mitigation Measures.** The likely impact framework shown above is generalized. However more information has to be collected based on newer studies and monitoring data. Further action on this account can be considered only in the following phases of the project. The flood pattern shall have to be closely analyzed during proposed life span of the embankment and take appropriate timely protective measures in case the flood levels increase earlier than the projected levels for 2041-2060 due to climatic changes.

5.2.5. Air Environment

Design and Construction Phase

229. **Impacts.** The ambient air quality of the area is good. The level of SPM, RSPM, NOx, SO_2, Pb, CO, is much lower at the location monitored (Bankoal) than the prescribed National Ambient Air Quality Standards for rural areas (Table 3.13). While various construction activities

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[24] The rate of compensatory afforestation mentioned here is as per the consultation with Chief Conservator of Forests, Forest Department, and as per Assam Government's Guidelines for Compensatory Afforestation, 2000.

[25] The SWAT water balance model has been used in this study for the river basins to carryout the hydrologic modelling of the country. The SWAT model has been used on each of the river basins separately using daily weather generated by the HadRM2 control climate scenario (1981-2000). The model has been run using climate scenarios for the period 2041 to 2060, without changing the land use pattern. The outputs of these two scenarios have been analyzed with respect to the possible impacts on the run-off, soil moisture and actual evapotranspiration.

will increase the ambient air quality but the level is likely to remain within the prescribed standards.

230. During the construction phase, there will be two main sources of air emissions, i.e. mobile sources and stationary sources. Mobile sources are mostly vehicles involved in construction activities, whereas emissions from stationary sources include construction equipments & machinery, diesel generator sets, excavation/ grading activities etc. Hot Mix Asphalt (HMA) plants will be one of the major sources of emission, which will be used for road carpeting. In addition to these, fugitive emissions will also form a major proportion of air pollution in the form of particulate matter from storage and handling of construction material.

231. HMA plants have two major categories of emissions: ducted sources (those vented to the atmosphere through some type of stack, vent, or pipe), and fugitive sources (those not confined to ducts and vents but emitted directly from the source to the ambient air). Dryers are the most significant ducted sources of emissions from both batch mix and drum mix HMA plants. Emissions from these sources consist of water (as steam evaporated from the aggregate); PM; products of combustion (carbon dioxide [CO_2], NOx, and sulfur dioxides [SO_2]); CO; and small amounts of organic compounds of various species (including VOC, methane [CH4],). The CO and organic compound emissions result from incomplete combustion of the fuel and also are released from the heated asphalt.

232. Fugitive dust sources associated with construction phase include vehicular traffic generating fugitive dust on paved and unpaved roads, aggregate material handling, and other aggregate processing operations. Fugitive dust generated from these activities may range from 0.1 µm to more than 300 µm in aerodynamic diameter. Dust emissions become crucial on embankment segments where a large number of residents have established their residents along or on the embankment.

233. The emission of particulate matter during the construction phase will be generated from the activities like receipt, transfer and screening of aggregate, crushing activity, road dust emissions. The likely emission levels from these sources are indicated at Appendix 5.1. In addition to that emissions from various construction machinery fueled by diesel and from mobile source will be in the form of PM_{10}, VOC, CO, NOx and SO_2. The emissions from stationary and mobile diesel engines with respect to their working/ movement are presented in Table 5.1:

Table 5.1 Exhaust Emissions for Stationary and Mobile Machinery

Source	PM_{10}	VOC	CO	NOx	SO_2
Diesel exhaust emissions (idle)	0.043 g/min	0.208 g/min	1.57 g/min	0.917 g/min	18.8 S g/l
Diesel exhaust emissions (moving)	0.4 g/mile	3.18 g/mile	18.82 g/mile	8.5 g/mile	18.8 S g/l

234. **Mitigation Measures.** Hot mix plants should be located away from the populated areas and be fitted with the air pollution control devices, the emission shall meet National/ State Pollution Control Board standards. Further, the hot mix plants must be sited at least 1 km in the downwind direction from the nearest human settlement. All hot mix plants will be have monthly emission monitoring to ensure compliance to the following source-specific air quality standards for particulates and sulphur emission. It shall be ensured that the dust emissions from the crusher and vibrating screen of the stone quarries do not exceed the standards.

235. Vehicles delivering loose and fine materials like sand and fine aggregates shall be covered to reduce spills on existing road. Water may be sprayed on earthworks, on a regular basis. During and after compaction of the sub-grade, water will be sprayed at regular intervals to prevent dust generation.

236. The following mitigation measures will also be taken to mitigate the dust entrainment and fugitive emissions from the various sources in Kaziranga reach:

- Covering of loads in trucks, and the paving of access areas to unpaved lots or construction sites, are examples of preventive measures. Examples of mitigative controls include water flushing, and broom sweeping and flushing.
- Redistribution of loose material onto the travel lanes will actually produce a short-term increase in the emissions. In general, preventive controls are usually more cost effective than mitigative controls.
- Sprinkling water will control fugitive dust entrainment.
- Sprinkling of water on the dust prone areas and construction yard.
- Regular maintenance of machinery and equipment will be carried out.
- Ambient air quality monitoring should be carried out during construction phase. If monitored parameters are above the prescribed limits, suitable control measures must be taken.
- Care shall be taken to keep all material storages adequately covered and contained so that they are not exposed to situations, where winds on site could lead to dust/ particulate emissions.
- Fabrics and plastics for covering piles of soils and debris is an effective means to reduce fugitive dust from the material stores/ warehouses.
- Spills of dirt or dusty materials shall be cleaned up promptly so that the spilled materials do not become a source of fugitive emission.
- Spilled concrete slurries or liquid wastes shall be contained/ cleaned up immediately before they can infiltrate into the soil/ ground or runoff in nearby areas.
- All slopes and embankments will be turfed as per best engineering practices to help minimize the dust generation during operation of the road.
- Plantation along the embankment should be maintained.
- Ambient air quality monitoring should be done for the first 3 years of the operation phase. If monitored parameters are above the prescribed limits, suitable control measures must be taken.

237. A wide variety of options exist to control emissions from unpaved roads in the form of:

- Vehicle restrictions that limit the speed, weight or number of vehicles on the road;
- Surface improvement, by measures such as (a) paving or (b) adding gravel or slag to a dirt road; and
- Surface treatment, such as watering or treatment with chemical dust suppressants.

Post construction/ Operation Phase

238. **Impacts.** The prime source for air pollution during post construction/operation phase will be the vehicular movement on the paved road on top of the embankment, which will be used for

transportation as well as maintenance of the embankment. However, as during the operation phase, the embankment will be strengthened & will be covered with turfing and construction of paved roads will reduce the fugitive emissions. Due to all these developments, impact on air quality during operation phase will be a beneficial impact.

239. **Mitigation Measures.** Plantation along the embankment and turfing on the embankment slopes should be maintained and their survival rates should be monitored. In addition to that regular maintenance of the road on the top of embankment as well as connecting roads shall be done for reducing fugitive emissions.

5.2.6. Noise

Design and Construction Phase

240. **Impacts.** During construction phase, noise will be generated from various activities such as site clearing, excavation, erection, finishing etc. The general noise levels during construction phase such as due to working of heavy earth moving equipments and machineries installation may sometimes go up to 100 dB(A) at the work sites[26]. It is also to be noted that significant amount of manual labor will be involved during construction of embankments.

241. As a worst case scenario considered for prediction of noise levels during construction phase, it has been assumed that all these equipments generate noise from a common point. The increase in noise levels[27] due to operation of various construction equipments is expected to increase the noise level from 100.3 dB(A) at a distance of 1m to 52.4 dB(A) at a distance of 250 m from the sources. The predicted levels are presented at Table 5.1:

Table 5.1 Increase in Noise Levels due to Operation of various Construction Equipments

Distance (m)	Ambient Noise Levels dB(A)	Increase in Noise Level dB(A)	Increase in Ambient Noise Levels dB(A)
1	51.0	100.3	49.3
10		80.3	29.3
50		66.3	15.3
100		60.3	9.3
150		56.8	5.8
200		54.3	3.3
250		52.4	1.4

242. In addition to the above, there will be significant increase in vehicular movement for transportation of construction material. At present, vehicular movement near the project site is

[26] The noise level from various construction equipment /machinery is (all levels are in dB(A)): Dozers (95-100), Front Loaders (72-84), Backhoes (72-93), Tractors (76-96), Toppers/Trucks (82-94), Concrete mixers (75-83), Concrete pumps (75-83), Concrete pumps (81-83), Cranes (movable) (75-86), Vehicular Traffic (construction material & plant & Machinery) (85-98), Dg Set (90-95), Pumps (69-71), Compressors (74-86), Pneumatic Wrenches (83-88), Jack Hammer and rock drills (81-98), Pile Drivers (peak) (95-105).

[27] In absence of the data on actual location of various construction equipments and machinery, all the equipments have been assumed to operate at a common point. This assumption leads to over-estimation of the increase in noise levels. However, the noise levels shall attenuate as the sound wave passes through a barrier. The transmission loss values for common construction materials like brick, light concrete, dense concrete, concrete block with a thickness of 4 to 6 inches vary in the range of 30 to 40 dB(A). Thus, the walls of various houses will attenuate at least 30 dB(A) of noise. In addition there will be attenuation due to Air absorption, atmospheric in homogeneities, and vegetal cover.

of the order of 5 to 10 vehicles/hour. During construction phase, the increase in vehicular movement is expected to increase up to a maximum of 40 to 50 trucks/ hour.

243. As a part of the EIA study, impact on noise level due to increased vehicular movement was studied using Federal Highway Administration model. The results of modeling are outlined in Table 5.2:

Table 5.2 Increase in Noise Levels due to Increased Vehicular Movement

Distance (m)	Ambient Noise Level dB(A)	Increase in Noise Level dB(A)	Increase in Ambient Noise Level dB(A)
10	51	72	21
20		67	16
50		61	10
100		57	6
200		52	1

244. Hence, during construction phase, increase is expected to be between 25 to 30%. However, the increase in noise levels will be localized, temporary in nature and mostly will be during daytime only.

245. **Mitigation Measures.** Following noise control measures shall be adopted, and included in the civil work contracts:

- Site Controls: Stationary equipments shall be placed along un-inhabited stretches meeting the National Noise Quality standard, particularly for residential areas (Category C) and silence zones (Category D: hospitals, educational institutions, courts, religious places, etc.), keeping the distance at least 150m (Category C) and 250m (Category D), to minimize objectionable noise impacts. In the event that potential noise sensitive receptors are identified who will fact higher noise due to construction, appropriate temporary noise barriers will be established.
- Scheduling of Project Activities: Operations will be scheduled to when people would be least likely to be affected. Construction activities shall be restricted between 10 P.M. and 6 A.M. near residential areas.
- Protection devices (ear plugs or ear muffs) will be provided to the workers operating in the vicinity of high noise generating machines.
- Construction equipment and machinery shall be fitted with silencers and maintained properly.
- Noise measurements shall be carried out along the reach as well as in nearby villages, to ensure the effectiveness of mitigation measures.
- Use of manual labor will be promoted.

<u>Post construction/Operation Phase</u>

246. **Impacts.** The prime source of noise pollution during operation phase will be the vehicular movement. However, as the roads will be paved and will provide smooth traffic movement, the impact due to vehicular movement will be less significant.

247. **Mitigation Measures.** Adequate signage shall be provided restricting use of pressure horn particularly in noise sensitive locations particularly near schools, hospitals and populated areas etc. Noise measurements shall be carried out along the road to ensure the effectiveness

of mitigation measures. Tree barriers between the road and village, semi urban and urban area shall be developed in a layered manner as suggested in air environment mitigation measures.

5.2.7. Terrestrial Ecology

5.2.7.1 Disturbance to Vegetation

<u>Design and Construction Phase</u>

248. **Impacts.** The river behavior has changed in last 20 years and river course has changed resulting in loss of terrestrial flora due to soil erosion. Due to Kaziranga sub-project, the progressive loss of land and flora (vegetation) will be prevented to the extant of 34 ha/year. The rhino and wild buffalo wallowing site identified near Agoratali & Mahkhuti area may get affected due to construction activities, if due care is not taken. A total of 1,393 trees on the riverside of the embankment and 604 trees on country side of the embankment are falling in the 100 m corridor of either side of embankment, which are likely to be cut.

249. **Mitigation Measures.** Efforts shall be made to minimise the tree loss. Provision shall be made for planting 3 trees for every tree cut. Plantation programme shall be initiated from the initial parallel to construction activity. The native and existing vegetation profile shall be maintained during plantation programme, so that local inhabitants can utilize their resources. The indigenous plants shall be preferred.

<u>Post construction/Operation Phase</u>

250. No direct impact is anticipated during operation stage except accidental damages or absence of tree management. On this account, Arrangement shall be made for tree management to ensure survivability of the tree plantation. The social forestry department may be consulted or involved in this programme. The tree survivability audit shall also be conducted at least once in a year to assess the effectiveness of the programme.

5.2.7.2 Habitat Fragmentation and Destruction

<u>Design and Construction Phase</u>

251. No habitat fragmentation is envisaged due to the project activities in this reach. Two spots of Rhino and Wild buffalo wallowing site have been located near Agoratali & Mahkhuti area (Coordination: 26°36′48″N-93°27′26″E and 26°40′50″N-93°35′35″E), respectively (Ch. 6.75 km – Ch. 12.0 km area of KNP), which may be affected due to the project intervention, if due care is not taken during construction activities in terms of vehicular movement, noise generation and waste handling. As mitigation measures, No construction camp shall be located near the above wallowing sites. The haulage road would also be located on eastern site of the embankment to prevent any damage to these sites.

5.2.7.3 Animal Distribution/Migratory Route

<u>Design and Construction Phase</u>

252. **Impacts.** At Bankoal Bali Sapori (Co-ordinates: 26°41′56″N-93°44′23″E) dolphins come during rainy season. Dolphin is sensitive to polluted water and any obstruction of the channels at this stage may disturb the breeding activities. No impact envisaged on to the dolphins in other seasons (except breeding period) since, they are confined to the deep water channels of the River Brahmaputra.

253. **Mitigation Measures.** All care shall be taken to ensure that construction waste does not find its way to water in this area and pollute it. Care shall also be taken to ensure those channels are not obstructed in any way. Given that the breeding season for almost 80% of fish species starts in April and ends in August (i.e., during the pre-monsoon and monsoon seasons), construction will be restricted during this period at the concerned breeding and spawning sites. Provision will be made to increase the fish productivity of wetlands, beels, and fish ponds substantially.

<u>Post construction/Operation Phase</u>

254. No impact is anticipated during operation stage with regards to animal distribution and migration.

5.2.7.4 Endangered Species

255. Due to the proximity of KNP, the area supports 40 globally threatened species, and 31 endangered mammals. However, no impact is anticipated on any endangered species due to project intervention.

5.2.8. Aquatic Ecology

5.2.8.1 Effect on Fishing Activities/productivity

<u>Design and Construction Phase</u>

256. **Impacts.** The areas between coordination of N: 26°07'58" E: 91°01'04" and N: 26°07'58" E: 91°20'52" supports comparatively very good vegetation types on the bank of the proposed project areas. So the bank of the river having sandy beds should not be disturbed during the project intervention. Special care should be taken to keep the breeding habitats in their natural conditions.

257. Temporary flushing of the fish species towards the deeper part of the river may happen during construction of bank line protection measures. The construction of spurs and deflectors will not affect the fish activity in the river as they move with the river current. The construction activity may increase the turbidity on the bank temporarily. However turbidity (siltation level as such is high and its species are accustomed to high siltation level). Hence no impact either anticipated due to this as well.

258. **Mitigation Measures.** Adequate provision shall be made in the design to ensure access to the fish landing site/Boatghat. Adequate requisite facilities shall be restored or maintained for undisturbed movement of the fishermen. The provision of sanitary facilities and concreted platform area with grease trap for collection of spill over or waste oil shall be provide at fish landing site/ boatghat to prevent contamination of river water specially at boatghat which is also the fish/ Dolphin breeding site.

<u>Post construction/Operation Phase</u>

259. No impact is anticipated during operation stage with regards to fish activities

5.2.8.2 Migratory Routes

260. The migratory fish species like Tor and Anguilla which have been encountered show anadromus and catadromous migratory behaviour respectively migrate through the main

channel of the river i.e. through the deeper zones of the river. The construction of the dyke will not have any negative effect on the migratory route.. Other fish species like *Crossocheilius, Tor* show only local migration from upper to lower reaches of the river.

5.2.8.3 Effect on Spawning and Breeding Grounds

Design and Construction Phase

261. **Impacts.** The breeding habitat of the riparian zones must not be disturbed at any cost. Heavy silting because of construction activities which would result in high turbidity should be avoided. Therefore precaution will have to be taken during the construction. During Monsoon at high flood level the fish and other vertebrates breed in the shallow marginal areas of the river bank. So the construction activities should be restricted at the time of breeding season. Free migration of brooders and juveniles of fishes from the river to the beel and vice-versa should be allowed.

262. **Mitigation Measures.** The construction activity should be restricted during the breeding period of April to August at above breeding sites (Bankoal Bali Sapori). All care shall be taken to ensure that construction waste does not find its way to water in this area and pollute it.

Post construction/Operation Phase

263. No impact is anticipated during operation stage with regards to fish activities.

5.2.8.4 Effect on Pond Fisheries

264. **Impacts.** No pond fisheries activities are found along the existing embankment. However pond fisheries are found in the study areas. The current productivity of these places is low. Once flood scenario is stabilised, siltation problems is minimised, the fish productivity of these areas will be improved.

265. **Mitigation Measures.** The fish productivity can be improved substantially with use of better fish culture and increasing the capacity of fish ponds as well institutional strengthening support. Fish productivity audit may also be undertaken to assess the effect of institutional support.

5.2.9. Socio Economic

5.2.9.1 Demography

Design and Construction Phase

266. **Impacts.** Owing to the proposed project, there will be establishment of construction camps that will add to the population of the study area. Migrant workers will have the potential impacts of conflicting culture and lifestyle compete with local labourers over job opportunities, and potential health issues such as HIV/AIDS. This shall also exert pressure on the natural resources in the project area. However, this will only be a temporary phase lasting only during the construction period.

267. **Mitigation Measures.** Early consultations will be made by the contractor with the local communities to determine the appropriate location of work camp sites with the encouragement that local people are given preference in employment when they meet basi job requirements. All

migrant workers will undergo workshop/briefings to sensitize them on local culture and lifestyle awareness.

5.2.9.2 Archaeological Sites to be Impacted

268. No archaeological sites will be impacted due to the proposed construction of river embankment along the Kaziranga reach

5.2.9.3 Places of Pilgrimage and Tourism to be Impacted

269. There is no pilgrimage or tourist spot along the Kaziranga reach. Hence, no impact to this valuable component is expected. In fact, with the strengthening of embankment and improvement of roads, will have positive impact on the accessibility of the villages along the reach.

5.2.9.4 Water Supply and Sanitation

Design and Construction Phase

270. **Impacts.** Local residents are depended on ground water for meeting their drinking water supply. The quality of ground water in this reach was found fit for drinking purposes. Project Activities are not likely to affect the water supply of the area. Sanitation facilities are poor in the area. Local residents go to river bank for their daily needs. Many a places bank has been damage to create access to river. Drinking water and sanitation becomes one of the major problems during floods.

271. **Mitigation Measures.** Access should to be provided to river near community settlements. Awareness should be created among the residents about the upkeep of the embankment. Garbage shall be collected at designated locations. No sewage shall be discharged into the surroundings, especially the water bodies.

Operation phase

272. Unplanned development, encroachment of the embankment, tree plantation on the embankment may affect the stability of the embankment. This will be mitigation by preventing uncontrolled and unplanned development. Awareness will be created amongst the people for the upkeep of the embankment.

5.2.10. Socio-Economic Impact – Land Use

Design and Construction Phase

273. **Impacts.** The large numbers of households are affected by flood and erosion. In the Kaziranga Reach alone about 82.40% of households surveyed by socio-economic team under this TA are affected due to flood and erosion. The proposed project will bring relief to all the residents in this area. Although the project will cause displacement to some of the persons, compensation shall be paid to the affected persons. The project will also provide employment to a large number of people for about 6 years. The project will also boost the local economy as small businessmen and entrepreneurs will provide the daily needs of the workers and officers of the proposed project.

274. With the stabilisation of the area and prevention of land loss due to erosion every year (about 34 ha/year) land availability for multiple crop will increase bringing positive impact on the

local economy. In addition, there are twelve major fish landing stations in this reach. The average fish collection at these centres is of the order of 75 to 150 kg per day. These stations may get disturbed during construction stage.

275. Some of the subproject infrastructure would require land acquisition and resettlement, including the renovation of existing embankments. Riverbank protection, sluice gates and associated structures will also require a certain amount of land acquisition and resettlement of embankment squatter population. For the purpose of the tranche-1 civil works, a resettlement plan has been prepared, which identified the need for land acquisition of 20.6ha of land with a total number of affected households at 80, of which 40 households are significantly affected.

276. The subproject area also has existing embankments and associated structures of which land acquisition process has not been completed. It is a strong demand of the concerned local population that the past dues of the land acquisition and resettlement payments should be provided in association with the improvements of the concerned infrastructure.

277. **Mitigation Measures.** All resettlement activities will be implemented in accordance with ADB's voluntary resettlement and other social safeguards policies, as well as the applicable laws and regulations of the Government of India and the Assam State. In the context of the project, a resettlement framework (RF) and indigenous people's development framework (IPDP) were prepared to cover the subproject infrastructure. To mitigate the impact and to ensure there is no impoverishment or affected HH, a detailed Resettlement Plan was prepared for tranche-1 civil works, and further plans will be prepared and implemented to ensure timely payment of compensation and restoration of assets and livelihoods of all affected households.

278. It is recommended that the project affected people are given preference as daily wage labourers. Proper income generation program should be included for the affected people for the post construction period. The training programmes for agriculture and fish production improvement shall be implemented so that the local economy is positively impacted by the proposed project. Farmers can also consider switching over to shallow water rice cultivation means from anaerobic verity to aerobic variety of rice cultivation. Framers will be able to get three crops which are otherwise mostly limited to two crops. Appropriate provision shall be made to provide alternate fish landing station so that economic activities of the fishermen are not disturbed due to project activities.

5.2.11. Accidents and Safety

Design and Construction Phase

279. The risks associated with the proposed project are minimal. However, roads being narrow, efforts shall be made that no hazardous traffic conditions are created due to construction vehicle movement. Local people may encroach to construction area and get hurt. This can be mitigated by adequate lighting and fluorescent signage shall be provided at the construction sites. Signage shall be made in local language. The workers shall be provided with necessary Personal Protective Equipments and a First Aid unit including adequate supply of dressing materials, transport means, nursing staff and an attending doctor, shall be available at each construction site. Health check up camps shall also be organized every year.

Operation Phase

280. Due to improved road condition, drivers may have tendency to drive fast on embankment road resulting in accidents. To mitigate the impacts, speed limits shall be

prescribed for vehicular movement on the embankment road to avert the accidents. Adequate signage and light reflectors shall be places along the road side.

5.2.12. Navigation

<u>Design and Construction Phase</u>

281. **Impacts.** This river section is navigated by people for moving to one place to another located at river bank and moving to char lands for fishing & farming. They use small motor boats and fish landing sites or boat Ghats for these movements. There are various fish landing sites in this sub project area. These landing sites could be temporarily disturbed due to project activities. However there will not be any impact on the general navigability of the river due to the project since project activities are limited to river bank and beyond.

282. **Mitigation Measures**. During construction, contractors are asked to provide alternate landing sites (ghats) with similar berthing facilities, access, and other common infrastructure, as part of the tender documents. In places the riverbank protection will provide steps to facilitate landing of local boats in support of trade and river crossings. The project design has additional provisions to closely monitor the general river behavior as well as its response to the new works and, within the concept of adaptive approach, to mitigate any negative impacts (through phased implementation).

5.3. Summary of Impacts and Residual Impacts.

283. With implementation of proposed mitigation measures, most of the residual impacts will be minimized. The summary of impacts and mitigative measures is given at Appendix 5.2.

6. ENVIRONMENTAL MANAGEMENT PLAN (EMP) AND MONITORING PLAN (EMOP)

284. The aim of the Environmental Management Plan (EMP) is to ensure implementation of the recommended mitigations measures throughout the subsequent subproject development stages. The mitigation measures are designed either to prevent impacts or by mitigating those to reduce the effect to an acceptable level by adopting the most suitable techno-economic option. The EMP also ensures that the positive impacts are conserved and enhanced.

6.1. The EMP

285. The Environmental Management Plan (EMP) consists of a set of mitigation, monitoring and institutional measures to be taken during the design, construction and operation stages of the project. The plan also includes the actions needed for implementation of these measures. The major components of the Environmental Management Plan are:

- Mitigation of potentially adverse impacts
- Monitoring during project implementation and operation
- Institutional Capacity Building and Training
- Implementation Schedule and Environmental Cost Estimates
- Integration of EMP with Project planning, design, construction and operation

286. The Environmental Management Plan is detailed at Appendix 6.1.

6.1.1. EMP Implementation Timetable

287. The mitigation measures shall be implemented depending on the nature and time of impact. The implementation schedule has been prepared considering 72 months of construction phase starting from year 2009 and Operating Phase of 30 years. The proposed implementation schedule is enclosed as Appendix 6.2.

6.1.2. Social Development Program

288. A separate social impact assessment study has been undertaken and social development programme is addressed as per SIA. The various impacts having significant impact of social nature like agriculture, fish catch etc. have also been addressed under this study. The mitigation measures including training aspects has been covered under this section and detailed at Chapter 8.

6.1.3. Contingency Response Plan

289. Field study, public consultation, and consultant’s experience reveal that this project may have only two environmental emergency i.e. accidents on paved roads and consequent spillage, and breach of embankment/overtopping of embankment.

290. It is suggested that the communication and response system be developed and practiced to minimize the response time. This should be covered under environmental guidelines to be prepared by WRD for effective implementation of mitigative measures. The local people/fishermen should be informed about likely accidental spills, nature of contamination and response. The project authorities (WRD) should ensure accidental spill management either by developing in-house capabilities or by associating with any competent third party.

291. Improved flood forecasting and warning by the WRD to communities is one of the components of this Project to be developed during Year 1 of implementation. A variety of national (CWC, IMD), State (WRD, Revenue and Disaster Management Department) and local government (deputy commissioners of district administration) agencies participate in the flood forecasting-warning process in Assam. The crucial element of this process is the provision of timely and accurate warning of villagers about an impending flood. Discussions to date indicate that most villagers receive no formal flood warnings. They generate their own warning by watching the river during the flood season, taking into account local rainfalls. Local villagers seem to be highly flood aware and flood resilient. Improvements to 'upstream' elements of the FFW process will be pointless if they are not translated into more effective responses at the community level. *Again, it would seem that improvements to the FFW system at the national and State levels will not provide a panacea to flood risk management in Assam.* It is noted that during the flood season, WRD station officers at 5 km intervals patrol the embankments, measure flood levels and report back to the flood control centre. These front-line observers have the training to provide effective and accurate local flood warnings with levels meaningful to villages along their respective 5-km sections of embankment.

292. The Project will review the various elements of FFW process, paying special attention to warning needs at the village level and possible improvements (i) at the community level and (ii) at the flood emergency management level. It is anticipated that an important element of an improved FFW system will be the provision of local forecasts by WRD, i.e. the translation of regional forecasts by CWC into clear and easily understandable warnings at the village level. Local communities will be centrally involved in this process. The Project will work with CWC and IMD regarding FFW.

6.1.4. Authorities and Their Responsibilities for Implementation of the EMP

293. The authorities and responsibilities for the implementation of the environmental management plans shall be tiered based on the activity. The suggested hierarchy and information flow is given at Figure 6.29.

294. All the policy decisions, including incorporation of the EMP requirements in compliance to loan covenants shall be the responsibility of the recommended Assam Integrated Flood Control and Riverbank Erosion Risk Management (AIFRERM) Society as the executing authority and will be registered under the Societies Act. The AIFRERM Society will be composed of representatives from State: departments of water resources, agriculture, char development, finance, fisheries, forest and environment, planning and coordination, public works, disaster management and revenue, rural development, soil conservation, and welfare of plain tribes and backward classes.

295. A Program Management Unit (PMU) will be established in AIFRERM Society that will have multi-disciplinary structure. One of the units in the PMU will be the social and environmental unit, which will include a senior environmental specialist seconded from the State Forestry and Environment Department or engaged externally from the market. The PMU will be assisted by a multidisciplinary team of consultants for institutional strengthening and project management (ISPM) for capacity development, quality control, and project management. The PMU-Social and Environmental Unit (SEU) will ensure that the environmental mitigation measures are being implemented by the subproject implementation offices (SIOs). The PMU will, among others ensure that the EIA Reports comply with national and Bank guidelines, monitor the status of implementation, and preparation of monitoring reports. The regional office

of ADB, in close consultation with RSDD, is recommended to confirm the compliance with ADB's safeguard policies by the PMU.

296. In each subproject, there will be subproject implementation unit (SIU) comprising technical team (SIU-T) and disaster risk management and coordination team (SIU-DRMC). The SIU-DRMC will have experts engaged from the market on environmental management and social safeguards, who will implement or cause the implementation of the monitoring and mitigation measures under the supervision of the PMU-SEU. The head of the SIU-DRMC, a nodal officer of the district administration in disaster risk management, will be assigned as chief safeguards officer.

6.1.5. Mechanisms for Feedback and Adjustment

297. The SIU with the help of contractors will submit a monthly progress report on implementation level of EMP to the SIU and PMU. Any deviation from the contract requirements with respect to proposed EMP should be corrected within a fortnight and records maintained for the same.

298. As part of the feedback mechanism, the SIU shall monitor project compliance with respect to:

- Environmental Management Plan
- Applicable laws, rules and regulations

299. Public involvement shall be encouraged and ensured throughout the lifecycle of the project. The SIU shall gather and maintain information on any damage or public concern that may be raised by the local people, NGOs and local authorities. While immediate solutions are to be worked out with the help of contractor, a detailed report will be submitted to the SIU for information or detailed consideration, as the case may be. The SIU will be responsible to bring it to the notice of the PMU. Resulting decisions shall be communicated back to SIU and contractor for correction and future implementation. An operation-period workshop may be required for effective implementation of the EMP.

6.2. Environmental Monitoring Plan (EMoP)

300. The aim of environmental monitoring during the construction and operation phases is to compare the monitored data against the baseline condition collected during the study period to assess the effectiveness of the mitigation measures and the protection of the ambient environment based on national standards.

301. A monitoring schedule has been drawn up based on the environmental components that may be affected during the construction and operation of the project. Since project is likely to have impact on various components of environment, a comprehensive monitoring plan covering wildlife, fisheries, cropping pattern, soil erosion, drainage congestion, tree plantation, air quality, noise & vibration are provided as Appendix 6.3. Monitoring Plan has been separately suggested for construction phase and operation phase. Monitoring points have been selected based on the sensitivity of the location with respect to sensitive receptors.

6.2.1. Monitoring Schedule

302. The monitoring schedule has been developed based on the possible occurrence of adverse impacts and required mitigation actions. However, this monitoring schedule is subject

to change depending on the analysis results obtained. The protocol for changing the monitoring schedule is given below :

6.2.1.1 River Hydrology, Morphology, and Sediment Transport

303. No significant external negative impacts on river hydrology, morphology, and sediment transport is expected due to the nature of the Project to support the strengthening of the existing embankment systems that will maintain or restore the intended functions of those systems and thus formalize the existing flooding behaviour that has persisted since these embankments were first constructed. Riverbank protection measures–with their focus on revetments and pro-siltation measures along the naturally developing bank lines in an adaptive manner–will not alter the existing unstable channel formation pattern of the Brahmaputra morphology. However, the project will put into operation systematic monitoring of river hydrology, morphology, and sediment transport and build sound knowledge base as an important component of the overall investment. This will facilitate the identification of any localized impacts in the subproject areas.

6.2.1.2 Terrestrial and Aquatic Fauna including Fisheries

304. The fish productivity monitoring are important and sensitive issues. In case, any significant decline in terms of fish productivity in the beels/wetlands or pond is noticed the monitoring frequency be increased till the effectiveness of mitigation measures are established.

6.2.1.3 Soil Erosion and Drainage Congestion

305. No significant soil erosion problem is anticipated due to the project either in the construction phase or in the operation phase. However, in the construction phase, some localised soil erosion may be noticed owing to construction activities. However, if soil erosion is noticed during construction and operation phase, the corrective action shall be initiated and frequency of check be increased to assessed the tendency of recurrence.

306. The performance and impacts of existing and strengthened embankment systems on the natural drainage including the wetlands within the systems will be closely monitored to facilitate appropriate mitigation measures such as provision of sluice gates and their proper operation to reduce post-monsoon drainage congestion and allow water level management in wetlands.

6.2.1.4 Air and Noise Quality

307. Due to the variability of the construction activities, namely changes in batch composition, type of construction activity and other anthropogenic influences, the air quality in the project area may change. If the air quality with respect to any parameter exceeds by more than 25% of its last monitored value, the monitoring frequency shall be doubled and cause of the increase investigated. If the construction activities are found to be the reason for this increase, suitable measures should be adopted.

308. Similarly due to the variability in traffic movement, namely changes in traffic volume, traffic compositions and other anthropogenic influences, the noise quality in the project area is likely to change. If the noise quality exceeds by 20% of the applicable ambient noise quality standard or 5% of its last monitored value, the monitoring frequency shall be increased cause of the increase investigated. If the construction activities are found to be the reason for this increase, suitable measures should be adopted.

6.2.1.5 Water Quality

309. No significant change in water quality is perceived due to the project in the operation phase. However, in the construction phase owing to construction activities the monitored values for pH, BOD, COD, TDS, DO and Oil & Grease might change. Hence, it is suggested that if the monitored value for any water quality parameter exceeds by more than 20% of its last monitored status the monitoring frequency shall be increased.

6.2.1.6 Tree Plantation

310. The 75% survival rate of re-plantation shall be monitored on the first year of the operation phase. If the survival rate is found below 70%, survival rate monitoring shall be again taken up after 3 years. This cycle should continue until the 70% survival rate is achieved.

6.2.2. Authorities and their Responsibilities for Implementation of EMoP

311. The most essential component of the Environment Monitoring Plan is the execution of the Plan in accordance with the monitoring schedule provided therein. The SIU-DMCT will be responsible for timely monitoring of various parameters and compliance with the mitigative measure proposed. A resultant data base is proposed to be maintained. A Management Information System (MIS) is also put in place for effective flow of information between various levels and functions within PMU.

6.3. Institutional Capacity

312. The proposed organisation structure to implement the AIFRERMIP and the environmental management plan is shown at Figure 6.29.

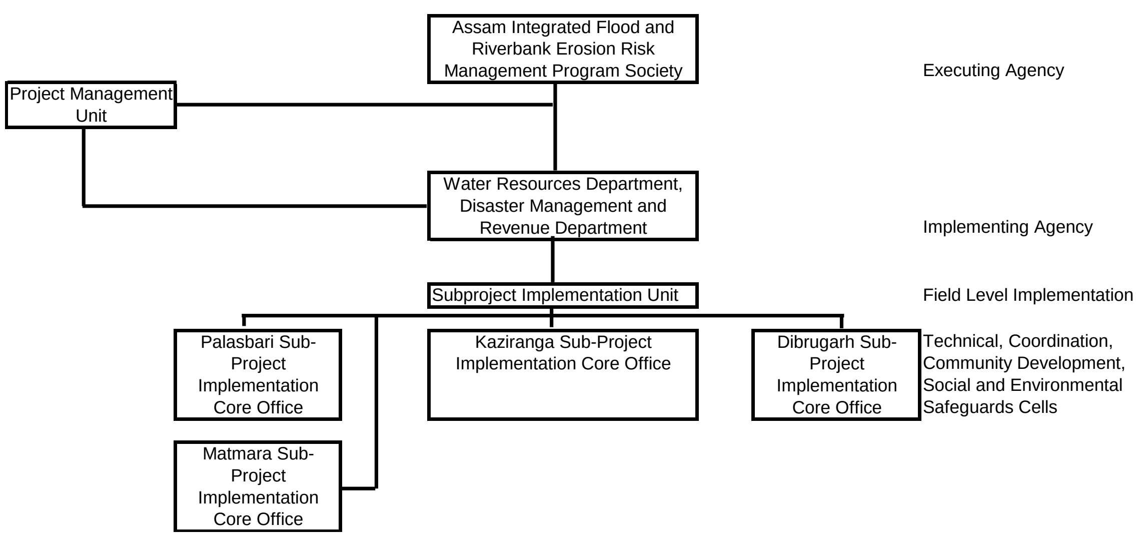

Figure 6.29 Proposed Organisation Structure

313. To enhance the capacity of the SIU for effective implementation of proposed mitigation measures and monitoring the resultant effect, some training programs are proposed. The detailed training plan is provided at Appendix 6.4.

314. It would be essential to understand the legislative framework and enhance capacity of WRD officials for analyzing the applicability of various environmental legislations and clearances, approvals and compliance monitoring requirements. An environmental legislation applicability matrix and legislative framework has already given in Chapter 2 above for ready reference.

6.4. Mitigation, Monitoring and Institution Strengthening Cost

315. The environmental budget has been worked out for the entire four projects together since various costs are common in nature. However summary table below highlights sub projects specific costs component. The mitigation cost, inclusive of monitoring cost and training during the project life cycle (construction and operation phase) amounts is estimated to be Rs 77.94 million for all the sub project put together. The mitigation cost including monitoring is estimated as Rs 57.89 million during construction phase and Rs 5.46 Million during operation phase. The costs of establishment and training are estimated as Rs 7.5 million. The detailed break up is given at Appendix 6.5 and summarised in Table 6.1 below.

Table 6.1 Summary of Mitigative, Monitoring and Institutional Costs

Component	Total Amount (In Million Rs)	Costs Breakdown where applicable (in Million Rupees)		
		Palasbari Reach	Kaziranga reach	Dibrugarh Reach
Design & Construction Stage				
Technical Support for preparation of Environmental Guidelines	0.5			
Flora- Tree plantation	42.12	23.40	3.12	15.60
Fisheries –Institutional support for improving fish productivity	3.0	1.0	1.0	1.0
Monitoring Fish Productivity	1.2	0.4	0.4	0.4
Water & Soil contamination prevention system /soak pits at construction camps	2.04	0.68	0.68	0.68
Health Check Up	1.8	0.6	0.6	0.6
Environmental Monitoring During Construction Phase	7.23	2.41	2.41	2.41
Operation Phase				
Tree survival and Additional Tree plantation	3.0			
Environmental Monitoring During Operation Phase	2. 46	0.82	0.82	0.82
Establishment & Training				
Establishment	3.5			
Training	3.0			
Management Information Systems	1.0			
Contingencies	7.09			
Total :	Rs. 77.94 Million			

(The components which are covered under engineering costs R & R Budget or Regular maintenance costs during operation phase are not highlighted above)

7. ECONOMIC ASSESSMENT OF THE ENVIRONMENTAL IMPACTS

7.1. The Need for Economic Assessment

316. The proposed project shall cause various short/ long term and primary/ secondary impacts on the study area considered as externalities. Although there are however mitigation measures and environmental management plan proposed, non-conformance to which will lead to much higher costs in terms of social and environmental concerns than the cost of the proposed mitigation measures. Hence, an environmental cost-benefit analysis has been carried out to evaluate the significant environmental impacts identified and their related mitigative costs.

7.2. Approach and Methodology

317. To carry out the environmental economic assessment of the project, economic value of different environmental aspects of the Integrated Flood & Erosion Management project has been quantified and evaluated. Various impacts expected during the construction and operation phases, without any mitigation measures and the cost of implementation of the proposed mitigation measures (Costing of mitigation measures has been computed in Chapter 6) are regarded as the costs to the project while positive benefits from the project after adequate implementation of these measures are taken as the benefits from the project. All the three reaches has been analysed together for the purposes of cost benefits analysis Different aspects considered for the environmental cost-benefit analysis is given in the following sections.

7.2.1. Erosion

318. **Impact Cost:** The River Brahmaputra is considered to be amongst the most vulnerable rivers in India. Every year considerable productive land is lost to erosion at various places along the river bank. The net project Erosion and average erosion considered for Kaziranga reach under the proposed Integrated Flood and River Bank Erosion Management Project are as follows:

Net Projected Erosion in (ha/year)	**33.60**
Average Erosion meter /year	**16.00**

319. In addition to protection of land from erosion, the farmers will be able to get definite third crop. There will be some land acquisition for embankment shifting but the loss of productive land will be minimal and not included here for analysis purposes. The erosion control is only a positive impact and there is no adverse impact cost associated with it. There would r be some impact during construction that has been address under air and noise pollution section of this chapter

320. **Mitigation Cost:** The cost of bank erosion control measures is included under the engineering cost of the project.

321. **Benefit Cost**: Although there is no impact or mitigation cost from erosion, the benefit is considerable. Based on land use record of Govt of Assam majority of the land in the project benefit area is agriculture which is about 62%. The major crops grown are Rice, Rabi, Khariff, Mustard and Tea, with rice accounting for 66% of the total. Considering the land use and existing cropping pattern a total benefit of Rs 0.81 M per annum or US $ 0.13 M for Kaziranga

reach can be achieved. Refer Table 7.2 for calculation basis. These benefits can further improve with improved cropping pattern and use of HYV seeds. With availability of land, even non-polluting industries as agro-based and cottage industries may also be promoted in the area.

Table 7.2 Benefits due to Prevention of Land Loss due to Erosion

Projected erosion	Eroded agriculture land	Crop Composition		Allotted land	Riverbank Length (km)	Average erosion (meter/yr)	Value added per ha.	Total benefits	Total benefits
(ha/yr)	(ha/yr)	Crop	E.f	ha			(Rs'000/ mt)	(Rs' mn)	mn. US$
33.60	21.62	Rice	0.96	20.8	21	16	0.02	0.44	0.011083586
		Veg(K)	0.05	1.0			0.06	0.06	0.001623581
		Veg(R)	0.08	1.7			0.06	0.09	0.002373156
		Mustard	0.10	2.3			0.01	0.02	0.000575793
		Others	0.16	3.4			0.04	0.13	0.003349292
		Tea		2.2			0.02	0.05	0.001188608
								0.81	0.020194018

322. **Net Benefit:** Since there is no impact cost, or mitigation cost, the net benefit equals the benefit which is Rs 0.81 M per annum or Rs. 24.3 M in thirty years.

7.2.2. Plantation

323. **Impact Cost:** The project also entails cutting of about 2000 trees in Kaziranga Reach due to renovation/construction of new dyke and other project activities. Needless to say, trees play an important role in the environment as oxygen purification, checking soil erosion, habitat of numerous different fauna, etc. The Bamboo and Simul trees are found in maximum quantity in all the sub project areas. The maturity period of Bamboo tree is about 3 years and Simul is about 10 years means most of the trees are fast growing. The economic benefit has been worked out based on direct sale value of a matured tree. The average value of a Simul tree is Rs 1500/tree and that of Bamboo is Rs 4000/ per Bunch[28]. For calculation purposes 60% tree are considered as Bamboo and 40% as Simul. On this basis the cost of tree loss is calculated as Rs 6 Million

324. **Mitigation Cost:** With regards to mitigation measures, it is planned to plant three times the tree cut. Means a total of 6,000 trees are to be planted. The cost of plantation and 3 years of maintenance is estimates as Rs 0.312 Million. Additionally the cost of monitoring and additional tree plantation is estimates as Rs 0.075 Million.

325. **Benefit:** Considering that 80% tree only will survive, a total of 4800 trees will be of economic value. Considering the same ratio of 60% Bamboo and 40% Simul, the economic value of these trees would be Rs 13.32 Million.

326. **Net Benefit:** Hence, against the ecological loss of Rs 6 Million and mitigation cost including monitoring of Rs 0.387 Million, an ecological gain of Rs 13.32 million is expected. The net ecological benefit from the proposed mitigation measures is thus Rs 6.933 million.

[28] One bunch of Bamboo tree has about 100 bamboo tree. Depending of its variety it is sold @ rate of Rs 35-80 per tree. For computation purposes average bunch cost has been considered as Rs 4000

7.2.3. Agriculture

327. The agricultural gain has been computed in the form of gain from prevention of soil erosion above. In addition to this gain farmers in the project benefit area are likely to gain from definite third crop.

7.2.4. Fishery

328. **Impact Cost:** Due to the proposed project no direct impact is anticipated on fisheries/fish productivity. However with the institutional support, the fish productivity can be enhanced which will have all positive impact.

329. **Mitigation Cost:** There is nil direct mitigative costs. However provision has been made for institutional support of Rs 1.0 Mn and Monitoring fish productivity of Rs 0.4 Million.

330. **Benefit**: Currently the fish productivity from pond fisheries and beel is of the order of average 100 to 120 kg/ha/annum (It varies though from 10 kg/ha to 250 kg/ha). This productivity can be doubled with proper institutional support. The area under fisheries in Kaziranga reach area is of the order of 556 ha. This means a total gain of fish productivity of about 66720 kg per annum (@ increase of fish productivity of about 120 kg/ha/annum). Considering a very average rate of Rs. 50/kg the total gain works out to be Rs 3.33 Million

331. **Net Benefit:** Hence against the (i) Rs 1.4 Million support cost (ii) a benefit of Rs 3.33 Million (iii) the net gain being Rs 1.93 million.

7.2.5. Water, Air and Noise Pollution

332. **Impact Cost:** The noise and emission generation from construction operations and the induced traffic after road construction on the embankment are likely to increase the ambient noise and air pollutant (mainly SPM) levels in the project area. This may cause disturbances to sensitive locations as schools, medical centres and religious places disturb sleep of the local people resulting in fatigue. This could not be quantified owing to absence of any specific studies conducted to quantify the same. The waste water is likely to be generated from camp and workshop which will be treated before disposal.

333. **Mitigation Cost:** The induced noise and air pollution levels are however expected to be mitigated by the proposed plantation costs and noise barriers at select locations. The cost of plantation is already accounted for in the Plantation section while the cost towards construction of noise barriers is considered part of engineering costs. The costs of waste treatment and oil and Grease trap are estimated to be Rs 0.68 Million. The total environmental monitoring including Air and Noise monitoring has also been proposed for the construction and operation phases to keep the levels in check. A budget of Rs 0.82 Million has been allocated for the same.

334. **Benefit:** It is expected that with the adequate implementation of the proposed mitigation measures, the adverse impacts will be nullified. There are however, no additional benefits anticipated from the implementation of these mitigation measures.

335. **Net Benefit:** Hence, as the benefits are expected to nullify the adverse impacts, the net befit will equal the mitigation costs which is in the negative i.e. Rs. 1.5 Million

7.3. Conclusion

336. Summary of the economic assessment of the project is given in Table 7.3. it can be concluded, that the net result from the project is positive environmental gains.

Table 7.3 Summary of cost benefit analysis (in Million Rs.)

Issue	Impact Cost (I)	Mitigation Cost (M)	Benefits (B)	Net Benefit N = B – (I + M)
Erosion	--	--	24.3	(+) 24.3
Plantation	6.0	0.387	13.32	(+) 6.933
Fisheries	--	1.4	3.33	(+) 1.93
Air, Water and Noise Pollution	--	1.5	--	(-) 1.5
Total	**6.0**	**3.287**	**40.95**	**(+) 31.663**

Hence, net positive gain from the project is estimated as Rs. 31.663 million, making the proposed project an environmentally viable project.

8. PUBLIC CONSULATION

337. The mode of consultation employed during the course of the study was informal consultation. Government officials from different departments that have relevance to the project were consulted. Environmental public consultations were held during field visits to different sectors of the study reach in December 2007, February and March 2008 covering various stakeholders in the impact corridor. Local people were also consulted from different socio-economic backgrounds in the villages along the Kaziranga reach.

338. In addition, two state level workshops were conducted. The first workshop was held in December 2007 on the interim progress of project preparation, and the second workshop in June 2008 on the draft findings of the study. Stakeholder consultations and socio economic and poverty surveys were done in 4 villages in the first phase up to Sept 2007, followed by more detailed surveys in 12 villages out of 119 villages in the subproject area, along with one village in char land and another village outside of the subproject area using focus group meetings (FGMs) and participatory rural appraisal techniques. Furthermore, surveys on most vulnerable people were conducted in 13 villages through focus group meetings. Group discussions with women facilitated by Women Enumerators on impact of disaster on their livelihood and their present coping mechanism were held in each village surveyed.

339. The second state workshop was conducted in February 4, 2009 at the Brahmaputra Hotel in Guwajati organized by the WRD, Government of Assam, and the ADB. During the State workshop technical features of the project design, and social and environmental impacts and corresponding mitigation measures were presented by the technical experts. A special session was also allocated as a special focus group discussion on any subject of the participant's interest (see Appendix 8.2).

8.1. Environmental Public Consultation Milestone

340. Different people contacted and consulted during the course of the project are given below. However, since the consultations were informal, no brochures were supplied to the participants.

PARTICIPANTS

Government Regulators

1. Department of Environment

Representatives	**:**	Dr. A. K. Baruwa, Director Assam Science, Technology & Environment Council & Assam Energy Development Agency
Mode of Consultation	**:**	**Informal Consultation**
Date	**:**	**December 2, 2007**

2. Department of Environment and Forests

Representatives	**:**	Mr. B. B. Hagjer (IAS) Secretary of Environment and Forests Government of Assam
Mode of Consultation	**:**	**Informal Consultation**

Date	**:**	**December 3, 2007**

3. Government of Assam

Representatives	**:**	Mrs. E. Choudhary (IAS) Principal Secretary, Soil Conservation Government of Assam
Mode of Consultation	**:**	**Informal Consultation**
Date	**:**	**December 3, 2007**

4. Water Resource Department

Representatives	**:**	Mr. Biren Thukuria Executive Engineer
Mode of Consultation	**:**	**Informal Consultation**
Date	**:**	**December 2, 2007**

5. State Pollution Control Board

Representatives	**:**	**Dr. Rafiqua Ahmed**
Mode of Consultation	**:**	**Informal Consultation**
Date	**:**	**April 25, 2008**

6. Department of Minority Welfare

Representatives	**:**	**Mr. Md. Allauddin**
Mode of Consultation	**:**	**Informal Consultation**
Date	**:**	**December 3, 2007**

7. Charland Development Directorate

Mode of Consultation	**:**	**Informal Consultation**
Date	**:**	**December 3, 2007**

NGOs

8. ASRSG

Representatives	**:**	Dr. Bibhab Kumar Talukdar Co-chair (South Asia) IUCN SSC Asian Rhino Specialist Group
Mode of Consultation	**:**	**Informal Consultation**
Date	**:**	**March 3, 2008**

9. Carrier Care Group

Representatives	**:**	Mr. Mintu Handique, Co-ordinator Mr. Gaurav Borgohain, Co-ordinator
Mode of Consultation	**:**	**Informal Consultation**
Date	**:**	**March 5, 2008**

10. CE-NES

Representatives	**:**	Mr. Sanjay Hazarika
Mode of Consultation	**:**	**Informal Consultation**
Date	**:**	**March 10, 2008**

Stakeholders

11. Kaziranga reach

Representatives	:	Hemen Doley, Bankoal Bali Chapori
	:	Rabison Kamar, Bholukaguri
	:	Dangor Pegu, Bankoal Gaon
	:	Kishor Doley, Riri Gaon
Mode of Consultation	:	**Informal Consultation**
Date	:	**March 2, 2008**

12. Kaziranga reach

Representatives	:	Kula Chetri, Bohikhowa Gaon
	:	Padma Nath Doley, Golaghat
	:	Sanki Doley, Palasguri
	:	Hari Chandra Pegu, IWD Employee
	:	Pradip Talukdar, Palasguri
	:	Rakesh Chinte, Polasguri
	:	Pradip Deka, WRD Employee
	:	Pradip Pujari, Bankoal
	:	Bipul Das, Bokakhat
Mode of Consultation	:	**Informal Consultation**
Date	:	**March 27, 2008**

8.2. Information Disclosed

341. The discussions were primarily focused on receiving maximum inputs from the participants regarding their acceptability and environmental concerns arising out of the project. Issues were discussed in depth with the government officials and NGOs while in case of the villagers those issues were touched upon which are relevant to them. To begin with, they were given a brief outline of the project's objectives, type and components of the project in a simplified manner and in their native language. A set of pre-determined common questions were provided to the stakeholders to seek their perception of the proposed subproject.

342. The discussions with the stake-holders were focussed mainly on the following points:

- Problem(s) related to environment as a result of flood and erosion of the Brahmaputra river,
- Whether the proposed project will help in providing safety to the people, their property and environment of the area,
- Any significant negative impact of the project on the overall environment of the area,
- Possible impacts of the project on agriculture, wetlands, drinking water facilities, and local economy

343. Impact on the flora and fauna was mainly discussed with the officers of the forest department. The effect of air and noise pollution due to the project (during the design and construction stage) and disturbance in river water was discussed at length.

344. The consultation process was undertaken after studying the project design and identifying the possible impacts due to the project execution and commissioning. The impact assessment study focused mainly on the findings of the assessment and acceptability of the proposed mitigation measures. Issues of tree cutting, impact on physical environment,

disturbance on fishing activities and fish productivity, productivity of beels in the study area and proposed mitigation measures were discussed at length.

345. For the purpose of the state-level workshop, the executive summaries of the study findings were shared in advance with the invited participants including the NGOs. The first workshop presented and discussed the interim findings of the project preparatory studies, including the problems and issues related flooding and riverbank erosion in Assam including lessons, key strategic elements for integrated FRERM, and peoples' perspectives on living conditions and aspirations. The second workshop presented the draft final findings, including the rationale and preliminary objective and scope of the IFRERM Assam, social impact assessment and safeguards, and environmental impact assessments. After the workshops, press briefings were organized with the circulation of the executive summaries. The presented materials at the workshops are posted in the following ADB websites on the IFRERM-Assam:

- 1st Workshop held on 1 December 2007 at Administrative Staff College of India, Guwahati (http://www.adb.org/Documents/Reports/Consultant/38412-IND/38412-IND-TACR.pdf)
- 2nd Workshop on 25 June 2008 at the Institute of Engineers Conference Hall, Guwahati (http://www.adb.org/Documents/Reports/Consultant/38412-IND/38412-01-IND-TACR.pdf
- 3rd Workshop held on 4 February 2009 at Brahmaputra Hotel, Guwahati (http://www.adb.org/Documents/Reports/Consultant/38412-IND/38412-02-IND-TACR.pdf).

8.3. Major Comments Received

346. While a wide range of people from different administrative, social and economic backgrounds were consulted, their concerns can be summarized in the following three categories of discussion of issues.

Local people's Comments

347. The project received unanimous support and consent from all local people including those who will be rehabilitated, provided adequate compensation is paid. Environmental awareness and likewise concern were found low and issues such as probable reduction in fish catch also did not raise any significant concern amongst the fishermen. The only concern of the villagers was pertaining to compensation against loss of land and the mode of payment. People are looking forward for quick compensation and early start of the project.

348. People welcomed the initiative of the Government of Assam for strengthening of embankment and providing revetment to the riverbank, as many of them were inundated during 2004 flood. Condition of the Panchayat Bundh has emerged as the major area of concern for the local people. They were looking forward for enhancement of ghat facilities and environment around it.

349. The local stakeholders were especially supportive of the project as it can reduce the flood inundation scenario as well as protect the land from erosion, which will result in significant safety scenario as well as socio-economic development of the region. The local people did not perceive any adverse impact due to the proposed project. A few people told that the present embankment is very weak and because of which flood water enters into their houses and paddy fields.

350. The potential project affected people repeatedly stated their resettlement and compensation worries and on being informed of increased air and noise pollution from induced traffic and construction activities, remarked that it does not concern them much.

351. Local people also highlighted the erosion due to Dhansiri flood and emphasised on protection of Bankoal – Moriahola area along with Kaziranga National Park. They also highlighted that it will have beneficial impact on their agriculture land.

NGOs' Comments

352. There are limited NGOs' active in the study area and directly dealing with environmental issues. All the NGOs' consulted had welcomed the flood control project and said that it will help in protection of agricultural land, domestic animals, fishermen communities etc. They also highlighted the importance of maintaining the natural drainage system along the project site. The NGOs during interaction also highlighted the relief work they are carrying out during the flood situations. They also suggested increasing forest cover through aforestation programme. Dr Sanjay Hazarika of CE-NES also indicated the need of enhancing institutional capacity and strengthening review mechanism. He also emphasis on the following :

- Prevent any change to natural drainage,
- Consider provision of alternate platform then only attached to embankment for use by animals and people during flood, and
- Protection of the fish spawning grounds during construction and operation.

Local Officers' Comments

353. Dr. Baruwa from Environmental Council of Assam had raised concern of leaching of arsenic into groundwater which is generally used for drinking water supply from the river bank filtration wells in the floodplains of Brahmaputra River and also asked about the possibility of integration of drinking water and irrigation projects. The analysis of water quality of surface and ground water samples taken in Kaziranga reach revealed very low arsenic content in river water as well as ground water and the water quality was found well within the desirable standards as per IS 10500:1991.

354. Mr. Biren Thukuria (EE, WRD) has highlighted the importance of study for impact on fish productivity due to reduced siltation, which can emerge as a benefit to local fishermen. Mr. B. B. Hagjer (Secretary, Department of Environment and Forests) has pointed out requirement of study of impact downstream and upstream of the reach which can be affected after protection of the reach.

355. During the interaction, Mrs. E. Choudhary (Principal Secretary, Soil Conservation) raised the issues of bed level raising, seepage of embankment/ softening of embankment, erosion and increase in sedimentation as well as the requirement of catchments area treatment plan. He also revealed the requirement of soil conservation, study of earthquakes and its effect on siltation in the river.

356. The interaction with Department of Minority Welfare and Charland Development Directorate revealed that most of the chars in Brahmaputra are semi-permanent and as per their record there are 2,251 char villages. Drinking water is mainly supplied from the handpumps and tubewells. The department also supports in the form of seed distribution, construction of raised platforms with and without sheds, repairing of schools, vocational training to local villagers,

357. The interaction with Chief Conservator of Forests, Forest Development Department and Head Assistant of the CCF office on May 19, 2008 has provided the useful comments and suggestions on possible intervention of proposed project on Forest and Wildlife. No specific suggestion or comment was made with respect to Kaziranga reach as no protected area is located in the project area. However, prior permission is needed from the Chief Conservator of Forests (Wildlife) for cutting of trees within the boundary demarcated as wildlife sanctuaries and national parks. If land is outside the protected areas, then the permission is not necessary from CCF or Forest Department. However, aforestation is needed if there is any loss of tree species during project intervention. At least three plants must be planted in place of one such tree cut during project intervention. For afforestration programme, bamboo, simul trees and banana plants must be planted along the side of embankment. These trees have no side roots to destroy the embankments. Again in the borrowing sites water resistant plants such as Salix tetrasperma, Buwal and Pani hizol should be planted.

358. The detail of formal and informal consultation held with various stakeholders with outcome is summarized at Appendix 8.1.

State Level Workshops

359. Public consultation was also held with the stakeholders during the two state workshops, which were held in the months of December 2007 and June 2008 in Guwahati. Taking into consideration the environmental importance of the project, a number of environmental NGOs were invited during these state workshops. However, only a few had turned up. The list of delegates and invitees of the workshops held during December 2007 and June 2008 have been kept with the Water Resources Department.

360. During the workshops most of the delegates and NGOs present in the workshops have supported the project. While similar comments as recorded for individual meetings were received, key recommendations in the workshops included (i) wider implications beyond the subproject areas should be assessed including downstream hydrology and sediment transport, impacts of global climate change, etc.; (ii) interventions should be carefully defined considering the data unavailability and unreliability, for which progressive knowledge development and adaptive approach learning lessons are critical; (iii) performance and lessons of FRERM (including its hydrological, social, and environmental implications) should be studied and reflected; (iv) livelihood implications of the poor should include those who live outside of the embankments and chars, and appropriate supporting measures should be included in the project design; (v) willingness of WRD to adopt people-centered approach as suggested by the team would remain a concern calling for serious pursuit; (vii) effective quality control and sustainability assurance measures should be put in place for FRERM structural measures with effective stakeholder participation; and (vi) details of the study finding should be made available to the local research organizations and interested groups.

8.4. Integration of comments

361. As observed from their responses, almost everyone interviewed was supportive of the project and believes that it will help provide the much needed protection against the recurrent ravage of erosion and flood and bring prosperity to the region.

362. During discussions, notes were taken for any issue raised and suggestions made. These were then tabulated for a comprehensive analysis of the concerns raised. References have been taken from public opinion where no official data were available, while the officially

available data have been extensively used for understanding of the study area characteristics. Each of the issue was then analysed on practical and scientific basis and accorded a likewise importance in terms of their magnitude in Chapter 4: Impacts and Mitigation. For any significant concern, preventive or mitigative measures have been suggested drawing points from all the suggested measures.

9. CONCLUSIONS

363. The conclusions are based on EIA carried out for the Kaziranga reach (upstream of Kaziranga National Park), which is one of the three reaches identified as most vulnerable to flood and erosion of the Brahmaputra river, under the Assam Integrated Flood and Riverbank Erosion Risk Management Investment Program (IFRERM-Assam). The project is needed to safeguard the people, property and environment from the risk of devastating floods of the Brahmaputra River. The project involves renovation of existing embankments, construction of retired embankment behind the existing embankments (facing riverbank erosion), and riverbank protection.

364. The project was initially considered as environmental category A by ADB. With the structural works focusing on sustaining the functions of the existing embankment systems through renovation of deteriorated embankments, provision of inner secondary embankment and sluice gates, and riverbank protection works, the present EIA indicates no significant adverse environmental impacts that are sensitive, diverse, or unprecedented, and affect an area broader than the sites. However, in consideration of the proximity of the KNR, and complex and dynamic nature of the natural river conditions and associated natural environment, the same categorization is maintained.

365. The EIA study was carried out from January to April 2008, and is based primarily on secondary data. However, primary data were also collected where secondary data were not available or not up to date. The environmental study covered the project area, as well as the area of direct and indirect impacts. The environmental assessment report was prepared in accordance with relevant applicable laws and regulations of the Government of India; and in conformity with the Environmental Policy of the ADB, 2002 and the Environmental Assessment Guidelines of the ADB, 2003.

9.1. Environmental Gains Due to Proposed Work Justifying Implementation

366. The project entails various impacts on the project setting. There are many impacts bearing benefits to the area against the limited number and magnitude of negative impacts. These include the following:

- The Brahmaputra River carries more water per unit area of basin than any other river in the world, with the average annual rainfall in the subproject area reaching 1,800 to 2,000 millimetre (mm). The proposed project–through strengthening the reliability of the existing embankments–will prevent people from the impacts of devastating floods.
- The Kaziranga reach is prone to extreme hazards of bank erosion and associated embankment breaches. This results in loss of productive agriculture land, infrastructure and damage to ecology. The proposed project will result in contained loss of precious agriculture and other lands from riverbank erosion and large scale channel migration.
- With improved reliability of the existing embankment systems, agriculture (cropping intensity and yields) and culture fishery productivity is expected to increase with better confidence of structure performance by the stakeholders.
- There are few wetlands, beels and other water bodies in the area however, these are not likely to be affected due to the project intervention. The proposed project will likely to enhance the fish productivity in these water bodies due to the support programme proposed under this project.
- The people are largely poor in the area (with headcount poverty ratio of 31% according to the socioeconomic surveys) with high percentage (41%) of indigenous peoples

mostly dependent on agriculture and fisheries activities. The economic and livelihood gain for the subproject interventions is expected to be high.

- The project area does not pass through any protected area (reserved forests, wild life sanctuaries, national park) or ecologically sensitive areas.
- The afforestation will not only help in compensating loss of trees but also increase tree cover in the long run due to the compensatory afforestation at the rate of 1:3 as per the state government policy.

9.2. Potential Negative Impacts, Mitigation, Management and Monitoring

367. The project entails various impacts on the environmental setting of the area. While some are negative, no significant negative impacts are anticipated. Impacts are not anticipated on endangered species like river dolphin, one-horned Rhinoceros due to project activities. While river dolphins are seen in the Brahmaputra River along the subproject area particularly near the Dhansiri River confluence, impacts can be avoided by ensuring that construction waste does not find its way to water and channels are not obstructed. Likewise, no construction camps shall be located near the wallowing site of the wildlife along the KNR. Care should also be provided that construction will not obstruct the breeding period (April–August) in the fish breeding sites and construction waste will not enter into water there.

368. No significant external negative impacts are anticipated on river hydrology, morphology, and sediment transport due to the nature of the project to support the strengthening of the existing embankment systems to maintain or restore their intended functions. They will formalize the existing flooding behaviour that has persisted since these embankments were constructed. Riverbank protection measures–with their focus on revetments and pro-siltation measures along the naturally developing bank lines in an adaptive manner–will not alter the existing unstable channel formation pattern of the Brahmaputra morphology. However, systematic monitoring of river hydrology, morphology, and sediment transport will be put into operation under the project, and due mitigation measures will be provided in case any unexpected effects caused by the subproject are observed.

369. There is a possibility that the subproject areas may be affected by the impacts of climate change and other external events including major earthquakes and upstream development works such as hydropower development. While the impacts of these events may well extend the economic life of the subproject investments (of 30 years), available study indicates the possible climate change impact of increased precipitation by up to 30% in the north-eastern region by 2040-60, although diverse anticipation still coexists. A large-scale earthquake (and landslides) may exacerbate the sediment loads of the Brahmaputra, whereas the hydropower dams upstream may reduce the sediment inflow. On these accounts, the systematic monitoring of the river dynamics to be strengthened under the project will facilitate the identification and implementation of necessary measures to adapt to any emerging changes in the construction and post-construction phase of the subproject.

370. During the construction stage, some trees along the embankment are likely to be cut, but if the proposed compensatory afforestation plans are effectively implemented and survival rate is monitored and sustained, the positive benefits are likely to be accrued. Project activities are likely to generate other adverse environmental impacts during construction. However these will be temporary. Implementation of the prescribed mitigation measures will minimize the adverse impacts, with the stipulated environmental management and monitoring plans.

371. The Project involves strip acquisition of land for strengthening the existing embankments and associated structural relocation. There are also pending land acquisition cases for infrastructure constructed in the past. The concerned land acquisition and resettlement cases including the pending cases will be addressed following the Government's and the SGOA's laws and regulations, and ADB's Involuntary Resettlement Policy, which has been stipulated in the resettlement framework, based on which resettlement plans are prepared and implemented to address all the cases. For tranche 1 works, extensive public consultation has been carried out, consistent with state guidelines. For affected persons, support will be provided to improve, or at least restore, the pre-intervention income and livelihoods standards, and productive capacity. In addition, the subproject will provide construction labor opportunities and community development assistance to nearby communities and to landowners whose land is acquired or structures be affected, including nontitle holders.

9.3. Irreplaceable Resources

372. Dolphin and other endangered species found in the river Brahmaputra and other nearby areas are not exclusive to the project site. No damage to the habitat of these species is anticipated. There are no other environmental sensitive resources found in the project area which is likely to be affected due to the project.

9.4. Post EIA Surveillance and Monitoring

373. While an EIA is meant to provide a comprehensive understanding of the environment status of the area under the study, post EIA surveillance will ensure that the significant impacts identified are adequately mitigated as per the proposed mitigation plan. A detailed monitoring plan has been provided as part of the Environmental Management Plan, including river hydrology, morphology, sediment transport, terrestrial and aquatic fauna, fisheries, cropping pattern, air, surface water quality, ground water quality, noise, soil erosion, drainage congestion, and tree plantation including tree survival rate monitoring and reporting, along with the follow up actions in case of deviation from the norms have been detailed out. The frequency has been set in consideration of the likely impacts.

9.5. Public Consultations

374. The project received unanimous support and consent from all local people including those who will be rehabilitated, provided adequate compensation is paid. People welcomed the initiative of the SGOA for strengthening of embankment and providing revetment to the riverbank, as many of them were inundated during 2004 flood. The subproject will result in significant safety scenario as well as socio-economic development of the region. The local people did not perceive any adverse impact due to the proposed project. Environmental awareness and likewise concern were found generally low and issues such as probable reduction in fish catch also did not raise any significant concern amongst the fishermen.

375. Nevertheless, local stakeholders as well as NGOs emphasized on the need to ensure the effectiveness of institutions and their program delivery mechanisms to implement the subproject structural and non-structural measures. In particular, villagers were concerned on the compensation against loss of land and the mode of payment, stating that the compensation payment of past land acquisition is still to be provided. Capacities and willingness of the project organizations to adopt people-centered approach as suggested by the project also remains a constraint. The project has included necessary provisions to address these concerns, including

the time-bound actions to address these institutional constraints with institutional reforms and capacity development support.

9.6. Recommendations

376. The EIA was carried out while the feasibility study was being prepared. Therefore, the detailed engineering design was not available. In this regard, any major changes during detailed design, or any major additional work other than the proposed project activities will require preparation of another environmental assessment. This additional assessment will have to be submitted to concerned Government authorities, if any clearance is involved. It shall also have to be sent to ADB for concurrence before civil works commence. Moreover, the executing agencies have to submit the detailed engineering designs to ADB, which will review them and examine whether major changes or major additional works have been included. In this context, changes that need to be reported to ADB involve changes with respect to opening or closing of any gap in the embankment with or without the provision of sluice gate, change in the embankment alignment, and significant change in design specification of the embankment.

377. The flooding and riverbank erosion pattern of the river shall have to be closely monitored and analyzed during the proposed life span of the embankment and riverbank protection measures, and appropriate and timely measures need to be taken to adapt to any changes in the natural river environment. Over the medium to long term, effective knowledge base needs to be established including the modeling of flooding and morphological behavior and sediment transport mechanisms of the Brahmaputra River and its tributaries to quantitatively assess the implications of any past and new water sector investments.

378. WRD has limited capacity to address the environmental measures in house. There is a need to enhance institutional capacity of the WRD with regard to environmental training, monitoring infrastructure and environmental guidelines. Adequate training shall be imparted as proposed under environmental management plan to enhance the capability of concerned EA officials. It is recommended to develop environmental guidelines focused on effective implementation of mitigation measures. Performance indicators may also be developed as part of these guidelines to monitor and assess the effectiveness of the mitigative measures.

379. Awareness programme for public shall be launched for flood embankment strengthening and river bank protection works, and conservation of natural environment and sanitation during construction and operation phase of the project.

APPENDIX 1. PROGRAM COMPONENTS

The specific components included in the Assam Integrated Flood and Riverbank Erosion Risk Management Investment Program are as follows:

Component 1: Institutional and Knowledge-Base Development

- Policy and strategic planning framework: (a) consultations towards finalizing a state water policy and steps for initiating implementation; and (b) long-term state flood and riverbank erosion risk management (FRERM) plan (building on existing plans, with integration to wider watershed issues).
- Database and knowledge-base (linking with central and state institutions): (a) database on hydrology, morphology, sediment transport, and topography; (b) tools including flood-risk mapping and short-term erosion prediction system; (c) strengthened of flood warning system; and (d) monitoring and evaluation, and research and development system.
- Institutional strengthening for integrated FRERM: (a) institutional development actions for the Water Resources Department and line departments; (b) improved guidelines and manuals including nonstructural measures, (c) FRERM infrastructure asset management information system, and (d) comprehensive capacity development.
- Regional knowledge and networking: (a) international networks for FRERM and disaster risk management, (b) knowledge exchange.

Component 2: Operationalizing Integrated FRERM in Selected Subproject Sites

(v) FRERM structural measures: (a) upgraded embankments with assured maintenance (with extended platforms as appropriate); (b) systematic riverbank protection exploring cost-effective, adaptive, and sustainable alternatives; and (c) associated infrastructure (e.g., drainage sluices, canals).

(vi) FRERM nonstructural measures: (a) flood and erosion risk mapping; (b) improved warning systems; (c) participatory flood emergency response system; and (d) other flood adaptation measures (e.g., adaptive cropping, fish culture).

(vii) Community-based risk management: (a) participatory systems integrated with local disaster management committees; (b) community FRERM plans; and (c) plan implementation such as community awareness, flood shelters, and associated flood coping and development programs, e.g., adaptive cropping, fisheries, and livelihoods

(viii) Sustainable FRERM infrastructure maintenance.

Component 3: Project Management

(iii) Project management support with community participation (through disaster management systems) with staffs including those seconded from the existing organizations or hired from the market, implementation consultants, and nongovernment organizations (NGOs).

(iv) Training for program-related operations.

APPENDIX 2.1 REGULATORY COMPLIANCE REPORT

Legislation	Key Requirement	Applicability	Remark	Granting Agency	Reporting Requirement	Monitoring Agency
Air (prevention and control of pollution) Act, 1972 and rules there under	An Act to prevent and control of Air Pollution	Applicable	Applicable during construction stage for the operation of air polluting units like Hot Mix Plant, if used	SPCB	Normally compliance monitoring report is to be submitted once in a year or as indicated in the consent letter	SPCB
Water (prevention and control of pollution) Act, 1972 and rules there under	An Act to Prevent and Control of Water Pollution	Applicable	Applicable during construction stage for discharge of waste from construction camps or maintenance of construction equipment	-do-	-do-	-do-
Environmental (Protection) Act, 1986 and rules there under including EIA Notification, 2006.	Requires prior environmental clearance for all River Valley projects for ≥ 25 MW hydroelectric power generation and ≥ 10,000 ha. of culturable command area	Not Applicable	The proposed project includes only activity related to existing river bank and embankment protection. No hydro power generation or new canal project having large culturable command area.	MoEF/ SEIAA	Once in six months	Regional Office of MoEF
Forest (conservation) Act, 1980 & rules there under	Restriction on the reservation of forests or use of forest land for non-forest purpose	Not Applicable[29]	No diversion of forests land in the whole stretch	MoEF/ State Forest Department	Once in six months	Regional Office of MoEF/ State Forest Department
Eco Sensitive Zone Notification – Numaligarh (East of Kaziranga) Zone SO 481 5th July 1996	The expansion of industrial area, townships, infrastructure facilities and such other activities which could lead to pollution and congestion	Applicable	To be obtained prior to start of construction	MoEF Central Government	As per NOC conditions	MoEF

[29] The land revenue records need to be verified again to ascertain if any forest land is require to be diverted. If yes then this ACT shall be applicable and necessary clearance for forest land diversion will have to be obtained. Permission for tree cutting in any case would be required from concerned forests/district authorities.

Legislation	Key Requirement	Applicability	Remark	Granting Agency	Reporting Requirement	Monitoring Agency
	shall not be allowed within "No Development Zone" except with the prior approval of the Central Government.					
Wildlife (protection) Act, 2002 & rules there under	No person shall destroy, exploit or remove any wild life including forest produce from a sanctuary/National park or destroy or damage or divert the habitat of any wild animal by any act whatsoever or divert, stop or enhance the flow of water into or outside the sanctuary, except under and in accordance with a permit granted by the Chief Wild Life Warden	Not Applicable	No wild life sanctuary/ National Park exist in the project area. However portion of project boundary runs adjacent to Kaziranga National Park Boundary.	Chief Wildlife Warden	As per the consent letter	Concerned protected area office/ Chief Wildlife Warden

APPENDIX 2.2 USE OF GEOTEXTILE BAGS FOR RIVEBANK EROSION MITIGATION

1. The use of geotextile bags plays a major role in mitigation of erosion in a way that is both economical and flexible. Geotextile bags have the two most important properties for erosion control, the filter function to prevent the undermining of the riverbank and the ability to withstand the hydraulic load of the current. Geotextiles were first introduced in the market in 1950ies and their use has increased rapidly due to the properties, flexible use and stability. Nowadays geotextile sand containers are used in the river and coastal engineering field as construction elements for erosion control, scour fill, artificial reefs, groynes, dams as well as in breakwater and dune revetments.

2. Geosynthetic containers are multi-purpose elements that can be manufactured according to almost any demand. The additional functions of geotextile bags, which make them so attractive, are as follows:

3. **Filtration:** Filtration restricts the migration of fine soil while remaining permeable to water movement at least greater than or at least to the permeability of the protected soil.

4. **Reinforcement**: The geotextile bags must also withstand the hydraulic load of the current which can reach up to 3m/s. This function involves the stabilization of a soil mass by providing a closed compartment.

5. The gradual natural changes to environment may not have much impact as it occurs slowly and fish may get opportunity to adapt. However, any man made and quick changes might have a more important impact. The various field studies and observations show that the overall number of species were better in geotextile bag areas than in areas exposed to erosion or protected by CC-blocks. So geotextile bags do not have any negative impact on fisheries rather the situation is slightly better. Small pockets in between bags, where flow velocity is decreased, may create shelter places for fishes (Munir Ahmed, 2007). After the geotextile gets the characteristics of the environment, fish species adapt to the new environment and hide in the shelter holes. During diving inspection, they feel the fishes and shrimp (Atiqur Afur, 2007).

6. There are no negative effects known on the flora if geotextile bags are used for river bank protection. The roots are small enough to pass through the geotextile. However, roots have negative effects on geotextile bags and on the whole protection design. In particular when roots dry out after having passed through the geotextile big pores remain where sand can be washed out. In this case the stability of the structure is reduced.

7. Under normal conditions polypropylene does not present any toxic hazard, either from skin contact or inhalation. The material is inert and shows no toxicity (Dow, 2007). Additionally, it can be said that polypropylene fabric are widely accepted. It is assumed that restrictions in these industries are much tighter. So it can be postulated that PP fabric for geotextile are harmless from a toxicological point of view. (Naue Fasertechnik, 1995). Hence, the use of geotextile bags has no negative effect on the environment, neither to the water quality nor the flora and fauna.

APPENDIX 2.3 RAPID ENVIRONMENTAL ASSESSMENT (REA) CHECKLIST FOR IRRIGATION SECTOR

Instructions:

- This checklist is to be prepared to support the environmental classification of a project. It is to be attached to the environmental categorization form that is to be prepared and submitted to the Chief Compliance Officer of the Regional and Sustainable Development Department.
- This checklist is to be completed with the assistance of an Environment Specialist in a Regional Department.
- This checklist focuses on environmental issues and concerns. To ensure that social dimensions are adequately considered, refer also to ADB checklists and handbooks on (i) involuntary resettlement, (ii) indigenous peoples planning, (iii) poverty reduction, (iv) participation, and (v) gender and development.
- Answer the questions assuming the "without mitigation" case. The purpose is to identify potential impacts. Use the "remarks" section to discuss any anticipated mitigation measures.

Country/Project Title: India: MFF–Assam Integrated Flood and Riverbank Erosion Risk Management Investment Program (Project 1)
Sector Division:
Note: This checklist has been used just for reference purposes being river based project even though project is not directly irrigation related. This checklist has been prepared covering all the three selected subprojects.

SCREENING QUESTIONS	Yes	No	REMARKS
A. Project Siting Is the Project area adjacent to or within any of the following environmentally sensitive areas?			
• Protected Area	☒	☐	Kaziranga Reach is located adjacent to Kaziranga National Park (KNR). However all project components/activities are outside the park boundary. No protected area is falling in the vicinity of all other three subprojects
• Wetland	☒	☐	There are many wetlands (Deepor Beel a designated Ramsar Site, Mora Kulsi, Bejisuti-Kalidas Beel in Palasbari Reach, Shohola Beel in Kaziranga Reach and Maijan Beel in Dibrugarh reaches). The productivity of these beels also depends on flow of flood water of Brahmaputra river or its tributaries. However, since the project will deal with sustained functioning of the existing embankments, none of these Beels are likely to be affected by the proposed project component. None of the channel of flow of water from Brahamputra river to these Beels like in case of Deepor Beel is proposed to be altered or closed under this project.
• Mangrove	☐	☒	

SCREENING QUESTIONS	Yes	No	REMARKS
• Estuarine		X	
• Buffer zone of protected area		X	
• Special area for protecting biodiversity	X		Proximity to Kaziranga National Park in case of Kaziranga subproject
B. Potential Environmental Impacts Will the Project cause…			
• Loss of precious ecological values (e.g. result of encroachment into forests/swamplands or historical/cultural buildings/areas, disruption of hydrology of natural waterways, regional flooding, and drainage hazards)?	X		The project is to strengthen the existing embankments with bankline protection through revetment and siltation-inducing measures. Primarily activities are confined to existing embankment alignment with its retirement at certain locations. The impacts therefore are likely to be confined primarily to design and construction stage. Some impacts shall occur during post implementation (operational) stage as well. Impacts are likely to be positive as well as negative. Positive Impacts are related to erosion control, land use, reduced recurring loss due to flood, siltation control, productivity improvement of beels, pond fisheries etc. Other impacts are related to change if any in hydrology and morphology (upstream and down stream effects), changes in river water levels, flow velocity, discharge intensities, terrestrial ecology (disturbance to vegetation, habitat, animal movement), aquatic ecology including dolphins (fish productivity, spawning site, breeding site including for dolphins, pond fisheries), air quality, water quality and socio economic.
• Conflicts in water supply rights and related social conflicts?		X	
• Impediments to movements of people and animals?		X	Temporary disturbance may occur during construction phase to people. No movement path of terrestrial animals is either likely to be affected. The movement of Dolphin and other fishes to breeding sites may be affected during their breeding period (generally from May to August) if construction activities are continued around the breeding sites in this period
• Potential ecological problems due to increased soil erosion and siltation, leading to decreased stream capacity?		X	This project rather will prevent soil erosion resulting in reduced siltation
• Insufficient drainage leading to salinity intrusion?		X	
• Over pumping of groundwater, leading to salinization and ground subsidence?		X	

SCREENING QUESTIONS	Yes	No	REMARKS
• Impairment of downstream water quality and therefore, impairment of downstream beneficial uses of water?	☐	☒	
• Dislocation or involuntary resettlement of people?	☒	☐	Embankment retirement and other project activities do involve land acquisition.
• Potential social conflicts arising from land tenure and land use issues?	☐	☒	
• Soil erosion before compaction and lining of canals?	☐	☒	
• Noise from construction equipment?	☒	☐	Likely during construction phase
• Dust?	☒	☐	Likely during construction phase
• Labour-related social problems especially if workers from different areas are hired?	☐	☒	Adequate sanitation and other facilities will have to be provided at labour camps.
• Water logging and soil salinization due to inadequate drainage and farm management?	☐	☒	No disturbance is expected to existing drainage pattern
• Leaching of soil nutrients and changes in soil characteristics due to excessive application of irrigation water?	☐	☒	
• Reduction of downstream water supply during peak seasons?	☐	☒	
• Soil pollution, polluted farm runoff and groundwater, and public health risks due to excessive application of fertilizers and pesticides?	☐	☒	
• Soil erosion (furrow, surface)?	☐	☒	It will be rather positive effect
• Scouring of canals?	☐	☒	
• Logging of canals by sediments?	☐	☒	
• Clogging of canals by weeds?	☐	☒	
• Seawater intrusion into downstream freshwater systems?	☐	☒	
• Introduction of increase in incidence of waterborne or water related diseases?	☐	☒	

APPENDIX 3.1 WATER QUALITY CRITERIA FOR DESIGNATED BEST USE

Designated-Best-Use	**Class of water**	**Criteria**
Drinking Water Source without conventional treatment but after disinfection	**A**	• Total Coliforms Organism MPN/100ml shall be 50 or less • pH between 6.5 and 8.5 • Dissolved Oxygen 6mg/l or more • Biochemical Oxygen Demand 5 days 20°C 2mg/l or less
Outdoor bathing (Organised)	**B**	• Total Coliforms Organism MPN/100ml shall be 500 or less pH between 6.5 and 8.5 Dissolved Oxygen 5mg/l or more • Biochemical Oxygen Demand 5 days 20°C 3mg/l or less
Drinking water source after conventional treatment and disinfection	**C**	• Total Coliforms Organism MPN/100ml shall be 5000 or less pH between 6 to 9 Dissolved Oxygen 4mg/l or more • Biochemical Oxygen Demand 5 days 20°C 3mg/l or less
Propagation of Wild life and Fisheries	**D**	• pH between 6.5 to 8.5 • Dissolved Oxygen 4mg/l or more • Free Ammonia (as N) 1.2 mg/l or less
Irrigation, Industrial Cooling, Controlled Waste disposal	**E**	• pH between 6.0 to 8.5 • Electrical Conductivity at 25°C micro mhos/cm Max.2250 • Sodium absorption Ratio Max. 26 • Boron Max. 2mg/l
	Below-E	• Not Meeting A, B, C, D & E Criteria

APPENDIX 3.2 NATIONAL AMBIENT AIR QUALITY STANDARDS

Pollutants	Time-weighted average	Concentration in ambient air			Method of measurement
		Industrial Areas	Residential, Rural & other Areas	Sensitive Areas	
SulphurDioxide (SO_2)	Annual Average*	80 µg/m^3	60 µg/m^3	15 µg/m^3	- Improved West and Geake Method - Ultraviolet Fluorescence
	24 hours**	120 µg/m^3	80 µg/m^3	30 µg/m^3	
Oxides of Nitrogen as (NO_2)	Annual Average*	80 µg/m^3	60 µg/m^3	15 µg/m^3	- Jacob & Hochheiser Modified (Na-Arsenite) Method
	24 hours**	120 µg/m^3	80 µg/m^3	30 µg/m^3	- Gas Phase Chemiluminescence
Suspended Particulate Matter (SPM)	Annual Average*	360 µg/m^3	140 µg/m^3	70 µg/m^3	- High Volume Sampling, (Average flow rate not less than 1.1 m3/minute).
	24 hours**	500 µg/m^3	200 µg/m^3	100 µg/m^3	
RespirableParticulate Matter (RPM) (size less than 10 microns)	Annual Average*	120 µg/m^3	60 µg/m^3	50 µg/m^3	- Respirable particulate matter sampler
	24 hours**	150 µg/m^3	100 µg/m^3	75 µg/m^3	
Lead (Pb)	Annual Average*	1.0 µg/m^3	0.75 µg/m^3	0.50 µg/m^3	- ASS Method after sampling using EPM 2000 or equivalent Filter paper
	24 hours**	1.5 µg/m^3	1.00 µg/m^3	0.75 µg/m^3	.
Ammonia1	Annual Average*	0.1 mg/ m^3	0.1 mg/ m^3	0.1 mg/m^3	.
	24 hours**	0.4 mg/ m^3	0.4 mg/m^3	0.4 mg/m^3	.
CarbonMonoxide (CO)	8 hours**	5.0 mg/m^3	2.0 mg/m^3	1.0 mg/ m^3	- Non Dispersive Infra Red (NDIR)
	1 hour	10.0 mg/m^3	4.0 mg/m^3	2.0 mg/m^3	Spectroscopy
*	Annual Arithmetic mean of minimum 104 measurements in a year taken twice a week 24 hourly at uniform interval.				
**	24 hourly/8 hourly values should be met 98% of the time in a year. However, 2% of the time, it may exceed but not on two consecutive days.				

APPENDIX 3.3 NATIONAL AMBIENT AIR QUALITY STANDARDS IN RESPECT OF NOISE

Area code	Category of Area / Zone	Limits in dB(A) Leq*	
		Day Time	Night Time
(A)	Industrial area	75	70
(B)	Commercial area	65	55
(C)	Residential area	55	45
(D)	Silence Zone	50	40

Note:-

1. Day time shall mean from 6.00 a.m. to 10.00 p.m.
2. Night time shall mean from 10.00 p.m. to 6.00 a.m.
3. Silence zone is an area comprising not less than 100 metres around hospitals, educational institutions, courts, religious places or any other area which is declared as such by the competent authority
4. Mixed categories of areas may be declared as one of the four above mentioned categories by the competent authority.

* **dB(A) Leq** denotes the time weighted average of the level of sound in decibels on scale A which is relatable to human hearing.

A “decibel” is a unit in which noise is measured.

“A”, in **dB(A) Leq,** denotes the frequency weighting in the measurement of noise and corresponds to frequency response characteristics of the human ear.

Leq: It is an energy mean of the noise level over a specified period.

Note : The Principal Rules were published in the Gazette of India, vide S.O. 123(E), dated 14.2.2000 and subsequently amended by the Noise Pollution (Regulation and Control) (Amendment) Rules, 2000 vide S.O. 1046(E), dated 22.11.2000 and by the Noise Pollution (Regulation and Control) (Amendment) Rules, 2002 vide S.O. 1088(E), dated 11.10.2002, under the Environment (Protection) Act, 1986.

APPENDIX 3.4 SAMPLING LOCATIONS FOR TERRESTRIAL ECOLOGY OF BANKOAL – DIFFALUPATHAR SUB-PROJECT SITE

S. No.	Sampled Location	Lat/Long	Remarks
Spot1	Bankual Bali Sapori	26°41′56″N-93°44′23″E	Dolphin comes here during rainy season, Common Shelduck (2), Yellow wagtail(7), White Wagtail(2) and Lesser whistling teal(50+) recorded
Spot2	Bankual Barali Muwa	26°41′39″N-93°44′05″E	62m
Spot3 Ch. 10.km	Bhalukaguri	26°42′42″N-93°45′49″E	In Bhalukaguri, the original embankment was break down during 2004 flood and to protect the rice fields Bankual Krishi bundh was made by Panchayat during 2004-2005 between the land of Bhalukaguri and Riri Goan.
Spot4	Kathonibari	26°41′41″N-93°43′53″E	57m
Ch.11	Bankuwal	26°42′31″N-93°45′08″E	Redwattled Lapwing(2), Ruddy shelduck(5), Yellow Wagtail(6), Cattle Egret(10+), Paddyfield pipit (6+) recorded
Spot5 Ch.11.0km	Majdulupa	26°42′31″N-93°45′08″E	
Spot6 ch.13km	Riri Goan	26°41′36″N-93°43′01″E	
Spot 7 ch.25km	Dhansirimukh	26°40′19″N-93°37′39″E	
Ch 26	Inside	26°40′37″N-93°36′44″E	Hoopoe(3), Green Bee-eater(2)
Spot 8 Ch. 21	Alengi	26°40′12″N-93°39′31″E	
Spot9 Ch. 6	Alami	26°42′58″N-93°46′26″E	
Spot 10 Ch. 0.0km	Afala	26°42′56″N-93°46′27″E	
Spot 11 Ch. 18	Kuruabahi	26°40′18″N-93°41′31″E	
Spot 12 Ch.19	Nikori Ghat	26°40′55″N-93°40′59″E	
Spot13 Ch.21	Jugonia	26°40′12″N-93°39′31″E	
Ch 23	no	26°39′49″N-93°38′44″E	1 Pied hrrier foun
Spot14 Ch. 24	Jugania Ati	26°39′59″N-93°38′13″E	
Spot 15 Ch.28	Kharu Goan	26°40′45″N-93°36′14″E	
Spot 16 Ch.29	Mohkhuti camp (inside)	26°40′50″N-93°35′35″E	Indian Roller(3)
Spot 17 Ch.30	Agoratali Shalabeel	26°36′48″N-93°27′26″E	Rhino mother calf and buffalos were found
Ch. 31	Tamul pathar		

APPENDIX 3.5 TOTAL TREE COUNT IN BOKNUWAL-DIFFALUPATHAR SUB-PROJECT SITE IN PROJECT INTERVENTION ZONE

Plant Species	Total Number	Total Outside	Total Inside
Sisoo-Delbergia sso	19	19	0
Kutoha banh-Bambusa arundinacea	31	29	2
Simul-Bombax ceiba	237	144	93
Gamari-Gmelina arborea	95	60	35
Satiana-Alstonia scolaris	58	54	4
Veleo-Tetramelos nudiflora	137	25	112
Owtenga-Dillenia indica	31	26	5
Karas-Pungamia pinnata	0	0	0
Bijuli banh-Bambusa pallida	0	0	0
Khongal Dimoru-Ficus tinctoria	0	0	0
Pakori-F. rumphii	7	7	0
BhimKol-Musa balbiciana	200	200	0
Chenikol-M. champa	35	35	0
Jati banh- Bambusa tulda	187	152	35
Mokal Banh-B. nutans	73	73	0
Bholukabanh-B. balcooa	108	108	0
Sunaru-Cassia fistula	19	15	4
Kathal-Artocarpus heterophylus	81	43	38
Palas-Butea monosperma	0	0	0
Phulkabi-Brassica oleracea var	0	0	0
Morapat-Corchorus capsularis	0	0	0
Ghehu-Triticum aestivum	0	0	0
Krishna sura-Delonix regia	8	8	0
Dimoru-Ficus lipidosa	110	65	45
Ahot-Ficus religiosa	34	26	8
Segun-Tectona grandis	31	20	11
Atlas-Annona squamosa	0	0	0
Kadam-Anthocephalus cadamba	25	25	0
Bogori-Zizipha zuzuba	222	20	202
Kolajamun-Syzygium cumini	0	0	0
Siris-Albizzia lebek	8	8	0
Jalphai-Elaeocarpus floribundus	0	0	0
Amita-Carica papaya	0	0	0
Sajina-Moringa oleifera	22	12	10
Narikol-Cocos nucifera	10	10	0
Kash Kol-Musa paradisiaca	90	90	0
Am-Mengifera indica	52	52	0
Erythrine indica	7	7	0
Terminalia arjuna	2	2	0
Areca catechu	58	58	0
Total	**1997**	**1393**	**604**

APPENDIX 3.6 MAMMALS OF KAZIRANGA

S. No.	Family	Scientific Name	Common Name	IUCN Status
1.	Loridae	*Nycticebus bengalensis*	Slow Loris	DD
2.	Hylobatidae	*Bunopithecus hoolock*	Hoolock gibbon	End.
3.	Cercopithecidae	*Macaca mulata*	Rhesus macaque	LR
4.		*Macaca assamensis*	Assamese macaque	VUL
5.		*Trachypithecus pileatus*	Capped langur	End.
6.	Cervidae	*Cervus unicolor*	Sambar	LR
7.		*Cervus duvaucelii*	Swamp deer	VUL
8.		*Muntiacus muntjak*	Indian Muntjac	LR
9.		*Axis porcinus*	Hog deer	LR
10.	Bovidae	*Bubalus arnee*	Asiatic wild buffalo	End.
11.		*Bos gaurus*	Gaur	VUL
12.	Suidae	*Sus scrofa*	Wild pig	LR
13.	Elephantidae	*Elephas maximus*	Asian elephant	End.
14.	Rhinocerotidae	*Rhinoceros unicornis*	Greater one-horned rhin Oceros	End
15.	Ursidae	*Ursus thibetanus*	Asiatic black bear	VUL
16.		*Helarctos malayanus*	Sun bear	DD
17.		*Melursus ursinus*	Sloth bear	VUL
18.	Canidae	*Canis aureus*	Jackal	LR
19.		*Cuon alpinus*	Wild dog	VUL
20.		*Vulpes bengalensis*	Indian fox	LR
21.	Felidae	*Panthera tigris*	Tiger	End.
22.		*Panthera pardus*	Common leopard	LR
23.		*Neofelis nebulosa*	Clouded leopard	VUL
24.		*Pardofelis marmorata*	Marbled cat	VUL
25.		*Catopuma temmincki*	Golden cat	VUL
26.		*Felis chaus*	Jungle cat	LR
27.		*Prionailurus bengalensis*	Leopard cat	LR
28.		*Prionailurus viverrinus*	Fishing cat	VUL
29.	Mustelidae	*Melogale moschata*	Small-toothed ferret bad Ger	End.
30.		*Melogale personata*	Large-toothed ferret bad Ger	VUL
31.		*Arctonyx collaris*	Hog badger	Unlisted
32.		*Amblonyx cinereus*	Small-clawed otter	
33.		*Martes flavigula*	Yellow-throated marten	

APPENDIX 3.7 SAMPLING LOCATIONS OF AQUATIC ECOLOGY

S. No.	Survey Point	GPS Position	S. No.	Survey Point	GPS Position
1	Alami	N: $26^0 42' 30''$	2	Afola (0 pt.)	N: $26^0 42' 56''$
		E: $93^0 48' 04''$			E: $93^0 46' 39''$
3	Bholukaguri	N: $26^0 42' 42''$	4	Bongkuwal	N: $26^0 42' 33''$
		E: $93^0 45' 49''$			E: $93^0 45' 05''$
5	Bongkuwal Bali-chapari	N: $26^0 41' 43''$	6	Ririgaon	N: $26^0 41' 37''$
		E: $93^0 44' 04''$			E: $93^0 43' 26''$
7	Dhansirimukh	N: $26^0 41' 41''$	8	Kurabahi	N: $26^0 40' 18''$
		E: $93^0 42' 58''$			E: $93^0 48' 56''$
9	Nikorihat	N: $26^0 40' 55''$	10	Jugonia	N: $26^0 40' 12''$
		E: $93^0 40' 59''$			E: $93^0 39' 31''$
11	Jugonia Ati	N: $26^0 39' 59''$	12	Dhansirimukh	N: $26^0 05' 48''$
		E: $93^0 38' 13''$			E: $93^0 37' 39''$
13	Kharugaon	N: $26^0 40' 45''$	14	Mohkhuti camp	N: $26^0 40' 58''$
		E: $93^0 36' 14''$			E: $93^0 35' 36''$
15	Aageratoli	N: $26^0 36' 48''$	16	Tamulipathar	N: $26^0 28' 48''$
		E: $93^0 27' 26''$			E: $93^0 18' 38''$

GLOBALLY ENDANGERED, AND ENDEMIC AVIAN FAUNA IN STUDY ZONE OF KAZIRANGA NATIONAL PARK AND SUBPROJECT AREA

Common Name	***Scientific Name***	***Status as per IWPA,1972***
Oriental white baked vulture	*Gyps bengalensis*	CR
Slender billed vulture	*Gyps tenuirostris*	CR
White bellied heron	Ardea insignis	En
Greater adjutant	*Leptoptilos dubius*	En
Bengal Florican	*Houbaropsis bengalensis*	En
Spotted greenshank	*Tringa guttifer*	En
Spot billed pelican	*Pelecanus philipensis*	V
Lesser adjutant	*Leptoptilos javanicus*	V
Lesser white fronted goose	*Anser erythropus*	V
Marbled teal	*Marmaronetta angustirostris*	V
Baer's Poachard	*Aythya baeri*	V
Pallas's sea eagle	*Haliaeetus leucoryphus*	V
Greater spotted eagle	*Aquila clanga*	V
Eastern imperial eagle	*Aquila heliacal*	V
Lesser kestrel	*Falco naumanni*	V
Swamp francolin	*Francolinus gularis*	V
Indian skimmer	*Rynchops albicollis*	V
Purple wood pigeon	*Columba punicea*	V
Hodgson's Bushchat	*Saxicola insignis*	V
Marsh babbler	*Pellorneumpalustre*	V
Jerdon's babbler	*Chrysomma altirostre*	V
Slender billed babbler	*Turdoides longirostris*	V
Black breasted parrotbill	*Paradoxornis flavirostris*	V
Finn's weaver	*Ploceus megarhynchus*	V
Darter	*Anhinga melanogaster*	NT
Black necked stork	*Ephippiorhynchus asiaticus*	NT
Oriental white ibis	*Threskiornis melanocephalus*	NT
Ferruginous Poachard	*Aythya nyroca*	NT
White tailed sea eagle	*Haliaeetus albicilla*	NT
Greater Grey headed fish eagle	*Ichthyophaga ichthyaetus*	NT
Cinereous vulture	*Aegypius monachus*	NT
Red headed vulture	*Sarcogyps calvus*	NT
White cheeked hill Patridge	*Arborophila atrogularis*	NT
Black bellied tern	*Sterna acuticauda*	NT
Blyth's kingfisher	*Alcedo herculis*	NT
Great pied hornbill	*Buceros bicornis*	NT
Long tailed Prinia	*Prinia burnesii*	NT
Rufous rumped grass warbler	*Graminicola bengalensis*	NT
Marsh babbler	*Pellorneum palustre*	Endemic
Black breasted Parrotbill	*Paradoxornis flavirostris*	Endemic

*(En: Endangered; CR: Critically endangered; V: vulnerable; NT: Near threatened)

ENDANGERED MAMMALIAN FAUNA IN KAZIRANGA SUB PROJECT AREA

Scientific Name	Common Name	IUCN,1972 Status
Pletinista gengeticus	River Dolphin	En
Macaca mulata	Rhesus macaque	LR
Macaca assamensis	Assamese macaque	V
Bubalus arnee	Asiatic wild buffalo	En.
Sus scrofa	Wild pig	LR
Elephas maximus	Asian elephant	En.
Rhinoceros unicornis	Greater one-horned rhinoceros	En
Canis aureus	Jackal	LR
Vulpes bengalensis	Indian fox	LR
Panthera tigris	Tiger	En.
Panthera pardus	Common leopard	LR
Pardofelis marmorata	Marbled cat	V
Catopuma temmincki	Golden cat	V
Felis chaus	Jungle cat	LR
Prionailurus bengalensis	Leopard cat	LR
Prionailurus viverrinus	Fishing cat	V
Melogale moschata	Small-toothed ferret bad-ger	En.
Melogale personata	Large-toothed ferret bad-ger	V

(En: Endangered; CR: Critically endangered; V: vulnerable; NT: Near threatened)

ENDANGERED MAMMALIAN FAUNA IN STUDY ZONE KAZIRANGA NATIONAL PARK

Scientific Name	Common Name	IUCN,1972 Status
Nycticebus bengalensis	Slow Loris	DD
Pletinista gengeticus	River Dolphin	En
Bunopithecus hoolock	Hoolock gibbon	En.
Macaca mulata	Rhesus macaque	LR
Macaca assamensis	Assamese macaque	V
Trachypithecus pileatus	Capped langur	En.
Cervus unicolor	Sambar	LR
Cervus duvaucelii	Swamp deer	V
Muntiacus muntjak	Indian Muntjac	LR
Axis porcinus	Hog deer	LR
Bubalus arnee	Asiatic wild buffalo	En.
Bos gaurus	Gaur	V
Sus scrofa	Wild pig	LR
Elephas maximus	Asian elephant	En.
Rhinoceros unicornis	Greater one-horned rhinoceros	En
Ursus thibetanus	Asiatic black bear	V
Helarctos malayanus	Sun bear	DD
Melursus ursinus	Sloth bear	V
Canis aureus	Jackal	LR
Cuon alpinus	Wild dog	V
Vulpes bengalensis	Indian fox	LR
Panthera tigris	Tiger	En.
Panthera pardus	Common leopard	LR
Neofelis nebulosa	Clouded leopard	V
Pardofelis marmorata	Marbled cat	V
Catopuma temmincki	Golden cat	V
Felis chaus	Jungle cat	LR
Prionailurus bengalensis	Leopard cat	LR
Prionailurus viverrinus	Fishing cat	V
Melogale moschata	Small-toothed ferret bad-ger	En.
Melogale personata	Large-toothed ferret bad-ger	V

(En: Endangered; CR: Critically endangered; V: vulnerable; NT: Near threatened)

AQUATIC ECOLOGY

Fishes are listed based on all available published information as shown in table. Current status of nomenclature and systematic are done based on Catalog of Fishes (Eschmeyer, 2006, online version, updated April 16, 2006). Tentative IUCN criteria (EW=extinct in wild, CR=critically endangered, EN=endangered; VU=vulnerable, LR=lower risk (-nt -near threatened, lc=least concern and cd=least concern), DD=data deficient) of fishes are based on CAMP (1998). For fishes which are not assessed, it is marked NA. (Not available)

Sl. No		Stations												Cons. Stat.
		1	2	3	4	5	6	7	8	9	10	11	12	
	Fish Sp.													
3.	*Hilsa ilisha*	-	-	-	-	+	+	-	-	-	-	-	-	Vu
5.	*Cirrhinus reba*	-	+	-	-	+	-	-	-	-	-	-	-	Vu
6.	*Labeo calbasu*	-	+	-	-	-	+	-	-	-	-	+	+	LRnt
7.	*Labeo gonius*	-	-	+	+	+	+	-	-	+	+	+	+	LRnt
8.	*Osteobrama cotio*	+	-	-	-	-	+	-	-	-	-	-	-	LRnt
10.	*Puntius sarana*	-	+	+	-	-	-	-	-	-	-	-	-	Vu
11.	*Puntius ticto*	-	-	-	+	+	+	-	-	-	-	+	-	LRnt
12.	*Puntius sophore*	-	-	+	+	+	-	-	-	-	-	-	-	LRnt
15.	*Salmophasia bacaila*	-	-	-	-	-	-	-	-	-	-	+	+	LRlc
16.	*Barilius barna*	-	+	+	+	-	-	+	+	+	-	-	-	LRnt
17.	*Barilius barials*	+	+	+	-	-	-	+	+	+	-	-	-	LRnt
19.	*Notopterus notopterus*	+	+	+	+	+	+	+	+	+	+	+	+	LRnt
	Notopterus chitala	+			+	+	+	+	+		+	+	+	
	Mystus cavasious		+	+	+			+	+	+	+	+		
	Mystus vitattus	+	+	+	+	+	+							
20.	*Devario aequipinnatus*	-	-	+	+	+	+	-	-	-	+	+	+	LRnt
21.	*Devario devario*	-	+	+	-	+	+	-	-	-	-	+	+	LRnt
22.	*Raiamas bola*	-	+	+	-	-	-	-	-	-	-	-	-	Vu
23.	*Crossocheilus latius*	-	+	-	-	-	-	+	+	-	-	-	-	DD
24.	*Garra gotyla*	+	+	-	-	-	-	+	-	-	-	-	-	Vu
25.	*Garra gotyla stenorhynchus*	-	+	-	-	-	-	-	-	-	-	-	-	EN
26.	*Garra nasuta*	+	+	-	-	-	-	-	-	-	-	-	-	NE
27.	*Psilorhynchus balitora*	-	+	+	+	-	-	+	+	-	-	-	-	NE
28.	*Acanthocobitis botia*	-	+	+	+	+	-	-	+	+	+	-	-	LRnt
30.	*Lepidocephalichthys guntea*	-	+	+	+	+	-	-	+	+	+	+	+	NE
31.	*Cantophrys gongota*	+	-	-	-	-	-	-	+	-	-	-	-	LRnt
32.	*Botia Dario*	-	-	-	-	+	+	-	-	-	-	+	+	NE
34.	*Batasio batasio*	-	+	+	-	-	-	-	-	-	-	-	-	NE
36.	*Clupisoma garua*	-	-	-	-	-	-	-	-	-	-	+	+	Vu
37.	*Eutropichthys vacha*	-	-	-	-	-	-	-	-	-	-	+	+	NE
38.	*Pseudeutropius atherinoides*	-	-	-	-	-	-	-	-	-	-	+	+	NE
39.	*Bagarius bagarius*	-	-	-	-	-	-	-	-	-	+	-	+	Vu
40.	*Erethistes pussilus*	+	+	-	-	-	-	+	+	-	-	+	+	NE
41.	*Erethistoides montana*	-	-	+	+	-	-	-	-	-	-	-	-	CR
42.	*Gagata cenia*	-	-	-	-	-	+	-	-	-	+	+	+	NE
43.	*Gagata gagata*	-	-	-	-	-	-	-	-	-	-	+	+	NE
44.	*Glyptothorax telchitta*	-	-	-	-	-	+	-	-	-	-	-	+	LRnt
45.	*Glyptothorax trilineatus*	-	+	-	-	-	+	-	-	+	-	+	-	NE
46.	*Hara hara*	-	+	-	-	+	+	+	-	-	+	-	+	NE
47.	*Pseudochenesis sulcatus*	-	-	-	-	-	+	-	-	-	-	+	+	Vu

Sl. No		Stations												Cons. Stat.
		1	2	3	4	5	6	7	8	9	10	11	12	
48.	*Laguvia shawi*	-	-	-	-	+	-	-	-	-	-	-	+	EN
49.	*Clarias batrachus*	-	-	-	-	-	-	-	-	+	+	-	-	Vu
50.	*Heteropneustes fossilis*	-	-	-	-	-	-	-	-	-	+	-	+	Vu
51.	*Olyra longicaudata*	-	+	+	-	-	-	+	-	-	-	-	-	NE
52.	*Xenentodon cancila*	-	-	-	-	+	-	-	-	-	+	-	+	LRnt
53.	*Macrognathus pancalus*	-	-	-	-	-	-	-	-	-	+	-	+	NE
54.	*Mastacembelus armatus*	-	-	+	-	+	-	-	-	-	+	-	+	NE
56.	*Chanda nama*	-	+	+	+	+	+	-	+	+	+	+	+	NE
57.	*Parambassis ranga*	-	+	+	+	+	+	-	+	+	+	+	+	NE
58.	*Catla catla*	-	-	-	-	-	-	-	-	-	-	+	+	NE
59.	*Badis badis*	-	+	+	-	+	+	-	-	-	+	+	+	NE
60.	*Glossogobius giuris*	-	-	-	-	-	-	-	-	-	+	+	+	LRnt
61.	*Channa gachua*	-	+	-	-	+	-	-	-	+	+	+	-	Vu
62.	*Channa punctatus*	-	-	-	-	-	-	-	-	-	+	+	-	LRnt
63.	*Channa striatus*	-	-	+	+	+	-	-	-	-	-	-	-	LRnt
	Channa orientalis	+	-	-	+	+	+	+	+		+	+	+	
	Walago attu	-	+	+	+	-	-	+	+	+	+	+	-	
	Anabas testudineus	+	+	+	+	+	+	-	-	-	+	+	-	
	Tetradon cutcutia	-	-	-	+	+	-	+	+	+	-	-	-	
Macro-Invertebrates														
	Gastropods													
	Pila globosa	-	-	+	+	+	+	-	-	-	+	+	+	
	Pila scutata	-	+	+	-	+	+	-	-	-	-	+	+	
	Brotia costula	-	+	+	-	-	-	-	-	-	-	-	-	
	Paludomus pustulosa	-	+	-	-	-	-	+	+	-	-	-	-	
	Bivalves													
	Lamellidens corrianus	+	+	-	+	-	-	-	+	+	+	-	-	
	Oligochaeta													
	Tubifex	-	-	+	+	+	+	-	-	-	+	+	+	
	Prawn													
	Macrobrachium malcomsoni	+	+	+	+	+	-	+	+	-	+	-	+	
	M. lanchesteri	-	-	+	+	+	+	-	-	-	+	+	+	
	Crabs													
	Sterteriane spinigera	+	+	+	-	-	-	+	+	+	-	-	-	
	Peratelphusa eduntula	-	+	+	-	-	-	-	-	-	-	-	-	
	P. spingera	+	+	+	+	+	+	+	+	+	+	+	+	
	Potaman woodmansoni	-	-	+	+	+	+	-	-	-	+	+	+	
	Amphibians													
	Chirixalus simus	-	+	+	-	-	-	-	-	-	-	-	-	
	Bufo melanostictus	-	+	-	-	-	-	+	+	-	-	-	-	
	Hoplobatrachus tigerinus	+	+	-	-	-	-	+	-	-	-	-	-	
	Chirixalus sp.	-	-	+	+	+	+	-	-	-	+	+	+	
	Turtles and Tortoises													
	Aspideretes gangeticus	-	+	+	+	-	-	+	+	-	-	-	-	
	Kachuga tecta	-	+	+	+	+	-	-	+	+	+	-	-	
	Kachuga smithii	-	+	+	+	+	-	-	+	+	+	+	+	
	Kachuga sylhetensis	+	+	-	-	-	-	+	-	-	-	-	-	
	Lizards													
	Gecko gecko		+		+	+			+	+	+	+	+	
	Hemidactylus frenatus	+			+	+	+	+	+		+	+	+	
	Varanus bengalensis		+	+	+			+	+	+	+	+		

Sl. No		Stations												Cons. Stat.
		1	2	3	4	5	6	7	8	9	10	11	12	
	Varanus salvator	+	+	+	+	+	+							
	Calotes emma		+				+	+	+				+	
	Calotes maria	+		+		+	+	+		+	+	+	+	
	Snakes													
	Ophiophagus hannah	+	+		+		+	+	+				+	
	Naja naja			+	+	+	+	+		+	+	+	+	
	Trimeresurus spp.	+		+		+	+	+		+	+	+	+	
	Amphiesma stolata	+		+	+	+		+	+	+			+	
	Mammals													
	River Dolphin	-	+	-	-	-	-	+	+	-	-	-	-	
	Otter	+	+	-	-	-	-	+	-	-	-	-	-	
	Plankton													
	Bacillariophyceae													
	Fragilaria	-	+	+	+	+	+	-	+	+	+	+	+	
	Synedra	-	+	+	+	+	+	-	+	+	+	+	+	
	Cocconeis	+	-	-	-	-	-	+	-	-	-	+	+	
	Achnanthes	-	+	+	-	+	+	-	-	-	+	+	+	
	Eucocconeis	+	-	-	-	-	-	+	+	-	+	+	+	
	Navicula	-	+	-	-	+	-	-	-	+	+	+	-	
	Gyrosigma	+	-	-	-	-	-	-	-	-	+	+	-	
	Frustulia	-	-	+	+	+	-	-	-	-	-	-	-	
	Gomphonema	+	+	-	-	-	-	-	-	-	-	-	-	
	Cymbella	-	+	+	+	-	-	+	+	-	-	-	-	
	Surirella	-	+	+	+	+	-	-	+	+	+	-	-	
	Melosira	-	+	+	+	+	-	-	+	+	+	+	+	
	Chlorophyceae													
	UlothrIx		+	+	+			+	+	+	+	+		
	Microspora	+	+	+	+	+	+							
	Cladophora	+	+	+			+	+	+		+	+	+	
	Closterium	+			+	+			+	+	+	+	+	
	Cosmarium	+			+	+	+	+	+		+	+	+	
	Spirogyra		+	+	+			+	+	+	+	+		
	Myxophyceae													
	Oscillatoria	-	-	+	+	+	-	+		+	+	+	+	
	Rivularia	+	+	-	+		+	+	+				+	
	Anabaena	-	-	+	+	+	+	+		+	+	+	+	
	Zooplankton													
	Vorticella	+			+	+			+	+	+	+	+	
	Cyclops	+			+	+	+	+	+		+	+	+	
	Daphnia		+	+	+			+	+	+	+	+		
	Keratella	+	+	+	+	+	+							
	Macrobrachium	+	+	+			+	+	+		+	+	+	
	Chironomous	+			+	+			+	+	+	+	+	
	Gomphus	+			+	+	+	+	+		+	+	+	
	Bosmina		+	+	+			+	+	+	+	+		
	Ceriodaphnia	+	+	+	+	+	+							
	Chydorus	+	+	+			+	+	+		+	+	+	
	Nauplis	+			+	+			+	+	+	+	+	
	Diaptomus	+			+	+	+	+	+		+	+	+	
	Canthocamptus		+	+	+			+	+	+	+	+		
	Asplanchna	+	+	+	+	+	+							
	Kellicotia		+				+	+	+				+	
	Arcella	+		+		+	+	+		+	+	+	+	
	Paramecium			+	+	+	-	+		+	+	+	+	

Sl. No		Stations												Cons. Stat.
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	
	Brachionus	+	+		+		+	+	+				+	
	Asplanchna			+	+	+	+	+		+	+	+	+	
	Filinia	+		+		+	+	+		+	+	+	+	
	Semiocephalus			+	+	+				+				
	Moinodaphnia		+	+	+		+	+	+		+	+	+	
	Sida	+	+	-	+		+	+	+			+		
	Macrothrix	+		+	+	+				+	+		+	
	Epistilis	+	+	+	+		+	+	+			+	+	
	Rotifer eggs		+				+	+	+				+	
	Gomphus	-	+	-	+	+	-	+	-	-	-	+	+	
	Benthos													
	Tubifex	-	+	+	+	-	+	+	+	-	+	+	+	
	Chironomus	+	+	-	+	-	+	+	+	-	-	+	-	
	Viviparus	+	-	+	+	+	-	-	-	+	+	-	+	
	Gyraulus	+	+	+	+	-	+	+	+	-	-	+	+	
	Pisidium	-	+	-	-	-	+	+	+	-	-	-	+	

APPENDIX 5.1 EMISSION FACTORS OF VARIOUS DUST GENERATION PROCESSES

Source	Unit	Emission Factor
Receipt of new aggregate at Hot Mix Plant	g/ton	1.86
Transfer of aggregate from storage to conveyor belt or between conveyor belts in Hot Mix Plant	g/ton	0.021
Screening of aggregate in Hot Mix Plant	g/ton	0.38
RAP crushing	g/ton	0.27
Paved road dust emissions	g/VMT	7.26
Unpaved road dust emissions	g/VMT	925.3

(Note: VMT: Vehicle Mile Traveled)

APPENDIX 5.2 SUMMARY OF IMPACT ASSESSMENT AND RESIDUAL IMPACT

Activity	Environmental Issue/ Component	Nature of Impact	Remedial Measures	Residual Impacts Level after Mitigation Measures
❖ DESIGN AND CONSTRUCTION PHASE				
Land use				
Change in Land use	❖ Loss of agriculture land ❖ Loss of homestead plantation in 100 m core zone around the embankment	❖ Adverse	❖ Use of uncultivated areas near embankments only for storage and/or handling of construction materials ❖ Construction camps on uncultivated areas only with requisite facilities of drinking water supply, sanitation, waste collection and fuel supply ❖ No land used within Kaziranga National Park ❖ No dumping of construction waste on agricultural land ❖ Adequate compensation for loss of land and/ or loss of crops ❖ Land used for construction camps shall made reusable/ cultivable after closer of construction camp ❖ All efforts during the design stage shall be made to minimize the tree felling requirement. ❖ Compensatory plantation shall be started during construction phase parallel to the construction activities. ❖ Monitoring of tree felling.	❖ Acceptable even though land use will be changed permanently around the core zone ❖ Restoration of sites used for construction material handling and storage as well as construction camps will be required
Borrow area location and rehabilitation	❖ Loss of agricultural land and homestead plantation due to borrowing earth from country side of embankment ❖ Permanent disfiguration of land ❖ Seepage to the foundations of embankment	❖ Adverse	❖ Borrow pits shall be preferred on river side to embankment as these can get silted in the course of time. No land is used within KNP. ❖ Use of waste land or excavation or enlargement of existing lank or any hump above ground level for borrowing of earth ❖ Strictly following WRD guidelines with respect to borrow area location and rehabilitation	❖ Acceptable in case of borrow areas will be located on river side ❖ Borrow pits on the country side shall be cut and interconnected to permit ordinary drainage ❖ IRC guidelines may also be followed for borrow pits.
Construction material sourcing (Quarrying)	❖ Illegal quarrying may lead to land use change, unstable rock formation, air and noise pollution	❖ Adverse	❖ Aggregates required for construction of embankment and roads shall be procured from quarries approved by SPCB. ❖ Air and noise emissions from quarries shall be well within the prescribed limits. ❖ Stone crushers, if required, shall be set up only after consent from SPCB and taking adequate measures for air pollution control. ❖ Land earmarked for dumping of construction	❖ Stabilization of quarries and dumping sites after use.

Activity	Environmental Issue/ Component	Nature of Impact	Remedial Measures	Residual Impacts Level after Mitigation Measures
			waste shall be free from any social and R&R issue and away from settlements	
Soil				
Soil erosion	❖ Soil erosion from construction sites during monsoon season ❖ Loss of topsoil	❖ Medium	❖ Opening of borrow areas near the embankments shall not be done during monsoon season ❖ Identification of potential erosion zones during construction phase ❖ Stabilization of soil around the approach roads/ slopes by turfing and tree plantation in ROW ❖ Slope stabilization measures on the embankment like selection of less eroding materials	❖ Acceptable but requires continuous monitoring of the stabilized areas and identification of potential erosion zones for advance mitigation for lowering any adverse impacts
Soil compaction	❖ Soil compaction around construction sites, haulage roads, construction camps, and workshops due to transportation of man, machine, and materials ❖ Construction waste handling	❖ Medium	❖ Movement of construction vehicles, machinery and equipments in embankment site and pre-defined haulage road ❖ Adequate provision for approach roads capable of handling movement and haulage of heavy vehicles and machines	❖ Restoration of compacted sites after construction will be required
Soil contamination	❖ Soil contamination around construction sites, machine maintenance areas, fuelling stations, construction camps, hot mix plant and haulage roads	❖ Medium	❖ Fuelling and maintenance of construction machinery and vehicles shall be carried out at designated place with proper arrangement of waste collection and disposal. ❖ Fuel storage and refuelling sites to be kept away from drainage channels. ❖ Unusable debris to be dumped in designated places. ❖ Provision of oil interceptors ❖ Waste oil shall be sold off to recyclers authorized by SPCB/ MoEF.	❖ No further mitigation will be required.
Site clearing etc	❖ Contamination of soil from construction wastes and quarry materials	❖ Medium	❖ All spoils to be disposed off as desired and the site to be restored back to its original conditions before handing over. ❖ Non-bituminous wastes from construction activities to be dumped in borrow pits and covered with a layer of the conserved topsoil. ❖ Bituminous wastes to be disposed of in identified dumping sites.	❖ No further mitigation required
Hydrology and Morphology				
Flood	❖ Inundation during heavy flood	❖ Medium	❖ Adequate provisions of sluice gates shall be made.	❖ Continuous maintenance and protection of embankments will be

Activity	Environmental Issue/ Component	Nature of Impact	Remedial Measures	Residual Impacts Level after Mitigation Measures
			❖ Natural drainage systems shall not be disturbed. ❖ Adequate provisions shall be made in engineering design to withstand extreme meteorological and geo-physical events	required
Changes in water levels	❖ No significant change due to project intervention	❖ Minimal to Nil	❖	❖ No residual impact
Effect on flow velocity/ discharge intensities	❖ No significant change due to project intervention	❖ Minimal to Nil	❖ Monitoring of flow shall be carried out at regular intervals using field data as well as satellite remote sensing data.	❖ No residual impact
Silt deposition and bed level change	❖ Prevention in silt deposition on agricultural land due to breach of embankments	❖ Minimal to Nil	❖ Monitoring of anti-erosion and river training works at regular intervals	❖ No residual impact
Water quality	❖ Impact on surface and ground water quality ❖ Contamination of water due to construction waste ❖ Contamination of water from fuel and lubricants	❖ Minimal to Nil	❖ Adequate supply of drinking water to workers. ❖ Septic tanks shall be provided to treat the domestic sewage from construction camps. ❖ Provision of mobile toilets for use at flood platforms ❖ Construction work close to the channels or other water bodies to be avoided. ❖ All necessary precautions to be taken to construct temporary devices to prevent water pollution due to increased siltation and turbidity. ❖ Oil and grease traps to be provided at fuelling locations, to prevent contamination of water. ❖ Slopes of embankment leading to water bodies to be modified and screened so that contaminants do not enter the water channel/ water body. ❖ Water quality to be monitored as envisaged in the environmental monitoring plan.	❖ No residual impact
Climate	❖ No direct impact but increase in temperature due to construction activities and trees to be cut	❖ Medium	❖ Minimization of tree cutting while designing the embankment ❖ Compensatory tree plantation preferably on the basis of 3 trees plantation against each tree cut	❖ Acceptable as increase in temperature due to project intervention will be minimized
Air Environment	❖ Change in air quality due to construction activities	❖ Medium	❖ Approach roads should be paved and widened ❖ All slopes and embankments to be turfed as per best engineering practices to minimize the dust generation ❖ All the machinery and plants to be placed at the downwind direction with respect to human settlements.	❖ No residual impact

Activity	Environmental Issue/ Component	Nature of Impact	Remedial Measures	Residual Impacts Level after Mitigation Measures
			❖ All vehicles, equipments and machinery used for construction to be regularly maintained. ❖ The hot mix plants, crushers and batching plants to be sited at least 500 m in the downwind direction from the nearest human settlement. ❖ Hot mix plants shall comply with applicable National/State Pollution Control Board Standards for emissions from hot mix plants. ❖ Fugitive emissions from handling of construction material, storage as well as from transportation shall be taken care. ❖ Speed restriction, surface improvement and surface treatment shall be taken as options for control of emissions from unpaved roads.	
Noise	❖ Increase in sound pressure levels due to construction machineries, vehicles etc.	❖ Minimal to Nil	❖ Options of noise control by site controls, scheduling of project activities, ❖ Protection devices (ear plugs or ear muffs) to be provided to the workers operating in the vicinity of high noise generating machines. ❖ Construction equipments and machinery shall be fitted with silencers and maintained accordingly. ❖ Construction of temporary noise barriers near the sensitive areas, e.g. schools ❖ Noise and vibration level monitoring as per monitoring plan.	❖ No residual impact
Terrestrial ecology				
Disturbance to vegetation	❖ Cutting of trees in core zone during project intervention	❖ Adverse	❖ Minimization of tree cutting while designing the embankment ❖ Compensatory tree plantation on the basis of 3 trees plantation against each tree cut	❖ Monitoring of survival rates of trees planted during afforestation programme
Animal distribution/ migratory route	❖ Impact on Dolphin breeding sites ❖ No Migratory route	❖ Minimal to Nil	❖ Construction activities shall be restricted during Dolphin breeding period (May to August) at breeding sites. ❖ Due to sensitivity of Dolphins with polluted water, construction waste should not dumped near the river bank	❖ No residual impact
Endangered species	❖ No adverse impact	❖ Minimial to NIl	❖ Not applicable	❖ No residual impact
Aquatic ecology				
Fishing activities/ productivity	❖ Impact on boat ghats ❖ Temporary flushing of	❖ Medium	❖ Adequate provision shall be made in the design to ensure access to the fish landing sites/ boat ghats	❖ No residual impact

Activity	Environmental Issue/ Component	Nature of Impact	Remedial Measures	Residual Impacts Level after Mitigation Measures
	fish species towards deeper parts of the river		❖ Undisturbed movement of the fishermen shall be provided	
Migratory routes	❖ No migratory route near the embankment	❖ Minimal to Nil	❖ Not applicable	❖ No residual impact
Spawning and Breeding Grounds	❖ Disturbance on breeding and spawning grounds	❖ Medium	❖ Restriction of construction activities near the identified breeding and spawning grounds during the breeding period of April to August	❖ No residual impacts
Pond fisheries	❖ No adverse impact	❖ Beneficial	❖ Fish productivity can be improved substantial with use of better fish culture and increasing the capacity of fish ponds	❖ No residual impact
Socio economic				
Demography	❖ Pressure on natural resources due to establishment of construction camps	❖ Minimal to Nil	❖ Construction camps shall be supported with all basic amenities such as drinking water, fuel, sanitation facilities etc.	❖ No residual impact
Establishments	❖ Impact on houses and establishments near core zone	❖ Medium	❖ Efforts shall be made to prevent any relocation or demolition ❖ Social infrastructure shall be rehabilitated with social and cultural values ❖ Temporary noise barriers shall be installed close to schools and places of worship ❖ Thick plantation shall be made close to these establishments	❖ No residual impact
Socio-economic impact	❖ Beneficial impact due to control in flood and erosion ❖ Impact on fish landing sites	❖ Low to Medium	❖ Daily wage workmanship during the construction phase to local people ❖ Training programmes for agriculture and fish production improvement ❖ Appropriate provisions shall be made to provide alternate fish landing stations so that economic activities of the fishermen can not disturb during project intervention	❖ No residual impact
Safety	❖ Risk of accidents and safety due to narrow roads and encroachment of people near construction areas	❖ Medium	❖ Adequate lighting and fluorescent signage shall be provided at construction sites. ❖ Signage in local language ❖ Setting up of speed limits ❖ Personal protective equipments for workers ❖ Health check up camps for workers	❖ Adherence to occupational health and safety norms shall be monitored
❖ OPERATION PHASE				
Land use				
Change in Land use and borrow area rehabilitation	❖ Encroachment on embankment for habitation and cultivation	❖ Low	❖ Provision shall be made in the embankment design for providing access to river bank close to the habitats.	❖ No residual impact

Activity	Environmental Issue/ Component	Nature of Impact	Remedial Measures	Residual Impacts Level after Mitigation Measures
	❖ Cutting of embankment to create approach to river side ❖ Non-rehabilitation of borrow areas		❖ Construction contractors shall ensure rehabilitation of borrow areas before handling over the project.	
Soil				
Soil erosion	❖ Net benefits due to construction of embankment and anit-erosion measures in river banks	❖ Beneficial	❖ Periodic checking of the stabilization measures	❖ Pro-siltation measures will promote sedimentation on crucial sections of the river which will protect the embankments
Hydrology and Morphology				
Upstream and downstream effects on river morphology	❖ Reduction of flood absorption due to the flood plains of the reach ❖ Impact on charlands near to bankline	Medium	❖ Erosion monitoring shall be carried out downstream as well. ❖ In case of impact on fringe areas of char, passive type of measures like porcupine screens shall be used.	
Flood	❖ Inundation during heavy flood	❖ Minimal to Nil	❖ Adequate provisions of sluice gates shall be made. ❖ Natural drainage systems shall not be disturbed. ❖ Adequate provisions shall be made in engineering design to withstand extreme meteorological and geo-physical events	❖ Continuous maintenance and protection of embankments will be required
Changes in water levels	❖ No significant change	❖ Nil	❖ None	❖ No residual impact
Silt deposition and bed level change	❖ Prevention in silt deposition on agricultural land during floods	❖ Minimal to Nil	❖ Monitoring of anti-erosion and river training works at regular intervals	❖ No residual impact
Drainage system	❖ Embankment acts like a barrier for the drainage of accumulating country side water into the Brahmaputra during monsoon season.	❖ Medium	❖ Provision shall be made to the extent possible not to obstruct the natural drainage.	❖ No residual impacts
Wetlands/ beels	❖ No impact	❖ Beneficial	❖ Institutional support to enhance the fish productivity	❖ Positive impact
Water quality	❖ Discharge of domestic effluents from nearby villages to the river	❖ Minimal to Nil	❖ Sanitation facilities shall be provided	❖ No residual impact
Climate	❖ No direct impact but changes in catchments area	❖ Minimal to Nil	❖ Attention shall be given for maintaining inland outflow of water to wetland areas.	❖ Flood pattern shall be closely monitored during the project life

Activity	Environmental Issue/ Component	Nature of Impact	Remedial Measures	Residual Impacts Level after Mitigation Measures
	of the river and global warming can have indirect impact		❖ Provision of sluice gates to be made in the embankment.	span of the embankment.
Air Environment	❖ Change in air quality due to traffic	❖ Minimal to Nil	❖ Plantation along the embankment ❖ Turfing of the embankment slopes ❖ Regular maintenance of the road on the top of embankment as well as approach roads	❖ No residual impact
Noise	❖ Increase in sound pressure levels due to traffic	❖ Minimal to Nil	❖ Adequate signage to restrict use of pressure horns particularly in noise sensitive locations ❖ Tree barriers between the road and village/ semi urban/ and urban areas	❖ No residual impact
Terrestrial ecology				
Disturbance to vegetation	❖ No direct impact	❖ Minimal to Nil	❖ Tree management to ensure survivability of the tree plantation ❖ Consultation with social forestry department	❖ Tree survivability audit once in a year
Aquatic ecology				
Fishing activities/ productivity	❖ Likely to increase due to institutional strengthening	❖ Beneficial	❖ None	❖ No residual impact
Spawning and Breeding Grounds	❖ No impact	❖ Nil	❖ None	❖

APPENDIX 6.1 ENVIRONMENTAL MANAGEMENT PLAN (EMP)

Activity	Environmental Issue/ Component	Remedial Measures	Legislative Requirement/ Framework	Approximate Location	Time Frame	Mitigation Cost (Rs.)	Institutional Responsibility	
							Implementation	Supervision
Climate Change	No direct impact but increase in temperature due to construction activities and trees to be cut	Minimization of tree cutting while designing the embankment Compensatory tree plantation preferably on the basis of 3 trees plantation against each tree cut	Kyoto Protocol	Through out the stretch of reach	Throughout the construction period	--	Contractor with guidance of Social Forestry Department	WRD and AIFRERM Agency
Change in Land use	Loss of agriculture land	Use of uncultivated areas near embankments only for storage and/or handling of construction materials	-	Construction sites and service areas throughout the reach	During design and construction phase	Included in construction cost	Contractor	WRD and AIFRERM Agency
		Construction camps on uncultivated areas only with requisite facilities of drinking water supply, sanitation, waste collection and fuel supply		Identified locations of construction camps (2 to 3)		Included under soil contamination prevention costs	Contractor	WRD and AIFRERM Agency
		No dumping of construction waste on agricultural land					Contractor	WRD and AIFRERM Agency
		Adequate compensation for loss of land and/ or loss of crops	As per Social Assessment and R&R	Identified as per the social assessment		Included in R&R Cost	WRD-SIO	SIU-DRMC
		Land used for construction camps shall made reusable/ cultivable after closer of construction camp		Sites used as construction camp	After completion of construction	Included in construction cost	Contractor	WRD and AIFRERM Agency
		All efforts during the design stage shall be made to minimize the tree felling requirement.		Entire project area	During complete construction phase	Included in design engineering cost	Engineering Team/WRD Field Officer	WRD and AIFRERM Agency

Activity	Environmental Issue/ Component	Remedial Measures	Legislative Requirement/ Framework	Approximate Location	Time Frame	Mitigation Cost (Rs.)	Institutional Responsibility	
							Implementation	Supervision
	Loss of homestead plantation	Compensatory plantation shall be started during construction phase parallel to the construction activities (1:3)		Entire project area	During construction	2340000	WRD-SIO	WRD and AIFRERM Agency
		Monitoring of tree felling (census of trees, their numbering etc. based on engineering design)		Entire project area	During complete construction phase	Included in the Monitoring Costs (refer Monitoring Plan)	Independent agency	WRD and AIFRERM Agency
	Impact on land use of the KNP	Where the construction activities are located near the Kaziranga National Park (KNR) no land use impacts will be attributable to the subproject. In addition to strict implementation of the WRD borrow area location, no borrow pit, workers camp, quarrying, an discharge of any wastes along the side of the parks boundary and the embankment.		Along the KNP boundary	During construction	restrictions shall form part of the contract documents for construction	WRD-SIO	WRD and AIFRERM Agency
Borrow area location and rehabilitation	Loss of agricultural land and homestead plantation due to borrowing earth from country side of embankment	Borrow pits shall be preferred on river side to embankment as these can get silted in the course of time or earth from retired Embankment	WRD guidelines	Identified locations for borrowing of earth	During complete construction phase	Included in construction cost	Contractor/WRD Field Officers	
	Permanent disfiguration of land	Use of waste land or excavation or enlargement of existing lank or any hump above ground level for borrowing of earth		Identified locations for borrowing of earth	During complete construction phase	Included in construction cost	Contractor	WRD and AIFRERM Agency

Activity	Environmental Issue/ Component	Remedial Measures	Legislative Requirement/ Framework	Approximate Location	Time Frame	Mitigation Cost (Rs.)	Institutional Responsibility	
							Implementation	Supervision
	Seepage to the foundations of embankment	Use of dredge material from River Dhansiri		From banks of River Dhansiri	During construction	Included in construction cost	Contractor	WRD and AIFRERM Agency
		Strictly following WRD guidelines with respect to borrow area location and rehabilitation		Entire project area	During construction phase as well as after construction	Included in construction cost	Contractor	SIU-DRMC
Change in Land use and Borrow Area Rehabilitation	Encroachment on embankment for habitation and cultivation Cutting of embankment to create approach to river side Non-rehabilitation of borrow areas	Provision shall be made in the embankment design for providing access to river bank close to the habitats. Constructions contractors shall ensure rehabilitation of borrow areas before handling over the project.		Entire project area and Borrow Areas	Operation Phase	Included in construction cost	Contractor, WRD (Field Staff)	WRD and AIFRERM Agency
Construction material sourcing (Quarrying)	Illegal quarrying may lead to land use change, unstable rock formation, air and noise pollution	Aggregates required for construction of embankment and roads shall be procured from quarries approved by SPCB.	Environmental Protection Act and Rules, 1986; Water Act, Air Act	River and Hill Quarries approved by Assam Govt.	During complete construction phase	Included in construction cost	WRD	WRD, AIFRERM Agency and SPCB
		Air and noise emissions from quarries shall be well within the prescribed limits for the protection of workers health		Quarrying sites	During complete construction phase	--	WRD	WRD, AIFRERM Agency and SPCB

Activity	Environmental Issue/ Component	Remedial Measures	Legislative Requirement/ Framework	Approximate Location	Time Frame	Mitigation Cost (Rs.)	Institutional Responsibility	
							Implementation	**Supervision**
		Stone crushers, if required, shall be set up only after consent from SPCB and taking adequate measures for air pollution control.		Location of stone crushers	During complete construction phase	Included in construction cost	Contractor	WRD, AIFRERM Agency and SPCB
		Land earmarked for dumping of construction waste shall be free from any social and R&R issue and away from settlements			During complete construction phase	Included in R&R Cost	Contractor	WRD and AIFRERM Agency
Soil erosion	Soil erosion from construction sites during monsoon season	Opening of borrow areas near the embankments shall not be done during monsoon season		Identified areas for borrowing earth	Except monsoon season during construction phase	Included in construction cost	Contractor	WRD and AIFRERM Agency
	Loss of topsoil	Identification of potential erosion zones during construction phase			Especially during monsoon season	Included in construction cost	WRD Field Officers	WRD and AIFRERM Agency
		Stabilization of soil around the approach roads/ slopes by turfing and tree plantation in ROW		Along the embankment and approach roads	Especially before monsoon starts	Included in construction cost	Contractor	WRD and AIFRERM Agency
		Slope stabilization measures on the embankment like selection of less eroding materials		As suggested by the engineering team	During the construction period	Included in construction cost	Contractor	WRD and AIFRERM Agency
	Net benefits due to construction of embankment and anti-erosion measures in river banks	Periodic checking of the stabilization measures		Project Benefit Area.	Post Operation Phase	Included in Monitoring Costs.	WRD	WRD and AIFRERM Agency

Activity	Environmental Issue/ Component	Remedial Measures	Legislative Requirement/ Framework	Approximate Location	Time Frame	Mitigation Cost (Rs.)	Institutional Responsibility	
							Implementation	**Supervision**
Soil compaction	Soil compaction around construction sites, haulage roads, construction camps, and workshops due to transportation of man, machine, and materials	Movement of construction vehicles, machinery and equipments in embankment site and pre-defined haulage road		Construction material dumping sites and construction sites	During the entire construction period	Included in construction cost	Contractor	WRD and AIFRERM Agency
	Construction waste handling	Adequate provision for approach roads capable of handling movement and haulage of heavy vehicles and machines		Approach roads used for material handling	During the entire construction period	Included in construction cost	Contractor	WRD and AIFRERM Agency
Soil contamination	Soil contamination around construction sites, machine maintenance areas, fuelling stations, construction camps, hot mix plant and haulage roads	Fuelling and maintenance of construction machinery and vehicles shall be carried out at designated place with proper arrangement of waste collection and disposal.		Fuel storage and workshop areas	During the entire construction period	3,20,000	Contractor	WRD and AIFRERM Agency
		Fuel storage and refuelling sites to be kept away from drainage channels.		Fuel storage and workshop areas	During the entire construction period	Included in construction cost	Contractor	WRD and AIFRERM Agency
		Unusable debris to be dumped in designated places.		Identified inert material dumping sites	During construction phase	Included in construction cost	Contractor	WRD and AIFRERM Agency
		Provision of oil interceptors		At fuel handling and workshop areas	During construction phase	Included above	Contractor	WRD and AIFRERM Agency
		Waste oil shall be sold off to recyclers authorized by SPCB/ MoEF.		At fuel handling and workshop areas	During construction phase	Earning from selling	Contractor	WRD and AIFRERM Agency

Activity	Environmental Issue/ Component	Remedial Measures	Legislative Requirement/ Framework	Approximate Location	Time Frame	Mitigation Cost (Rs.)	Institutional Responsibility	
							Implementation	Supervision
Site clearing etc	Contamination of soil from construction wastes and quarry materials	All spoils to be disposed off as desired and the site to be restored back to its original conditions before handing over.		Construction material handling areas and construction sites	After completion of construction phase	Part of Construction Costs	Contractor	WRD and AIFRERM Agency
		Non-bituminous wastes from construction activities to be dumped in borrow pits and covered with a layer of the conserved topsoil.		Inert material dumping sites	After completion of construction phase	Included in construction cost	Contractor	WRD and AIFRERM Agency
		Bituminous wastes to be disposed off in identified dumping sites.		Identified dumping sites	After completion of construction phase	Included in construction cost	Contractor	WRD and AIFRERM Agency
Flood	Inundation during heavy flood	Natural drainage systems shall not be disturbed.		In proposed embankment	During the construction phase	Included in construction cost	Engineering team and contractor/WRD Field Officer	WRD and AIFRERM Agency
		Adequate provisions shall be made in engineering design to withstand extreme meteorological and geo-physical events		Southern part of the reach	During the construction phase as well as operation phase	Included in construction cost	WRD	WRD and AIFRERM Agency
Drainage system	Embankment acts like a barrier for the drainage of accumulating country side water into the Brahmaputra during monsoon season.	Provision shall be made to the extent possible not to obstruct the natural drainage.		Entire project area	During the detailed engineering design stage	Included in engineering design cost	Engineering Team	WRD and AIFRERM Agency
Upstream and downstream effects on river morphology	Reduction of flood absorption due to the flood plains of the reach	Erosion monitoring shall be carried out downstream as well. In case of impact on fringe areas of char,		Entire project area	Operation Phase	Monitoring Costs included under Monitoring Costs	WRD Field Officer	WRD and AIFRERM Agency

Activity	Environmental Issue/ Component	Remedial Measures	Legislative Requirement/ Framework	Approximate Location	Time Frame	Mitigation Cost (Rs.)	Institutional Responsibility	
							Implementation	Supervision
	Impact on charlands near to bankline	passive type of measures like porcupine screens shall be used.				Included in engineering design cost.		
Effect on flow velocity/ discharge intensities	No significant change due to project intervention	Monitoring of flow shall be carried out at regular intervals using field data as well as satellite remote sensing data.		At upstream and in between the reach	During the lifespan of the project	Part of Engineering Cost	Engineering Team	WRD and AIFRERM Agency
Silt deposition and bed level change	Prevention in silt deposition on agricultural land due to breach of embankments	Monitoring of anti-erosion and river training works at regular intervals		At upstream and in between the reach	During the lifespan of the project	WRD shall take initiative	WRD	WRD and AIFRERM Agency
Impacts from external factors such as climate change, upstream dam construction, and watershed development	Design parameters may need to be changed over the years Impacts may include reduced discharge, artificial change in discharge volumes, reduced sediments	Systematic monitoring of hydrology, morphology, and sediment transport with acquisition of data Establishment of information network of discharges from upstream reservoirs Developing capacities in WRD to cope with changes in environment		Subproject reach in particular, but also include basin wide information and tributaries	During the lifetime of the project	Included in data and knowledge development component of AIFRERMIP	WRD	WRD and AIFRERM Agency
Water quality	Impact on surface and ground water quality	Adequate supply of drinking water to workers.	The Water (Prevention & Control of Pollution) Act, 1974 and amendments thereof	At construction camps and construction sites	During construction phase	3,60,000	Contractor	WRD and AIFRERM Agency
	Contamination of water due to construction waste	Septic tanks shall be provided to treat the domestic sewage from construction camps.		At construction camps	During construction phase			
		Provision of mobile toilets for use at flood platforms		At high altitude areas	During Operation Phase	Included in construction cost	WRD Field Officer	SIU-DRMC

Activity	Environmental Issue/ Component	Remedial Measures	Legislative Requirement/ Framework	Approximate Location	Time Frame	Mitigation Cost (Rs.)	Institutional Responsibility	
							Implementation	Supervision
	Contamination of water from fuel and lubricants	Construction work close to the channels or other water bodies to be avoided.			During construction phase	--	WRD Field Officer	WRD and AIFRERM Agency
		All necessary precautions to be taken to construct temporary devices to prevent water pollution due to increased siltation and turbidity.			During construction phase	Included in construction cost	Contractor	SIU-DRMC
		Oil and grease traps to be provided at fuelling locations, to prevent contamination of water.		Fuel handling and workshop areas	During construction phase	Included in construction cost	WRD Field Officer	WRD and AIFRERM Agency
		Slopes of embankment leading to water bodies to be modified and screened so that contaminants do not enter the water channel/ water body.		Along the reach	During construction phase	Included in construction cost	WRD Field Officer	WRD and AIFRERM Agency
		Water quality to be monitored as envisaged in the environmental monitoring plan.		As per monitoring plan	During construction phase	Included in the monitoring costs		WRD and AIFRERM Agency
	Discharge of domestic effluents from nearby villages to the river	Sanitation facilities shall be provided		Entire Project Benefit Area	Operation Phase	WRD to Initiate with concerned civic authorities		WRD and AIFRERM Agency
Air Environment	Change in air quality due to construction activities	Approach roads shall be paved and widened	Environmental Protection Act, 1986; The Air (Prevention and Control of Pollution) Act, 1981 and amendments	Approach roads to construction sites	At the start of construction activity	Included in construction cost	Contractor/ WRD	WRD and AIFRERM Agency
		All slopes and embankments to be turfed as per best engineering practices to minimize the dust		Construction area	During construction phase	Included in construction cost	Contractor	WRD and AIFRERM Agency

Activity	Environmental Issue/ Component	Remedial Measures	Legislative Requirement/ Framework	Approximate Location	Time Frame	Mitigation Cost (Rs.)	Institutional Responsibility	
							Implementation	Supervision
		generation	thereof					
		All the machinery and plants to be placed at the downwind direction with respect to human settlements.			Construction period	Included in construction cost	Contractor	WRD and AIFRERM Agency
		All vehicles, equipments and machinery used for construction to be regularly maintained.		Workshop areas	Construction period	Included in construction cost	Contractor	WRD and AIFRERM Agency
		The hot mix plants, crushers and batching plants to be sited at least 500 m in the downwind direction from the nearest human settlement.			At the start of construction activity	Included in construction cost	Contractor	WRD and AIFRERM Agency
		Hot mix plants shall comply with applicable National/State Pollution Control Board Standards for emissions from hot mix plants.						
		Fugitive emissions from handling of construction material, storage as well as from transportation shall be taken care.		Construction and storage sites	During the construction period	Included in construction cost	Contractor	WRD and AIFRERM Agency
		Dust Suppression by water sprinkling		Construction and storage sites	During the construction period	Included in construction cost	Contractor	WRD and AIFRERM Agency
		Monitoring of Ambient Air Quality		near sensitive locations/ human settlements near to construction	During the construction period as per environmental monitoring plan	Included in the monitoring costs	WRD	WRD and AIFRERM Agency

Activity	Environmental Issue/ Component	Remedial Measures	Legislative Requirement/ Framework	Approximate Location	Time Frame	Mitigation Cost (Rs.)	Institutional Responsibility	
							Implementation	Supervision
				sites, crushers and hot mix plants				
		Speed restriction, surface improvement and surface treatment shall be taken as options for control of emissions from unpaved roads.		Approach roads	During the construction period	Included in project cost	WRD	WRD and AIFRERM Agency
	Change in air quality due to traffic	Plantation along the embankment Turfing of the embankment slopes Regular maintenance of the road on the top of embankment as well as approach roads		Entire Project Area	Operation Phase	Included as part of regular Maintenance costs	WRD	WRD and AIFRERM Agency
Noise	Increase in sound pressure levels due to construction machineries, vehicles etc.	Options of noise control by site controls, scheduling of project activities	Noise Pollution (Regulation and Control) Rules, 2000 and amendments thereof	At all construction sites	During the construction period	Included in engineering cost	Contractor	WRD and AIFRERM Agency
		Protection devices (ear plugs or ear muffs) to be provided to the workers operating in the vicinity of high noise generating machines.		At all construction sites of high noise intensities	During the construction period	Part of Contractor Obligation	Contractor	WRD and AIFRERM Agency

Activity	Environmental Issue/ Component	Remedial Measures	Legislative Requirement/ Framework	Approximate Location	Time Frame	Mitigation Cost (Rs.)	Institutional Responsibility	
							Implementation	Supervision
		Construction equipments and machinery shall be fitted with silencers and maintained accordingly.		Construction sites	At the start of construction activity and also during the construction phase	Included in construction cost	Contractor	WRD and AIFRERM Agency
		Construction of temporary noise barriers near the sensitive areas, e.g. schools		At identified sensitive locations near the construction sites	Before start of construction activities near sensitive locations	Included in construction cost	Contractor	WRD and AIFRERM Agency
		Noise and vibration level monitoring as per monitoring plan.		As per monitoring plan	Once in every year	Included under Monitoring Costs	WRD	WRD and AIFRERM Agency
	Increase in sound pressure levels due to traffic	Adequate signage to restrict use of pressure horns particularly in noise sensitive locations Tree barriers between the road and village/ semi urban/ and urban areas						SIU-DRMC
Disturbance to vegetation	Cutting of trees in core zone during project intervention	Minimization of tree cutting while designing the embankment		Entire project site	During complete construction phase	--	Engineering Team	WRD and AIFRERM Agency
		Compensatory tree plantation preferably on the basis of 3 trees plantation against each tree cut		Entire project site and nearby areas	Starting from construction phase	Already indicated above	WRD	WRD and AIFRERM Agency
Animal distribution/ migratory route Endangered Species	Impact on wildlife and Dolphin No Adverse	No encroachment on KNP Construction activities shall be restricted during		Identified breeding sites	During construction phase		WRD	WRD and AIFRERM Agency

Activity	Environmental Issue/ Component	Remedial Measures	Legislative Requirement/ Framework	Approximate Location	Time Frame	Mitigation Cost (Rs.)	Institutional Responsibility	
							Implementation	Supervision
	Impact of Endangered Species. Precaution shall be taken that there is no effect on wild animals and dolphin.	Dolphin breeding period (May to August) at breeding sites. Due to sensitivity of Dolphins with polluted water, construction waste should not dumped near the river bank						
Fishing activities/ productivity, Migratory Route	Impact on boat ghats. No Migratory Route near the embankment	Adequate provision shall be made in the design to ensure access to the fish landing sites/ boat ghats		Identified sites along the reach	During construction phase itself	Included in engineering design cost	Contractor	WRD and AIFRERM Agency
	Temporary flushing of fish species towards deeper parts of the river	Undisturbed movement of the fishermen shall be provided		Along the riverbank	During construction phase itself	Included in engineering cost	WRD (Environmental Division)	SIU-DRMC
Spawning and Breeding Grounds/Pond Fisheries	Disturbance on breeding and spawning grounds. No Adverse Impact on Pond Fisheries	Restriction of construction activities near the identified breeding and spawning grounds during the breeding period of April to august Fish productivity can be improved substantial with use of better fish culture and increasing the capacity of fish ponds		At identified spawning and breeding grounds	During April to august in construction phase	--	Contractor	WRD and AIFRERM Agency
Wetlands/ beels	Positive impact	Due to various institutional measures proposed		Project Benefit Area	Operation Phase	--	WRD	WRD and AIFRERM Agency

Activity	Environmental Issue/ Component	Remedial Measures	Legislative Requirement/ Framework	Approximate Location	Time Frame	Mitigation Cost (Rs.)	Institutional Responsibility	
							Implementation	Supervision
Demography	Pressure on natural resources due to establishment of construction camps	Construction camps shall be supported with all basic amenities such as drinking water, fuel, sanitation facilities etc.		Construction camps	During construction phase	Included in construction cost	Contractor	WRD and AIFRERM Agency
Establishments	Impact on houses and establishments near core zone	Efforts shall be made to prevent any relocation or demolition		Near embankment sites	During construction phase	Included in R&R Cost	Contractor	WRD and AIFRERM Agency
		Social infrastructure shall be rehabilitated with social and cultural values		Near embankment sites	During construction phase	Included in construction Costs	WRD	SIU-DRMC
		Temporary noise barriers shall be installed close to schools and places of worship		Near identified sensitive sites	During construction phase	Included in construction Costs	WRD	WRD and AIFRERM Agency
		Thick plantation shall be made close to these establishments		Near identified sensitive sites and human settlements	During construction phase	Already included above	WRD	WRD and AIFRERM Agency
Socio-economic impact	Impact on fish landing sites	Training programmes for agriculture and fish production improvement		Project buffer zone	During construction phase	Already included above	WRD	WRD and AIFRERM Agency
		Appropriate provisions shall be made to provide alternate fish landing stations so that economic activities of the fishermen can not disturb during project intervention		Identified fish landing sites	During construction phase	Included in construction cost	Contractor/ WRD	WRD and AIFRERM Agency
Safety	Risk of accidents and safety due to narrow roads and encroachment of	Adequate lighting and fluorescent signage shall be provided at construction sites.		Construction sites and approach roads	During construction phase	Included in construction cost	Contractor	WRD and AIFRERM Agency

Activity	Environmental Issue/ Component	Remedial Measures	Legislative Requirement/ Framework	Approximate Location	Time Frame	Mitigation Cost (Rs.)	Institutional Responsibility	
							Implementation	Supervision
	people near construction areas	Signage in local language		Construction sites and approach roads	During construction phase	100,000	Contractor	WRD and AIFRERM Agency
		Setting up of speed limits and speed brakes		Construction sites and approach roads	During construction phase	50,000	Contractor	SIU-DRMC
		Personal protective equipments for workers		At construction sites	During construction phase	Included in construction cost	Contractor	WRD and AIFRERM Agency
		Health check up camps for workers		At construction camps	During construction phase	6,00,000	WRD (Environmental Division)	WRD and AIFRERM Agency

APPENDIX 6.2 MITIGATION MEASURES & IMPLEMENTATION SCHEDULE

Environmental Issue	EMP	Time line															
		Construction Phase					Operation Phase										
		1	2	3	4	5-6	1	2	3	4	5	6	7	8	9	10	11 -
Technical Support	Preparation of environmental guidelines																
Flora	Compensatory aforestation (minimum 1:3) (plantation and maintenance for one year)																
Agriculture	Technical support to farmers																
	Monitoring of cropping pattern																
Fisheries	Institutional support for productivity improvement for Wetland, beel, and pond fisheries																
	Monitoring of fisheries, breeding and spawning grounds																
	Maintenance and operation of sluice gates																
Drainage Congestion	Provision of adequate opening																
	Monitoring analysis of drainage congestion if any																
Hydrology and Morphology	River bank protection measures																
	Soil conservation																
	Monitoring of river erosion, water levels, and sediments																
Land	Compensation against land acquisition																
	Provision of access to riverbank near habitat areas, Construction of flood platforms																
	Rehabilitation of borrow areas																
Water & Drinking Water Supply	Installation of grease traps at construction sites																
	Construction of soak pits at construction sites																
	Monitoring of surface and ground water quality																
	Ensuring availability of arsenic free drinking water for construction camps																
Air Quality & Dust Management	Water spraying and watering																
	Monitoring of ambient air quality																
Work Safety	Provision of personal protective equipment																
Health Issues	Health checkup camps																
Tree & noise Barriers	Monitoring of tree felling and plantation																
	Maintenance of tree (additional two years)																
	Provision of additional tree plantation																
	Provision of noise barriers																
	Monitoring of noise and vibration																
Establishments	Construction stage																
Training	Environmental training and awareness																
MIS	Establishment and operation																

Legends

- Critical
- High priority
- Medium priority
- Low priority

APPENDIX 6.3 ENVIRONMENTAL MONITORING PLAN (EMOP)

Environmental Component	Project stage	Parameter	Standards	Location	Duration / Frequency	Cost (Rs.)	Implementation	Supervision
Terrestrial and aquatic fauna	Construction Stage	Surveillance Audit for status of fish species, their movement and breeding grounds	None specific	Near the identified spawning and breeding grounds along the reach	Prior to breeding season and during the breeding season (During construction stage)	200,000	Independent Fisheries Expert	WRD and AIFRERM Agency
	Operation Stage	Terrestrial and aquatic fauna status Benefit assessment of the support during the project as a whole	None Specific	Fish landing sites, breeding grounds and near the core zone of the embankment	First two years of construction	200,000	Independent Terrestrial and Aquatic Experts	WRD and AIFRERM Agency
Fisheries	Construction Stage	Fish productivity,	None Specific	Flood plains, beels, rivers and ponds	Once in a year throughout the construction phase	300,000	Survey by Fisheries Experts	WRD and AIFRERM Agency
	Operation Stage	Fish productivity	None Specific	Flood plains, beels, rivers and ponds	Once in a year	100,000	Survey by Fisheries Experts	WRD and AIFRERM Agency
Cropping Pattern	Construction and Operation Stage	Survey of existing cropping pattern and effect of change in cropping pattern in the impacted areas	None Specific	Construction areas, service areas, rehabilitation sites	Once during construction and once after six months of completion of project	Project Management Costs	Institutional support	WRD and AIFRERM Agency
Air Quality	Construction Phase	SPM, RSPM, SO2, NOx, CO, Pb	National Ambient Air Quality Standards	With in 100 m of Hot mix plant, construction camp, crusher and near sensitive locations/ settlement	Continuous 24-hourly, twice a week, for two weeks once every year (summer)	750,000 (@RS 1,25,000/year for six year)	Independent Environmental Laboratories approved by SPCB/ MoEF	WRD and AIFRERM Agency

Environmental Component	Project stage	Parameter	Standards	Location	Duration / Frequency	Cost (Rs.)	Implementation	Supervision
	Operation Phase	SPM, RSPM, SO2, NOx, CO, Pb	National Ambient Air Quality Standards	3 to 4 locations near the embankment sites	Continuous 24-hourly, twice a week, for one week, once in winter and Summer	50,000	Independent Environmental Laboratories approved by SPCB/ MoEF	WRD and AIFRERM Agency
Surface Water Quality	Construction Stage	pH, BOD, COD, TDS , TSS, DO, Oil & Grease	As per CPCB Water Quality Criteria	Brahmaputra river and wetlands/ ponds	Once during the dry season.	300,000 (@ Rs 50,000/year for six year)	Independent Environmental Laboratories approved by SPCB/ MoEF	WRD and AIFRERM Agency
	Operation Phase	pH, BOD, COD, TDS , TSS, DO, Oil & Grease	As per CPCB Water Quality Criteria	Brahmaputra river and wetlands/ ponds	Once during the dry season.	30,000	Independent Environmental Laboratories approved by SPCB/ MoEF	WRD and AIFRERM Agency
Ground water and Drinking Water Quality	Construction Stage	pH, BOD,DO, total coliform, As, Cd, Mn and Ground Water levels	As per IS 10500:1991	Construction site, Rehabilitation site, service areas,	Once at the start of construction	30,000	Independent Environmental Laboratories approved by SPCB/ MoEF	WRD and AIFRERM Agency
	Operation Phase	pH, BOD,DO, total coliform, As, Cd, Mn and water levels	As per IS 10500:1991	Construction site, Rehabilitation site, service areas,	Once at the start of construction	30,000	Independent Environmental Laboratories approved by SPCB/ MoEF	WRD and AIFRERM Agency
Noise and Vibration	Construction Phase	Noise Level in dB (A)	As per National Standards for Noise	Near the construction sites and sensitive locations close to embankment	One day hourly measurement, once in six months	30,000	Independent Monitoring Agency	WRD and AIFRERM Agency
	Operation Phase	Noise Level in dB (A)	As per National Standards for Noise	Near the habitats close to embankment	One day hourly measurement at 3-4 locations once	10,000	Independent monitoring agency	WRD and AIFRERM Agency
Soil Erosion (inland erosion) and siltation	Construction Phase	Visual check for Soil erosion and siltation	--	River bank and River training Structure	After first precipitation	Part of routine action of engineering team	Engineering Team	WRD and AIFRERM Agency
	Operation Phase	Study of Soil erosion and siltation	--	River Training Structure, Up stream and Down Stream of the reach	Once during operation of 1st year	Part of routine action of Engineering	Engineering Team	WRD and AIFRERM Agency

Environmental Component	Project stage	Parameter	Standards	Location	Duration / Frequency	Cost (Rs.)	Implementation	Supervision
						Team		
Drainage Congestion	Construction Phase	Visual check	--	Project benefit area	After one year of construction.	Part of routine action of Engineering Team	Engineering Team	WRD and AIFRERM Agency
	Operation Phase	Visual check	--	Project benefit area	Once during operation of 1st year	Part of routine action of Engineering Team	Engineering Team	WRD and AIFRERM Agency
River Hydrology, Morphology and Sediment Transport	Construction Phase	Scientific techniques applicable to the monitoring of these components	-	Entire Sub-project area	Regular	Part of routine action of Engineering Team	Engineering Team	WRD and AIFRERM Agency
	Operation Phase	Scientific techniques applicable to the monitoring of these components	-	Entire Sub-project area	Regular	Part of routine action of Engineering Team	Engineering Team	WRD and AIFRERM Agency
Tree Plantation	Construction Phase	Surveillance monitoring of trees felling	As laid out in the detailed design for project	Entire stretch of the project reach	During site clearance in construction phase	600,000	WRD Field Officers	WRD and AIFRERM Agency
	Operation Phase	Survival rate of trees success of re-plantation	The survival rate should be at least 70% below which re-plantation shall be done.	Entire stretch of the project reach	Every year for 3 years	300,000	WRD Field Officers with the help of Social Forestry Programme	WRD and AIFRERM Agency
Total Costs of monitoring construction stage						**Rs22,10,000**		
Total Costs of monitoring operation Stage						**Rs7,20,000**		
Transportation for sample collection, contingencies and other logistic support (Rs. 2,00,000 construction stage, and Rs 1,00,000 Operation stage)						**Rs. 300,000**		
Total cost of monitoring						**Rs. 3,230,000**		

APPENDIX 6.4 TRAINING[30]

No.	Target group	Subject(s)	Method	Time Frame
Planning, and Construction Phase[31]				
1	All WRD program staff	**Environmental Overview:** Environmental regulations and national standards, process of impact assessment and identification of mitigation measures, importance of EMP and monitoring, and monitoring methodology	Lectures (by consultants and local training institutes)	Before implementation of the program
2	Environmental engineers, field officers, contractors, supervision consultants	**Implementation of EMPs:** Basic features of an EMP, planning, designing and executing of environmental mitigation and enhancement measures, monitoring and evaluation of environmental conditions during construction and operation	Workshops and seminars (by consultants and trained PMU staff)	Before the construction begins
3	Environmental engineers, field officers, contractors, supervision consultants	**Environmentally Sound Construction Practices:** Soil conservation; vegetation protection; waste management and minimization in construction; pollution control at construction camps, construction sites, hot mix plants, and material transportation; devices and methods for construction sites and equipment; environmental clauses in contract documents and their implications; environmental monitoring during construction	Seminars, lectures and site visits (by consultants and trained PMU staff)	Before the construction begins
4	Environmental engineers, field officers, contractors, supervision consultants	**Monitoring Environmental Performance during Construction:** Monitoring air, water, soil erosion, noise, and their effect on vegetation and fisheries; evaluation and review of results; performance indicators and their applicability; possible corrective actions; reporting requirements and mechanisms	Lectures, workshop, and site visits (by consultants and trained PMU and SIO staff)	During initial phases of construction
5	Construction laborers	**Waste Handling and Sanitation at Construction Sites and Construction Camps:**	Workshops and signage (by consultants and trained SIO staff)	During initial phases of construction

[30] The training programs are to be conducted through in house trainers and hired consultants/professionals. The train the trainer mode delivery may also be considered for in house training capacity development.

[31] During construction phase training/awareness programs will be organised twice a year. During operational phase one workshop/awareness program should be organised every year for the first 3 years. This workshop should highlight the details of environmental condition monitored and tips for environmental protection.

No.	Target group	Subject(s)	Method	Time Frame
During Operation Phase				
6	Environmental engineers, field officers, contractors	**Long-Term Environmental Issues in Program Management:** Designing and implementing environmental surveys for ambient air, noise, biological, and water quality; data storage, retrieval, and analysis; contract documents and environmental clauses; risk assessment and management; contingency planning and management; and value addition	Workshops and seminars (by consultants and local trainint institutes	During implementation of the program
7	Farmers of the area program benefit area, fishers associated with beel and pond fisheries	Cropping Pattern and high yielding crop production techniques	Workshops and seminars (by consultants, and resource persons from research institutes and line departments)	Construction and operations phase
8	Public	Environmental protection awareness program	Workshops and seminars (by consultants and trained PMU and SIO staffs)	Construction and operations phase

EMP = environmental management plan, PMU = program management unit, SIO = subproject implementation office, WRD = Water Resources Department.

Source: Water Resources Department, State Government of Assam.

APPENDIX 6.5 ENVIRONMENTAL BUDGET

Component	Item	Unit	Quantity	Rate	Amount (million Rs)
CONSTRUCTION STAGE					
Technical Support	Preparation of Environmental guidelines and performance indicators	Lumpsum	-	Rs 0.5 million	0.50
Flora	Clearing of plantation	km		Covered in engineering costs	
	Compensatory afforestation (Minimum 1:3) (Plantation and maintenance for one year)	No of tree	45000for Palasbari	Rs. 20 per sampling and RS 500 for maintenance	23.40
			6000 for Kaziranga	Rs. 20 per sampling and RS 500 for maintenance	3.12
			30,000 for Dibrugarh	Rs. 20 per sampling and RS 1500 for maintenance	15.60
	• Technical Institutional Support to farmers for change in cropping pattern and monitoring agriculture productivity	Lump sum		Included in the overall project management costs	
Fisheries	• Intuitional support for Improving fish productivity at wetlands/beel and pond fisheries.)	Rupees per /reach	3 reaches	Rs 1.0 million per reach	3.00
	• Monitoring of Fish Productivity	Rupees per /reach	3 reaches	Rs 0.4 million per reach	1.20
Drainage Congestion	• Provision of adequate opening	Covered in engineering cost			
Navigation	• Adequate lighting & Signals	Covered in engineering cost			
Erosion & Sedimentation	• River Bank Protection Measures	Covered in engineering cost			
Land	• Compensation against land acquisition and Development of Rehabilitation sites	Covered in R&R Budget			
Soil	• Maintenance cost in Soil Conservation	Covered in engineering cost			
Noise	• Provision for Noise Barriers	Covered in engineering cost			

Component	Item	Unit	Quantity	Rate	Amount (million Rs)
Water	Installation of oil and grease traps at construction sites and Waste Water Collection & Disposal system	No	4 per reach for three reaches	0.080 million/system	0.96
	Construction of soak pits at construction sites	No	4 per reach	Rs 0.090 million/soak pit	1.08
Dust Management during construction	Water Sprayer / Watering	Covered in Engineering cost			
Construction Safety	Accident risks in construction activity	Covered in Engineering cost/insurance			
	General Safety (provision of PPE like ear muffs, gloves etc.)	No of labour	Av. 1000 labourer/reach	Average 100/labour/year for construction period or six years	To be part of contractors costs
Health	Health check up camps for construction workers	camps	1camp/year/reach	Rs 0.1 million/camp for six years	1.80
Environmental Monitoring in the construction phase	Terrestrial and Aquatic Fauna including Fisheries	Cost as mentioned in monitoring plan. Monitoring Costs considered on an average same for each reach. (@ Rs 2.41 Million per reach for entire construction period)			7.23
	Cropping Pattern				
	Ambient air quality				
	Surface Water Quality				
	Ground Water /Drinking Water Quality				
	Noise & Vibration				
	Soil Erosion & Siltation				
	Drainage Congestion				
	Monitoring Tree Felling & Plantation				
		SUB TOTAL (CONSTRUCTION STAGE)			57.89
OPERATION STAGE					
Erosion Control and land scaping	Reserve Fund for Erosion Control and Embankment Protection.	Lump Sump	- To be part of Regular maintenance and operation costs		-

Component	Item	Unit	Quantity	Rate	Amount (million Rs)
Tree survival	Survivance monitoring and Provision of additional tree plantation	Lump sum	Costs towards survival monitoring are included in the Monitoring budget.		3.00
Monitoring of performance indicators	Terrestrial & Aquatic Fauna including Fisheries	Cost as mentioned in the Monitoring plan Monitoring Costs considered on an average same for each reach. (@ Rs 0.82 Million per reach for entire construction period)			2.46
	Ambient air quality				
	Surface Water Quality				
	Ground Water Quality & Levels				
	Noise & Vibration				
	Soil Erosion & Siltation				
	Drainage Congestion				
	Monitoring Tree Plantation and Cropping Pattern				
		SUB TOTAL (OPERATION PHASE)			5.46
ESTABLISHMENT & TRAINING					
Establishment	Construction Stage	Per son month s	12	Rs 75,000 per person month + plus expert advise support lumpsum Rs 1.0 Million	1.90
	Operation Stage	Per son Month s	15	Rs 75,000 per person month (@ 2 person month for five years and one person months for additional five year) plus additional experts support lumpsum Rs 0.5 million	1.60
Training	Environmental training & awareness	Lump sum	As per training details	-	3.00
Management Information System		Lump sum	-	-	1.00
Subtotal (Establishment & Training)					7.50
Subtotal (Construction, And Operation And Mobilization)					70.85
Contingencies @ 10 % on total environmental costs					7.09
Grand Total (in Rs)					77.94
Grand Total (in US$) (@ 1 US $ = Rs. 40.10)					US $1.94 Million

APPENDIX 8.1 SUMMARY OF PUBLIC CONSULTATION

Date	Name and Address of Persons Consulted	Topics of Discussion	Important Outcome
2/12/2007	Dr. A. K. Baruwa, Director Assam Science, Technology & Environment Council And Assam Energy Development Agency	1.Regarding any specific problem(s) related to environment as a result of flood & erosion of the Brahmaputra 2. If the proposed project will help in providing safety to the people , their property and environment of the area 3. Any significant negative impact of the project on the overall environment of the area 4. Possible impacts of the project on Agriculture,Wetlands, Drinking Water & Local Economy 5. Suggestion or comment on isssues other than those discussed so far	❖ He has raised concern of leaching of arsenic into groundwater which is generally used for drinking water supply from the river bank filtration wells in the floodplains of Brahmaputra river and also asked about the possibility of integration of drinking water and irrigation projects.
3/12/2007	Mr. B. B. Hagier (IAS) Secretary of Environment and Forests, Government of Assam		❖ He has pointed out requirement of study of impact downstream and upstream of the reach which can be affected after protection of the reach.
3/12/2007	Mrs. E. Choudhary (IAS) Principal Secretary Soil Conservation Government of Assam		❖ She has raised the issues of bed level raising, seepage of embankment/ softening of embankment, erosion and increase in sedimentation as well as the requirement of catchments area treatment plan. She also revealed the requirement of soil conservation, study of earthquakes and its effect on siltation in the river.
2/12/2007	Mr. Biren Thukuria EE, WRD		❖ He has highlighted the importance of study for impact on fish productivity due to reduced siltation, which can emerge as a benefit to local fishermen.
25/04/2008	Dr. Rafiqua Ahmed State Pollution Control Board, Assam		❖ She has highlighted the problem of water contamination in some parts of the Brahmaputra river valley. She was also asked for the pollution problems in the sub-project reaches.
3/12/2007	Mr. Md. Allauddin Department of Minority Welfare		❖ Most of the chars in Brahmaputra are semi-permanent and as per their record there are 2,251 char villages. ❖ Drinking water is mainly supplied from the hand pumps and tubewells. The department also supports in the form of seed distribution, construction of raised platforms with and without sheds, repairing of schools, vocational training to local villagers
19/5/2008	Chief Conservatory of Forests	Related to tree cutting, aforestation programme etc.	❖ Prior permission is needed from the Chief Conservator of Forests (Wildlife) for cutting of trees within the boundary demarcated as wildlife sanctuaries and national parks. If land is outside the protected areas, then the permission is not necessary from CCF or Forest Department. However, afforestation is needed if there is any loss of tree species during project intervention. ❖ At least three plants must be planted in place of one such tree cut during project intervention. ❖ For afforestration programme,

Date	Name and Address of Persons Consulted	Topics of Discussion	Important Outcome
			bamboo, simul trees and banana plants must be planted along the side of embankment. These trees have no side roots to destroy the embankments. Again in the borrowing sites water resistant plants such as Salix tetrasperma, Buwal and Pani hizol should be planted.
3/3/2008	Dr. B. K. Talukdar Co-chair (South Asia) IUCN-SSC Asian Rhino Specialist Group	1.Regarding any specific problem(s) related to environment as a result of flood & erosion of the Brahmaputra 2. If the proposed project will help in providing safety to the people , their property and environment of the area 3. Any significant negative impact of the project on the overall environment of the area 4. Possible impacts of the project on Agriculture,Wetlands, Drinking Water & Local Economy 5. Suggestion or comment on isssues other than those discussed so far	❖ All the NGOs' consulted had welcomed the flood control project and said that it will help in protection of agricultural land, domestic animals, fishermen communities etc. ❖ They also highlighted the importance of maintaining the natural drainage along the project sites. The NGOs during interaction also highlighted the relief work they are carrying out during the flood situations. ❖ They also suggested increasing forest cover through afferoestation programme. Dr Sanjay Hazarika also indicated the need of enhancing institutional capacity and strengthening review mechanism. ❖ Prevent any change to natural drainage. ❖ Consider provision of alternate platform then only attached to embankment for use by Animals and people during flood and protection of the fish spawning grounds during construction and operation.
5/3/2008	Mr. Mintu Handique & Mr. Gaurav Borgohain, Carrier Care Group		
10/3/2008	Mr. Sanjay Hazarika CE-NES		
27/03/2008	Kula Chetri Bohikhowa Gaon, Dhansirimukh Bokakhat,Golaghat	1.Regarding any specific problem(s) related to environment as a result of flood & erosion of the Brahmaputra 2. If the proposed project will help in providing safety to the people , their property and environment of the area 3. Any significant negative impact of the project on the overall environment of the area 4. Possible impacts of the project on Agriculture, Wetlands, Drinking Water & Local Economy 5.Suggestion or comment on isssues other than those discussed so far	❖ Project is very much necessary. Erosion is a major problem. Dhansiri flood is also severe. ❖ The Bankoal-Moriahola area needs to be protected. Kaziranga NP should be saved from erosion and flood. ❖ Project will benefit the entire area including KNP. Should start early. All project affected people should get compensation before starting of the project. ❖ The work is necessary. It should be done urgently. No bad effect seen. Will benefit the people and the KNP. Should be properly done. Benefits will be there. The KNP needs urgent protection. ❖ The govt. should take up the project. If properly done it will benefit people and KNP. ❖ No adverse impact visualized. Will help to protect the area from erosion and flood. ❖ Our agriculture productivity will improve. Land will be protected. KNP will be secured from erosion. ❖ This is a good project initiated by the Government and local people will be benefited.
	Padma Nath Doley Branch Post Master Golaghat		
	Sanki Doley Palasguri Dhansirimukh		
	Hari Chandra Pegu IWD Casual Employee		
	Pradip Talukdar Vill-Palasguri P.O.-Dhansirimukh		
	Rakesh Chinte President, Polasbari Village Defence Party		
	Pradip Deka WRD Employee Bokakhat		
	Pradip Pujari		

Date	Name and Address of Persons Consulted	Topics of Discussion	Important Outcome
	Bankoal, Bokakhat Bipul Das Bokakhat Dist.- Golaghat		
2/03/2008	Hemen Doley Bankual Bali Chapori **Profession**: farmer Rabison Kamar Bholukaguri **Profession**: farmer Dangor Pegu Bankual Goan Profession: Fisherman Kishore Doley Riri Goan Prof: farmer	1.Regarding any specific problem(s) related to environment as a result of flood & erosion of the Brahmaputra 2. If the proposed project will help in providing safety to the people , their property and environment of the area 3. Any significant negative impact of the project on the overall environment of the area 4. Possible impacts of the project on Agriculture, Wetlands, Drinking Water & Local Economy 5.Suggestion or comment on isssues other than those discussed so far	❖ The present embankment is very weak; hence the proposed embankment is very essential for them. Every year floodwater entered the houses and paddy field of the person. His land is situated inside the embankment. He seeks compensation from the Govt. ❖ Embankment will benefit the people inhabited there, because of the regular flood. This embankment also protect the human life and as well as their livelihood. ❖ People who reside inside the embankment had asked for compensation. ❖ Government must be compensated for their land or alternative land should be allotted in nearby safe place. ❖ Government should be very careful during the process of embankment and the actual value of the land should be given during land acquisition for embankment. If Government gives proper compensation for land during the embankment project, and has no objection otherwise people will oppose the embankment. Because many people might loss their land during this project.

The three state-level workshop materials are available in the following website.

- 1st Workshop (1 December 2007 at Administrative Staff College of India, Guwahati)
  http://www.adb.org/Documents/Reports/Consultant/38412-IND/38412-IND-TACR.pdf
- 2nd Workshop (25 June 2008 at the Institute of Engineers Conference Hall, Guwahati)
  http://www.adb.org/Documents/Reports/Consultant/38412-IND/38412-01-IND-TACR.pdf
- 3rd Workshop (4 February 2009 at Brahmaputra Hotel, Guwahati)
  http://www.adb.org/Documents/Reports/Consultant/38412-IND/38412-02-IND-TACR.pdf

PHOTO DOCUMENTATION (PLATES)

Plate 1: Erosion near Dhansirimukh

Plat 2: Erosion at Dhansirimukh

Plat 3: Erosion at Sakopara

Plat 4: Vegetation along the Embankment

Plate 5: Interaction with the villagers

Plate 6: Public Consultation with NGO at Kaziranga

Plate 7: Porcupine ready for use

Environmental Assessment Report

Environmental Impact Assessment
Project Number: 38412
June 2009

INDIA: ASSAM INTEGRATED FLOOD AND RIVERBANK EROSION RISK MANAGEMENT INVESTMENT PROGRAM

PALASBARI SUBPROJECT
KAMRUP DISTRICT

Prepared by the Water Resources Department of the State Government of Assam for the Asian Development Bank

CURRENCY EQUIVALENTS

(As of 1 June 2009)

Currency Unit – rupee (Re/Rs)
Re1.00 = $0.02122
$1.00 = Rs47.11

ABBREVIATIONS

ADB	–	Asian Development Bank
DMO	–	disaster management organization
EA	–	executing agency
EARF	–	environmental assessment and review framework
EIA	–	environmental impact assessment
EIRR	–	economic internal rate of return
EMOP	–	environmental monitoring plan
EMP	–	environmental management plan
FRERM	–	flood and riverbank erosion risk management
IUCN	–	International Union for Conservation of Nature
IWAI	–	Inland Water Transport Authority
KNP	–	Kaziranga National Park
MFF	–	multitranche financing facility
NGO	–	nongovernment organization
PMU	–	project management unit
PPTA	–	project preparatory technical assistance
SEIA	–	summary environmental impact assessment
SIO	–	subproject implementation office
SPCB	–	State Pollution Control Board
WRD	–	Water Resources Department

WEIGHTS AND MEASURES

dBA	–	decibel
Ha	–	hectare
Km	–	kilometer
km^2	–	square kilometer
m	–	meter
mm	–	millimeter
m^3/s	–	cubic meters per second

GLOSSARY

porcupine	–	Tetrahedron-shaped concrete frames commonly made of six concrete members, each 3 meters long connected with bolts, which are placed in an arrayed manner in the riverbed to retard river water flow and induce sedimentation.
revetment	–	A riverbank protection structure constructed on the bottom or banks of a river by placing a layer of material, such as rock, stones, concrete blocks, or mattresses including sand-filled geo-textile containers.
spur	–	A river training structure built from the bank of a river in a direction transverse to the current, by placing a large quantity of rocks, stones, or concrete blocks (or earth armored with these heavy materials).

NOTES

The fiscal year (FY) of the Government of India ends on 31 March. FY before a calendar year denotes the year in which the fiscal year ends, e.g., FY2009 ends on 31 March 2009.
In this report, "$" refers to US dollars.

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1. INTRODUCTION

1. The Water Resources Department (WRD) of the state government of Assam, India engaged consultants to undertake an environmental impact assessment (EIA) of a multitranche financing facility (MFF) for the Assam Integrated Flood and Riverbank Erosion Risk Management Investment Program. The Program aims to enhance the effectiveness and reliability of flood and riverbank erosion risk management (FRERM) systems in three existing flood embankment systems (or subprojects) protecting urban, suburban, and other strategic areas of Assam: (i) Palasbari reach (74 kilometers [km]) in Kamrup (south) district; (ii) Kaziranga reach (29 km) in Golaghat district, adjacent to the Kaziranga National Park (KNP); and (iv) Dibrugarh reach (25 km) in Dibrugarh district. The Program also aims to strengthen the policy, planning, and institutional bases to support better FRERM operations. Comprehensive and adaptive structural and nonstructural FRERM measures will be provided in the three subproject areas. These are provided in two tranches during the 7-year implementation period, based on the local priorities.

2. The following presents the EIA undertaken to determine the likely significant environmental changes as a result of the project implementation, and if these changes are negative, what mitigation measures are included in the environmental management plan.

1.1. Background

3. The state government of Assam submitted an investment proposal to ADB in 2006 for strengthening key existing FRERM infrastructure along the vulnerable reaches of the Brahmaputra River that is protecting the vital economic, social, and ecological interests of the state. The Brahmaputra River is the main cause for erosion and flooding in the Assam. This river instability (river bank erosion and flooding) hampers development and poverty reduction in the state. In response to the proposal, Technical Assistance (TA No. 4896-IND) has been provided to WRD in two phases. Phase I (May through September, 2007) covered the strategy and options studies included in the pre–feasibility of three priority sites. Phase II (November 2007 through June 2008) included subproject option finalization and feasibility studies, institutional assessments, and project packaging.

1.2. IFRERM Assam Subproject Locations and Palasbari Subproject

4. Under this TA three most vulnerable reaches located in the State of Assam (Latitude 24°08' N & 27°59' N and Longitude 89°42' E & 96°01' E) along the bank of Brahmaputra River have been selected. The locations of the sub-project reaches are: (i) Majirgaon - Nagarbera (Palasbari Reach) in south bank of Kamrup district, (ii) Oakland-Bogibeel (Dibrugarh Reach) in Dibrugarh district, and (iii) Bankoal-Moriholla-Diffalupathar (Kaziranga Reach) in Golaghat district are shown in Figure 1.1: This report covers the environmental assessment of sub-project – Palasbari Reach.

1.3. Nature, Size and Location of Sub-Project-Palasbari Reach

5. The proposed sub-project (Palasbari reach) is located downstream of the narrowest point of the Brahmaputra River within the State of Assam, controlled by the two successive nodal points at Pandu and Soalkuchi. Sediment deposition in the Palasbari Reach has resulted in the river widening and lateral erosion of the river banks for many decades. The project involves retirement of Brahmaputra dyke, revetment of certain length, construction of inspection road, construction of 2 gated drainage sluices, revetment/ pro-siltation measures in certain

length of the reach, and rehabilitation & strengthening of 3 boulder deflectors. The sub-project alignment is shown at Figure 1.2:

6. The subproject will be implemented in two Tranches; Tranche 1 in general, focuses on controlling erosion while Tranche 2 will rehabilitate and strengthen existing flood control embankments. More specifically, Tranche 1 involves the retirement of 4.9 km Brahmaputra Dyke from Majirgaon to Dakhala Hill, riverbank revetment of 4.9 km length between Palasbari and Dakhala Hill, While Tranche 2 requires the retirement of 10.2 km Brahmaputra Dyke from the Khanajan Sluice to Majirgaon, construction of 15.1 km inspection road from Khanajan to Dhakala Hills, construction of 2 gated drainage sluice, revetment f 7.1 km length between Majirgaon and Palasbari, revetment/pro-siltation measures of 4 km length downstream of the Dakhala Hill, and Rehabilitation and strengthening of 3 boulder deflectors near Gumi. The total subproject costs for Tranche 1 and 2 are Rs. 56.5 Crore and Rs 141 Crore, respectively.

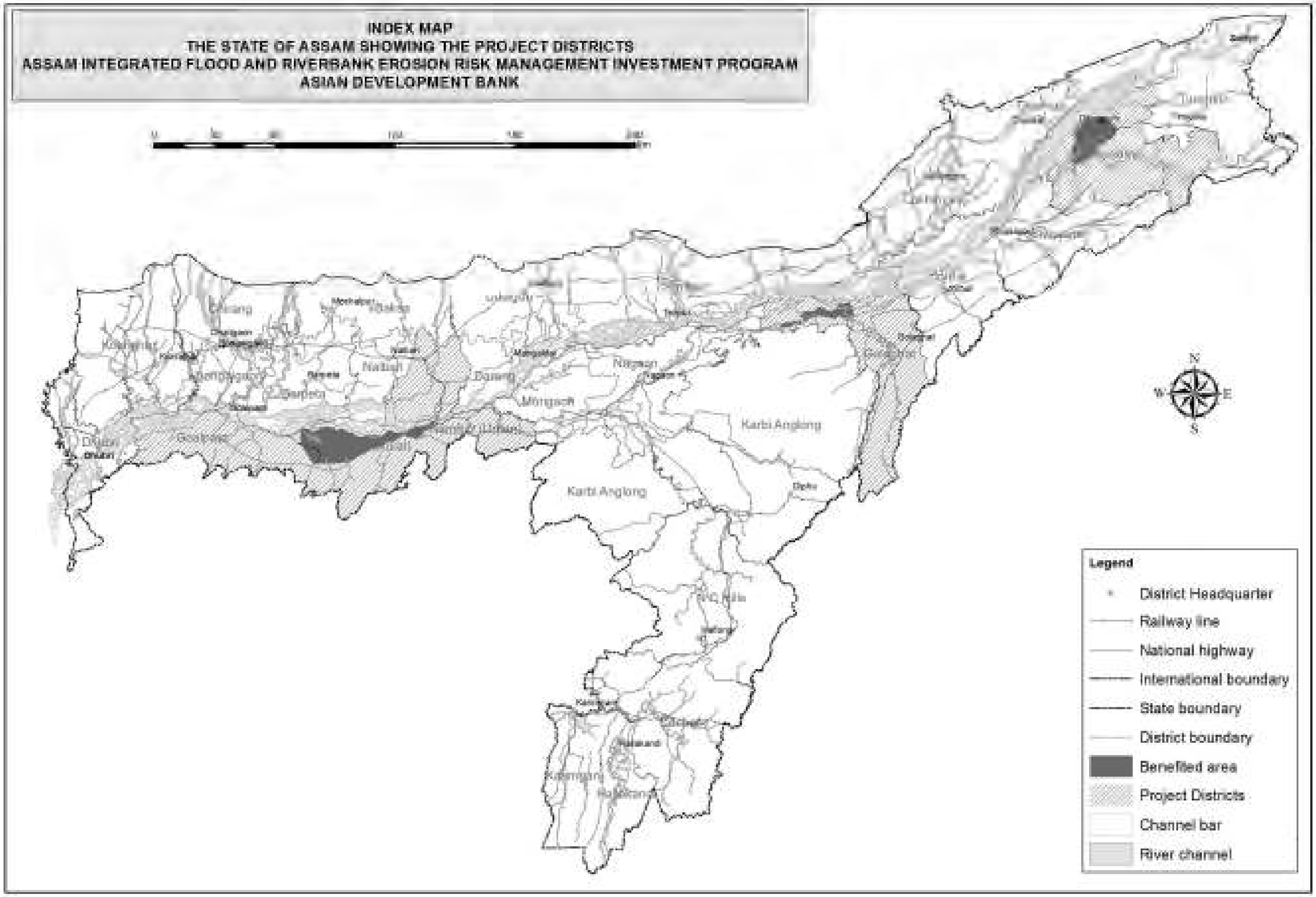
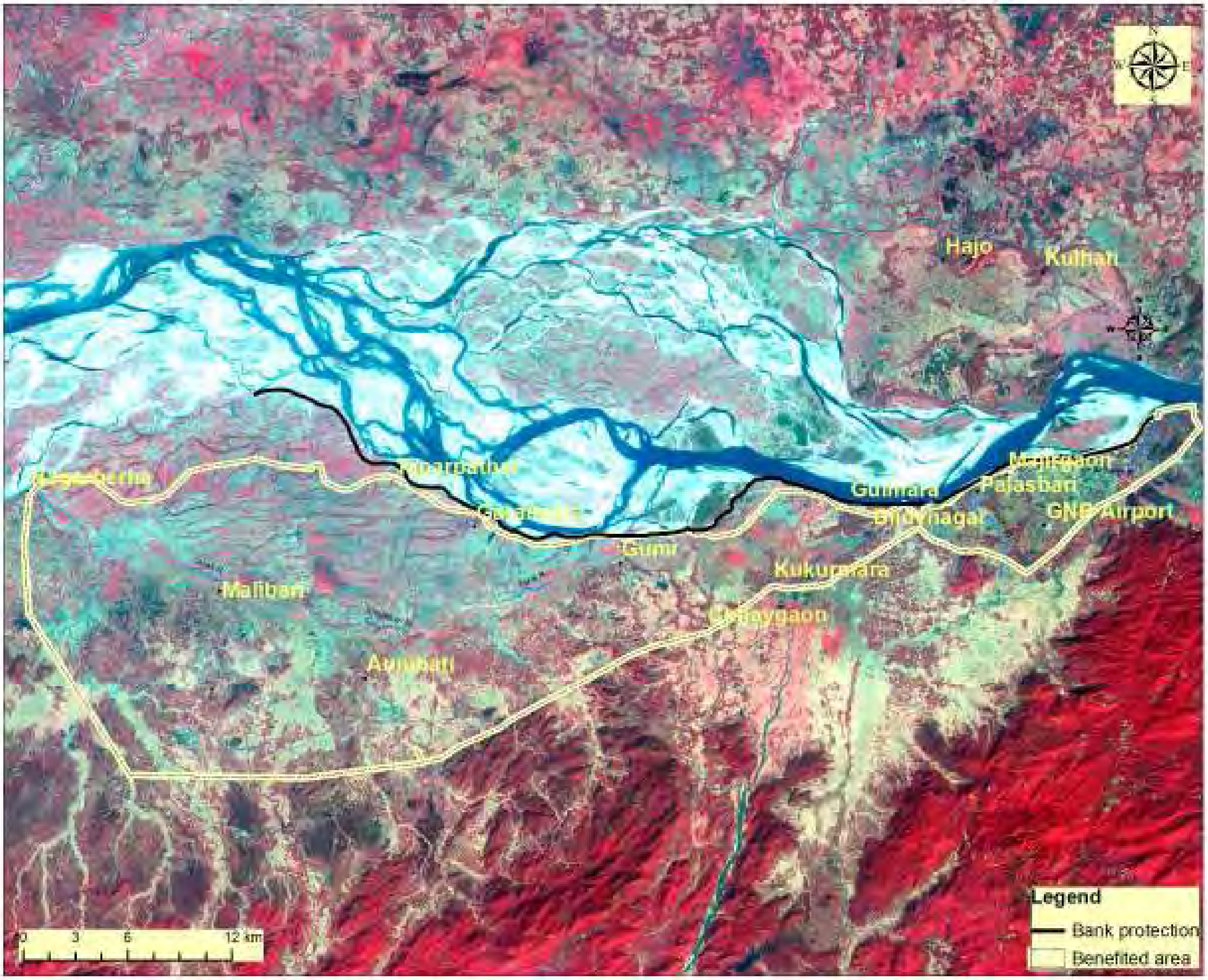


Figure 1.1 Location Map of the Sub-Projects



Satellite image of the Palasbari sub-project site

IRS LISS3 image of November, 2006

Figure 1.2 Alignment of the Sub-Project (Palasbari Reach)

(Source: IRS Image, 2007)

1.4. Purpose of the Report

7. This report primarily focuses on the environmental impacts of the structural components of the IFRERM-Assam, public consultations conducted and recommended mitigation and monitoring measures

8. The Subproject focuses on the Palasbari Reach of the Brahmaputra River located in Kamrup District, about 25 kilometers from Guwajati, and between kilometer 150-190 from the Bangladesh (Dubri) border. The subproject are investigated under this study is consist 88,850 hectares hectares of mostly agricultural and homestead areas confined between elevations 40-55 meters above mean sea level.

9. Currently, increased breach of embankment or bank overtopping is one of the reasons for maximum flood hazard. Assessment has been made for hydrological, morphological,

climatic, socio-economic factors responsible for such floods. Impacts have been identified of such floods on physical, aquatic and terrestrial ecology valued environmental components. The mitigation, management and monitoring programs have been suggested to minimise the impact and sustain the benefits.

10. In this report, the different activities that are likely to take place to achieve the project objectives have been analyzed and the potential environmental impacts that may accompany them have been discussed. In order to mitigate the potential impacts, appropriate measures have also been proposed under impact assessment and mitigation measure section. Extensive public consultation undertaken as part of the Environmental Impact Assessment (EIA) work has also been documented in this report.

1.5. Extent of the EIA study

11. The environmental assessment was done in tandem with the preparation of the feasibility report. The EIA is based on most up-to-date subproject details/ concept design provided by the Design Team during the preparation of this report. Minor changes may occur in the sub-projects structural component, but these changes are expected to be limited to implementation schedule. References have also been made on the pre feasibility report.

12. The EIA study covered all activities proposed for the integrated flood and riverbank erosion management in Palasbari Reach. The impact area covers section of river Brahmaputra (complete reach length, its immediate upstream and downstream sections, area 100 m either side of the reach,[1] project benefit area, and beels/wetlands/ tributaries connected with the river in the reach area). The study area has been extended to cover a buffer zone of 8 km wide[2] on either side of the embankment to analyze the land use, identify environmentally sensitive locations, if any, and understand the overall drainage pattern of the area. Geographical Information System (GIS) techniques have been used based on recent satellite data of the project area to analyze the baseline physical, ecological and cultural landscapes and to gather the relevant data for EIA purpose. Impact on aquatic life including Dolphin, their breeding/spawning areas, migratory route of fishes has also been assessed. Assessment of vegetation cover, migratory route of animals, and sourcing of construction material particularly borrow earth and aggregate has also been undertaken.

13. The scope of the EIA study has been confined to the structural-component of the project such as embankment renovation or new construction, bank protection, site clearing, transportation, construction camp and operation.

14. The report has been prepared by :

- **S K JAIN**, Environmental Expert, EQMS India Pvt. Ltd.
- **Prof. D C Goswami**, Environmental and Geo Hydrology Expert
- **Naval K Chaudhary**, Environmental Specialist

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[1] Core zone of the impact was taken as 100m on either side of the reach based on the expert judgement as most of the project activities related to embankment renovation and/or new construction, bank protection will primarily be limited to this zone.

[2] The study area has been selected based on the following two considerations:
The sub-project specific benefit area which is varying up to about 8 km from the embankment in case of Palasbari reach. The practice adopted by Ministry of Environment and Forests (MoEF), Government of India for delineating environmental assessment of the project, which is 10 km around the project boundary (Though we have followed MoEF guidelines but this project will not require any formal clearance from MoEF as detailed under Section 2.2.1)

15. Additional inputs have been provided by

- **Dr. P K Saikia, Reader,** Department of Zoology, Gauhati University for Terrestrial Ecology
- **Dr. Amalesh Dutta, Professor,** Department of Zoology, Gauhati University for Aquatic Ecology
- **Environmental Science Department,** Gauhati **University** for Ambient Air Quality, Ambient Noise Monitoring, Soil and Water Quality Testing
- **Dr. Sarat Phukan & Ms. Chinmoyee Gogoi**, Gauhati University For Remote Sensing And GIS Related Inputs

1.6. EIA Content

16. This EIA report is presented in nine chapters, consistent with he ADB's Environmental Assessment Guidelines (2003). This includes this introduction, and individual chapters describing the subproject, environment, alternatives, anticipated environmental impacts and mitigation measures, economic assessment, environmental management plan, public involvement and disclosure, and conclusion.

1.7. Methodology

17. The EIA study was carried out using reconnaissance survey, review of previous studies, field visits, consultation with stake holders & NGOs, review of existing data, assessment to identify adverse impacts, and the preparation of environmental management plan (EMP). Extensive use of geographic information system established by the project as part of the engineering and knowledge base component was made. The assessment also builds on the Brahmaputra morphology study using satellite imagery, risk maps, and studies on the influence of spurs and anti-erosion activities of the Water Resources Department (WRD) in Assam. The scope of the EIA extends well beyond the vicinity of the proposed structural measures and covers the entire Brahmaputra River section fronting the existing and proposed measures, and to the extent possible, 8 kilometers radius as the general impact zone. While, the immediate 100-meter corridor centered along the existing and proposed embankment alignments as the primary impact zone where most of the adverse impacts may occur. The decision to expand the environmental assessment impact zone to 8-kilometer radius is based on the following: i) to ensure that environmental impacts attributable to the project are comprehensively identified and assessed, ii) allow flexibility in the detailed design of Tranche II measures, which will adapt to the rapid changes in Brahmaputra River morphology, by providing a comprehensive environmental baseline information, and iii) recognizes that FRERM measures to influence the flow direction and promote siltation in strategic areas may have environmental impacts downstream.

1.8. Data Collection

18. The objective of data collection was to provide a database on existing conditions, to be used for predicting the likely changes that are expected and for monitoring such changes. The first step was to undertake a subproject scoping exercise, identify the parameters to be considered, and outline the activities for collecting data on identified parameters. Sources of data were identified and relevant existing data on the physical, biological, and socio-economic aspects of the environment from authentic secondary sources were collected. Data collected, sources, and application are summarized in the succeeding Table.

Table 1.1 INFORMATION COLLECTED AND SOURCES

Information Collected	Sources	To be Used in
Project location, project objectives, project designs, and sourcing of construction materials	Pre-feasibility Report; Concept design prepared by TA Consultant team and WRD	Project description and impact assessment
Wildlife, forest areas in project vicinity, flora and fauna details, and possible ecological impacts and mitigation actions	Department of Zoology, Gauhati University; District Forest Office; Department of Environment and Forests, Govt. of Assam	Project description, impact assessment and mitigation actions, alternative analysis, and economic assessment
Engineering details	TA consultants	Project description, impact assessment, and mitigation actions
Existing quality of the environment, land use, meteorological data, possible impacts because of the project and proposed action plans, identification of ecologically sensitive locations, regulatory compliance	Primary data collection; Department of Environment and Forests; Department of Fisheries; District Forest Office; Census Report, Govt. Of Assam; IMD Regional Office, Guwahati; Gauhati University Library, State Pollution Control Board, Assam	Project description, impact assessment and mitigation actions, management plan, and environmental economic assessment
River geomorphology, hydrology, and flood pattern	Published Research; Govt. Reports; Unpublished Doctoral thesis's, ARSAC reports, Brahmaputra Board, WRD, and GSI Reports	Project and environmental descriptions, and impact assessment

19. Primary data was also collected for noise, water quality, air quality and soil. Since Dolphin is also endangered species, special efforts were made to identify their activity close to river bank and their breeding grounds.

1.9. Public Consultation

20. Local knowledge about the ecosystem and problems associated with river behavior, existing flood protection, and erosion control measures were carefully recorded and used in impact assessment and developing mitigation plan. Consultations were held focusing on aquatic and terrestrial flora and fauna to identify sensitive ecosystems that may be affected by the subproject. Formal institutional level public consultation and opportunistic informal meetings involving local villagers, fishermen, and those who are likely to be affected due to the proposed projects were organized to determine potential socio-economic impacts. Finally, interactions were made with various NGOs and concerned government officials.

21. Public consultations were held with the stakeholders during the two state workshops, on December 2007 and June 2008 in Guwahati. Taking into consideration the environmental importance of the project, a number of environmental NGOs were invited during these state workshops. However, only a few had turned up. A detailed description of the public consultation has been presented in Chapter 8.

2. DESCRIPTION OF THE PROGRAM AND SUBPROJECT

2.1. Rationale

22. India is one of the most disaster-prone countries in the world. Flooding is a major recurrent natural disaster, causing damage of average $450 million annually with increasing incidence in the recent years. The country has a flood prone area of 46 million ha (accounting for some 14% of the geographical area and 25% of cultivable area). A national level policy framework for flood management is promoting short- to long-term programs for both structural and non-structural measures with a basin wide approach with improved catchment management. About 18 million ha in flood prone area has so far been protected with flood embankments and other structures, whereas nation wide flood forecasting and warning system has been set up. However, large gaps still exist between the policy framework and operations at the individual state level.

23. Flooding in the Brahmaputra plain in Assam is a complex phenomenon with different factors often changing roles. These factors are: (i) the Brahmaputra River in high spate has the potential to flood major parts of the plain for extended period of time; (ii) tributaries flood their adjacent plains, but for shorter periods being of short term character in steeper hilly parts with longer-term flooding, influenced by Brahmaputra water levels, in their lower floodplains; and (iii) local rainfall can cause flooding (local floods associated with drainage congestion) even when rivers not overspilling, but commonly drain away after hours or days. Overall, the effective FRERM requires a long-term basin wide approach with a sound planning framework integrating short- to longer-term programs including (i) improved catchment management, (ii) multipurpose reservoirs including flood cushion where feasible, and (iii) balanced combination of structural and nonstructural measures to cope with immediate annual risks.

24. Assam remains one of the poorest states in India, with per capita income 45% below the national average in 2005. An inability to minimize the impacts of frequent flooding remains one of the serious development constraints.[3] Flooding and river erosion have devastating impacts each year. The floods are caused by the runoff of extremely heavy rainfall during the monsoon and high sediment loads from upper watersheds that are geologically unstable and degraded because of deforestation and changing land use. Their effective management requires a long-term, basin-wide approach with a sound planning framework integrating short- to longer-term programs, including (i) better catchment management, (ii) multipurpose reservoirs where feasible, and (iii) a balanced combination of structural and nonstructural measures to cope with immediate annual flood and erosion risks.

25. While the state has flood embankment systems protecting 50% of its flood-prone areas, their reliability is constrained by deterioration associated with poor maintenance, failure from river erosion, and local riverbed rising. The improvement of the existing embankments needs to be prioritized, particularly along high-value locations with assured maintenance, supported by riverbank protection where feasible. More cost-effective and flexible options that can adapt to the dynamic river process should be explored. Alternative risk management measures need to be pursued in other areas, such as flood proofing, strategic retirement of embankments, and a range of nonstructural measures including flood and erosion risk prediction and mapping, advance warning, and safety nets for the people threatened and displaced by flooding and river

[3] The Brahmaputra Valley in Assam is one of the most acutely hazard-prone regions of the country, with more than 40% of its land (3.2 million hectares) susceptible to flood damage. This is 9.4% of the country's total flood-prone area. The erosion hazard is also extremely severe in several vulnerable reaches. About 7% of land in the state's 17 riverine districts has been lost because of river erosion over the past 50 years.

erosion. Comprehensive strengthening of the policy, planning, and institutional basis, data, and knowledge base are also required, along with the effective participatory mechanisms to ensure accountable program management.

26. The Government, in its Eleventh Five Year Plan,[4] has prioritized flood management, in line with the paradigm shift of the country's disaster management strategy to focus more on preparedness than responses. This is also in line with a growing concern about the impacts of climate change. The state government has also initiated steps to establish a sound policy, planning, and institutional framework for water resources management, including drafting a state water policy and a vision for holistically managing flood and riverbank erosion from a basin perspective. The Program is designed to support the state government's initiatives by promoting necessary reforms and strengthening key sector organizations, such as the WRD and local participatory disaster management organizations (DMOs). Structural measures will focus on the three existing embankment systems protecting key urban and productive rural areas, which were selected as the priority sites for putting into operation effective FRERM systems. The establishment of a sound data and knowledge base to effectively manage or respond to the dynamic natural river processes will be emphasized.

27. The IFRERM Assam is needed to support the SGOA's initiatives to start taking the specific steps towards more effectively managing the risk of flood and river erosion problems with long-term integrated perspective. Support is to be provided to promote the necessary reforms and capacity strengthening in terms of policy and institutional bases and a sound planning framework placed within a long-term basin context while institutionalizing comprehensive and effective structural and non-structural measures in strategic locations of the state. Structural measures will focus on proper functioning as per the intended design of the existing embankment systems protecting key urban and productive rural areas and requiring upgrading and protection against river erosion exploring alternative (cost effective and sustainable) designs, whereas non-structural measures will extend to the most vulnerable locations to the impacts of chronic flooding. Significant emphasis will also be placed on establishing sound data and knowledge base to effectively manage or respond to the dynamic natural river processes while not disturbing them as much as possible.

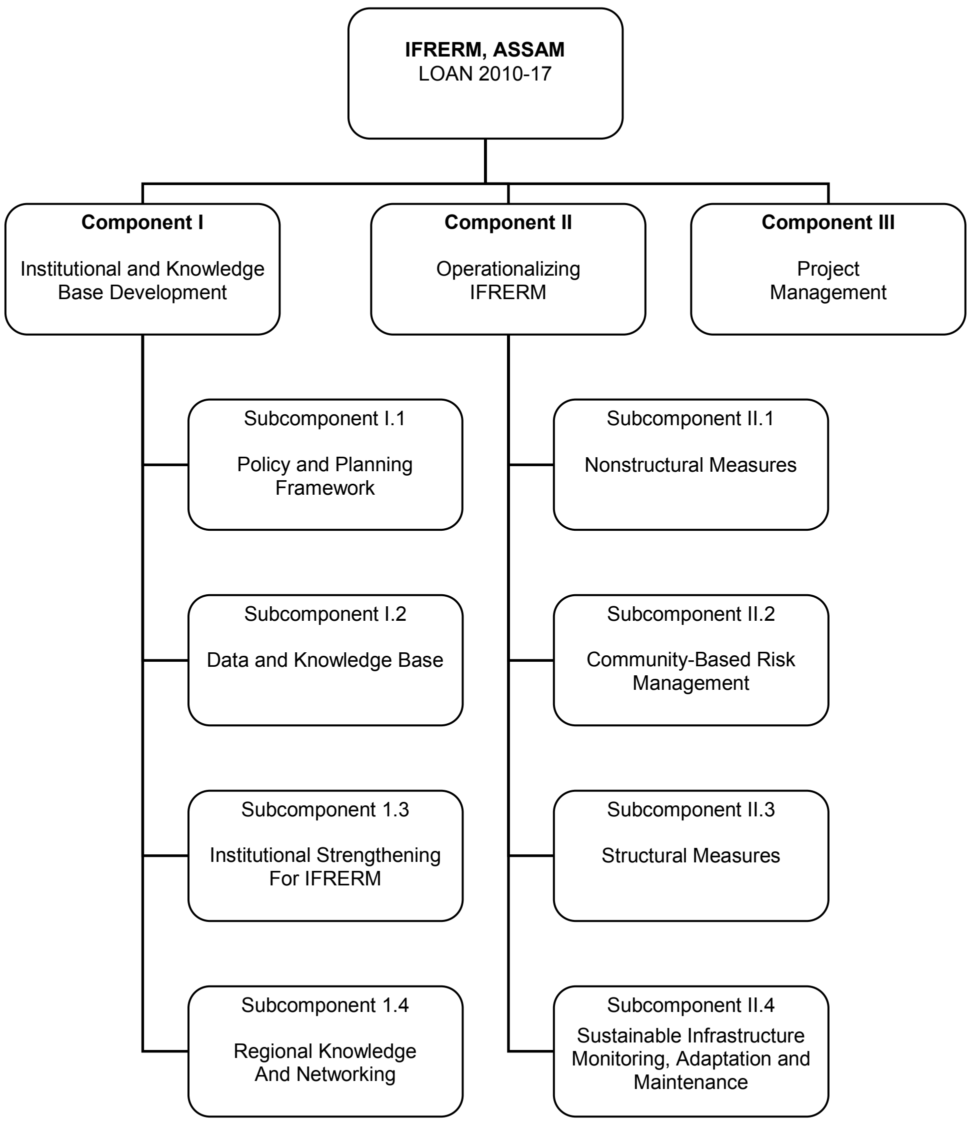
2.2. The Program

28. The Program intends to (i) improve the state's ability to mitigate flood and erosion damage at three priority subprojects that have embankment systems, (ii) increase economic development, and (iii) reduce poverty. Recognizing the need for a holistic approach to FRERM, the Program has several components that mix structural and nonstructural measures, as shown in **Figure 2.1**. Component I will address the enabling environment and institutional framework, particularly the policy and planning framework, institutional strengthening, and capacity building. Component II will address the operationalization of integrated FRERM through structural, nonstructural, and community-based risk management measures. Structural measures include the renovation of existing embankments, including their retirements, to maintain their intended design functions; provision of riverbank protection; and associated drainage structures, such as sluice gates along the embankments, to improve local drainage. Component III will address project management and training of project organizations. It is estimated to cost $149 million including financial charges. The Program is described in more detail in Appendix 1.

[4] Government of India. 2007. Eleventh Five Year Plan (2007-2012). New Delhi.

29. The Program is to be implemented over 7 years, from 2010 to 2016 (including 1 year for maintenance support). Although designed as a project loan having three appraised subprojects, an MFF is adopted for the implementation of the Program to achieve higher quality implementation, progressively improve program design by incorporating lessons, and progressively develop institutional basis and capacities. Within the MFF framework, the implementation philosophy follows an adaptive approach to allow construction at the right place at the right moment. The flexible response largely applies to the implementation of riverbank protection measures. As such, the subproject works are divided into two tranches. The first tranche is more definitive for immediate implementation following local priorities, while the second tranche is indicative at this stage and a more definite scope will be defined at the time of its processing. An updated or revised EIA will be prepared at that time as required.

Figure 2.1 Program Components



30. A participatory and holistic FRERM will be used to implement the Program. For this purpose, a multidisciplinary project management unit (PMU) will be established under the

Assam Integrated Flood and Riverbank Erosion Risk Management Agency, which is being established with registration under the Societies Registration Act. The PMU will provide stable leadership and strong coordination of technical, nonstructural, and participatory agendas. At the subproject level, multidisciplinary subproject implementation offices will be set up, combining technical, disaster management, and coordination functions. The established system of DMOs, implemented under the United Nations Development Program Disaster Risk Management Project, will be extended to include a wider range of stakeholders and jointly decide on and monitor implementation. The concerned state departments, including the WRD, will be held accountable to DMOs for sound program delivery.

31. The more specific scope of the IFRERM ASSAM will include the following:

Component I: Institutional and Knowledge Base Development

(i) Policy and Strategic Planning Framework: (a) consultations towards finalizing State Water Policy and steps for initiating implementation; (b) long term state FRERM plan (building on existing plans, with integration to wider watershed issues)

(ii) Institutional Bases: (a) institutional development actions for WRD and line departments; (b) improved guidelines and manuals including nonstructural measures; (c) FRERM infrastructure asset management information system (MIS); (d) comprehensive capacity development

(iii) Data and Knowledge Base (linking with central and state institutions): (a) data base on hydrology, morphology, sediment transport, topography; (b) tools including flood risk mapping and short-term erosion prediction system; (c) strengthened flood warning system; (d) M&E and R&D system

(iv) Regional Knowledge Sharing and Networking: (a) international networks for FRERM and disaster risk management (DMS); (b) knowledge exchange

Component II: Comprehensive FRERM Systems in Selected Subproject Sites

(i) FRERM Nonstructural Measures: (a) flood and erosion risk mapping; (b) improved warning systems; (c) participatory flood emergency response system; (d) other flood adaptation measures (adaptive cropping, fish culture, etc.)

(ii) Community-based Risk Management: (a) participatory systems integrated with local disaster management committees (DMCs); (b) community FRERM plans; (c) plan implementation such as community awareness, flood shelters, associated flood coping and development programs, e.g., adaptive cropping, fisheries, and livelihood

(iii) FRERM Structural Measures: (a) upgraded embankments with assured maintenance (with extended platforms as appropriate); (b) systematic riverbank protection exploring cost-effective, adaptive, and sustainable alternatives; (c) associated infrastructure (drainage sluices, canals, etc.)

(iv) Sustainable FRERM Infrastructure Maintenance

Component III: Project Management and Associated Capacity Strengthening

(i) Project management support with community participation (through disaster management systems) with incremental staffs including those hired from the market, implementation consultants, and other operations

(ii) Training for Project-related operations

32. The proposed program will be implemented in two Tranches at three sub-project sites with each Tranche having 3 year duration. Tranche I focus on the development and provision of

urgent structural works, knowledge base development to add to the understanding of flood behavior and riverbank erosion process in the subproject areas, and cost effective structural flood protection measures specific to Assam. Based on the lessons learned and developments of Tranche I, structural works will be finalized, taking into account the rapid changes of the river environment.

33. Structural measures will renovate and strengthen existing flood embankments as opposed to new construction, with a focus on the systems protecting the vital areas of economic interests. The existing system of flood embankments needs to be supported by riverbank protection measures where feasible, as the Brahmaputra is widening – eroding more and more embankments and posing the risk of large scale avulsion or channel migration in certain locations. Riverbank protection provides the additional benefit of safeguarding the valuable flood plain habitat between existing flood embankments and river. Flood plain land is higher in biodiversity than lower lying often sandy and less valuable amphibian river habitat into which the floodplains turn after erosion. In order to improve the water exchange on the floodplain, especially for drainage but also to allow targeted replenishment of beel areas, a large number of sluice gates will be constructed under this Project.

34. The project implementation philosophy follows an adaptive approach, which means being flexible to respond to unpredictable river changes in future and as such reducing structural work, especially riverbank protection measures, to only those areas immediately threatened. Recognizing the unpredictability of the Brahmaputra River and driven by the objective to minimize cost, the planning framework of structural component incorporates great flexibility in order to allow construction at the right place at the right moment. The flexible response largely affects the implementation of riverbank protection measures, but to a certain degree also the strengthening or rebuilding of embankments. In the case of riverbank protection, the work location might shift upstream or downstream than previously envisaged during planning, in response to the changes in the river channel pattern particularly if previously completed structures are at risk of being outflanked by the river. In case of embankments, this could mean the rebuilding of an embankment that was once envisaged for strengthening if it has already eroded.

35. In implementing the subprojects, IFRERM-Assam will put into operation participatory, effective, and comprehensive FRERM at the community and subproject levels. For this purpose, the SGOA will establish a multidisciplinary project management unit anchored to WRD and Disaster Management Department (DMD), possibly registered under the Societies Registration Act as an autonomous agency, which will provide stable leadership and strong coordination of technical and non-structural agendas including safeguards required for integrated FRERM. At the subproject level, there will also be subproject implementation offices (SIOs) comprising technical team (constituting the WRD’s field offices) and disaster management and coordination team (constituting multidisciplinary staff in disaster risk management, social mobilization, and safeguards, who will be engaged locally). Existing disaster management committees at sub-district and village local government levels will be extended and utilized to jointly decide on and monitor implementation, to which the concerned state departments including WRD will be held accountable.

2.3. The Palasbari Sub-Project

36. The Palasbari Sub-project is located on the southern bank of the Brahmaputra River in the Palasbari Circle of Guwahati Sub-Division, District of Kamrup. The Sub-project has been defined over a 74 km reach of the Brahmaputra River (the Palasbari Reach) that runs from

around the confluence of the Jaljali River, which is near the village of Nagarbera and defines the downstream limit of the reach to around the confluence of the Khanijan River, which is near the village of Mazirgaon and defines the upstream limit of the reach.

37. The Brahmaputra River shifted over time to the southern bank where it has formed a more established channel since about a decade. Most of the bank is clayey with slow erosion rates, however, in places starting undercutting the existing embankment. The related loss of flood protection could endanger the development of the area west of Guwahati including the airport and required for the extension of the city. The succeeding figures provide a summary of the geomorphic features and potential hazards affecting the Palasbari area.

38. A case of regular hardship and occasional disaster through negligence can be observed in Palasbari. The town area is supposed to be protected against flooding by an embankment. But the mouth of the Kalbag tributary that discharges through that embankment is not provided with a regulating structure. Therefore, the town is regularly flooded from the backside through this tributary. Without plugging of the river Kalbag confluence with the Brahmaputra the embankments are of no use. This has been voiced several times to the authorities by the town committee however, but there has not been a response yet.

39. In 2005, a breach between the Gumi and Taparpathar embankment at approximately 30 km chainage deposited massive amount of sand and silt (sand casting) on some 1,100 ha of agricultural land plus the erosion of several bridges when the Brahmaputra inflows entered the Jaljali River with great force. Without countermeasures, such as closing the breach, there is the added risk that the Brahmaputra erodes the smaller tributaries over time, eventually including the tributaries and all land towards the main river into its active braided belt.

40. As mentioned, the Palasbari sub-project area is located downstream of the narrowest point on the Brahmaputra River within the State of Assam, controlled by the two successive nodal points at Pandu and Soalkuchi (northern bank). Sediment deposition within the reach has resulted in the formation of a large clustered island or char in the river accompanied by lateral erosion of the river banks for many decades. As a result the system of embankments has had a long history of erosion and retirement. The succeeding Figure presents the areas undergoing or threatened by accretion, erosion, and location of existing bank protection, and the areas that will be protected against flooding.

41. Figure 2.4 demonstrates tributary flooding in the Jaliali River during July 2004, when the Brahmaputra (shown in white with 2008 low-water channels) was at its peak. Water levels in the Brahmaputra create a substantial backwater effect up the Jaliali River inundating a large area behind the embankment in the Palasbari reach. Local observations confirm that in general water levels in the protected areas behind embankments are lower than in the Brahmaputra at full spate. Already differences of 30 cm matter, as the higher water level would damage crops or flood houses. As such the main purpose of the embankment strengthening is to reduce the risk of high floods from the primary source, the Brahmaputra

42. A nearly continuous system of embankments and bundhs has been constructed by the WRD and maintained along the length of the sub-project area, stretching from just downstream of the nodal point to Nagarbera Hill. Dakhala Hill is one exception where the embankment is interrupted by the high ground of this rock outcrop. The chainage system is interrupted by the boundaries of the various divisions of the Water Resources Department. The sections of the dyke system are as follows:

- Approximately 9.8 km of embankment from the outfall of Kanjan River (Ch. 0 km) to the start of the Marginal Bundh,
- Approximately 4.9 km of bundh opposite the town of Palasbari,
- Approximately 21 km of embankment from the end of Marginal Bundh to the village of Gumi, and
- Approximately 38 km of embankment from Gumi to Nagarbera Hill at the mouth of the Jaljali River.

Figure 2.2 Areas Threatened by Erosion and Accretion, and Location of Existing Brahmaputra River Embankments-Palasbari Reach

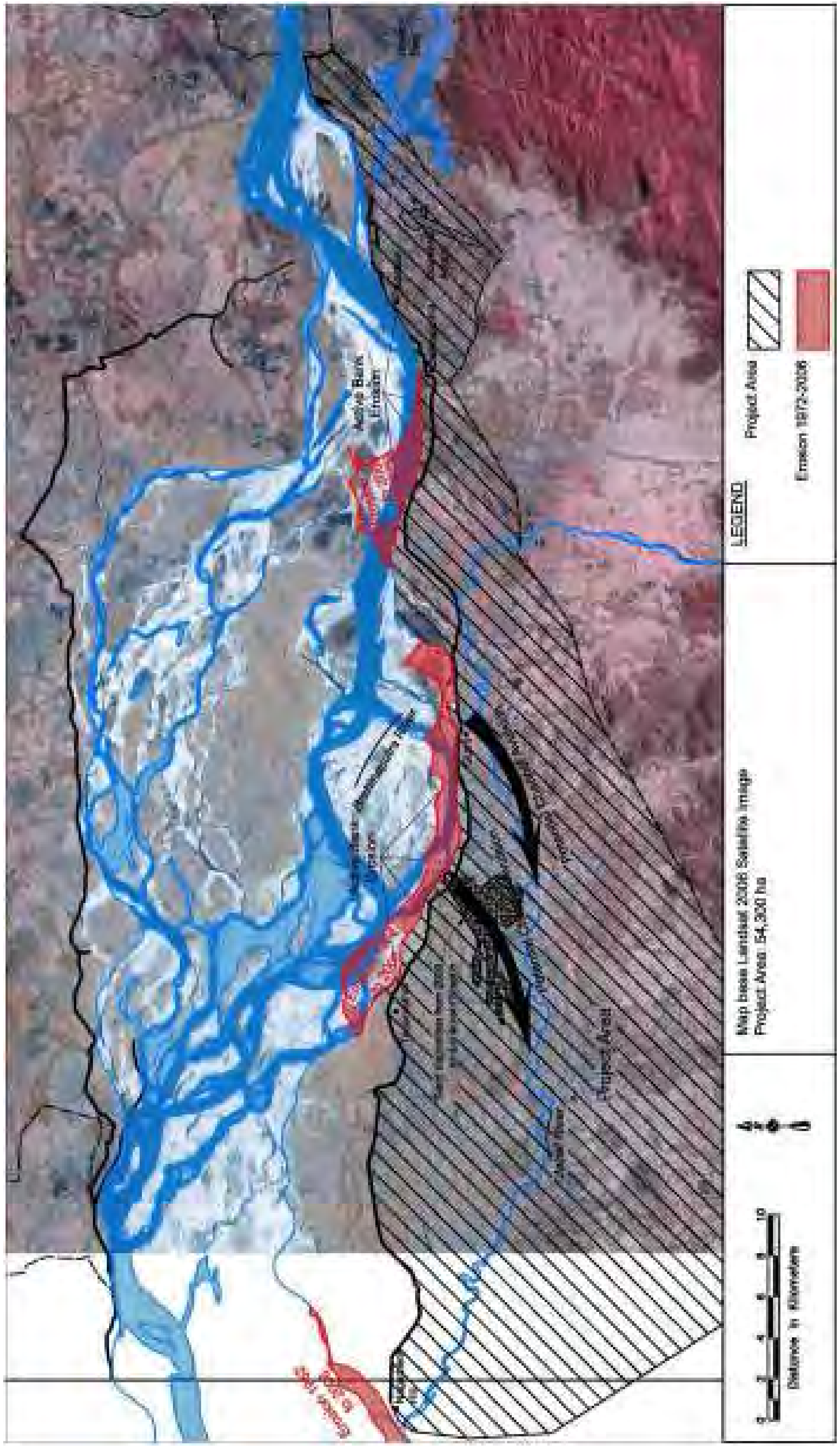


Figure 2.3 Geomorphic features and potential hazards of the Palasbari sub-project site.

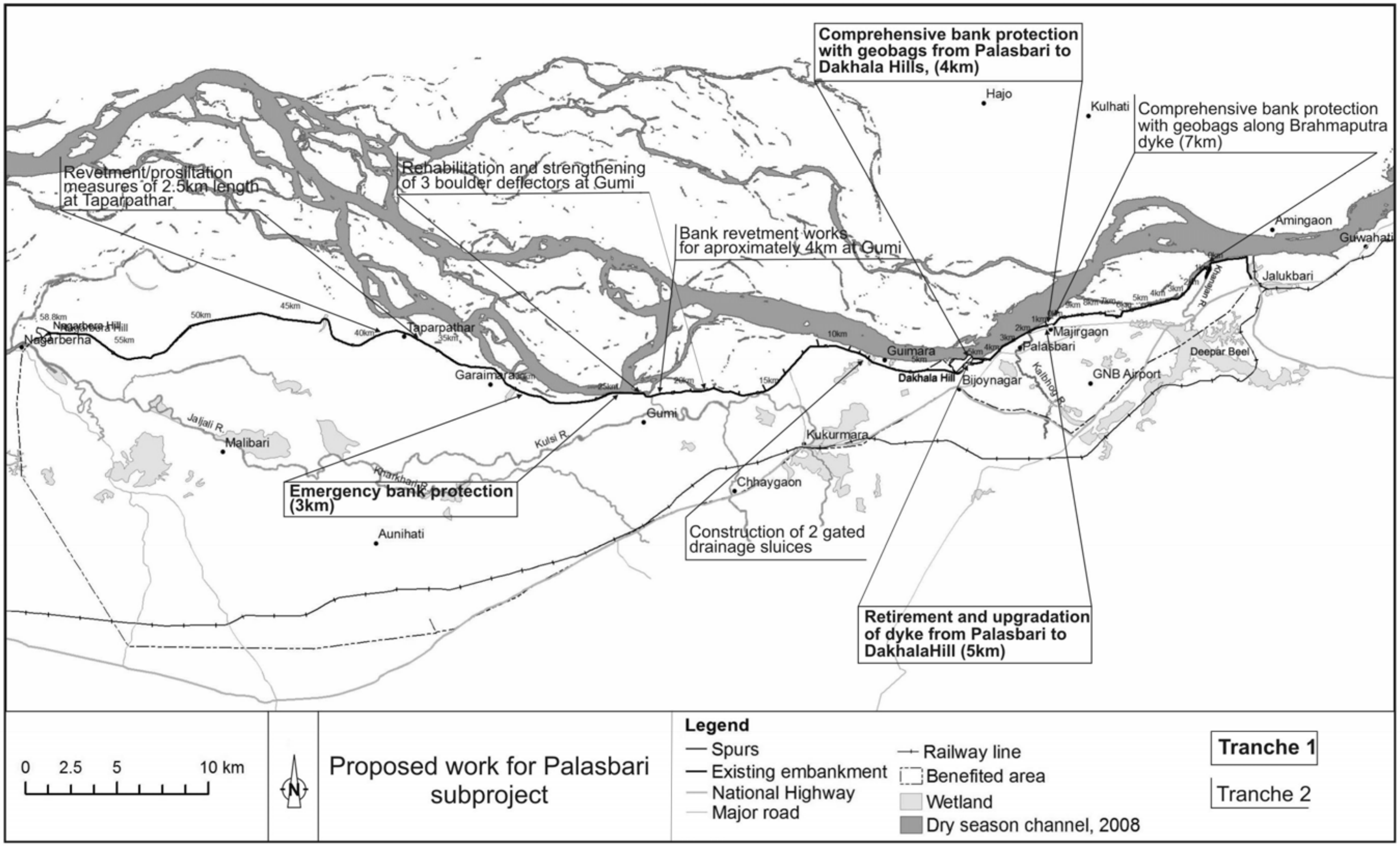
43. Bank protection works, in the form of rock spurs and land spurs, have also been

constructed by the WRD along various portions of this reach. The works comprises of:

- 7 land spurs, which were constructed in 1984-85 between village Simian and Panikathi at the following locations: Spur No 1 at ch. 10.50 km; Spur No 2 at ch. 11.50 km; Spur No 3 at ch. 13.0 km; Spur No 4 at ch. 14.60 km; Spur No 5 at ch. 16.0 km; Spur No 6 at ch. 17.30 km; Spur No 7 at ch. 18.60 km
- 2 boulder deflectors were constructed in 1988-89 near the village Panikathi at ch 19.60 km and ch 20.40 km.
- A few boulder deflectors were constructed near Gumi in 1988-89.
- 3 land spurs were constructed on the upstream of land spur No 1 at ch 6.83 km, ch 7.53 km and ch 8.13 km subsequently.
- 1 land spur was constructed near Palasbari at ch 0.70 km subsequently.
- Bank revetment, porcupine screen works etc. have been constructed at different locations for short reaches subsequently.

44. Current flood and erosion protection measures over the Palasbari Reach include flood protection embankments over 74.1 km under three divisions (Guwahati East (GE), Palasbari Gumi Project (PGP), Guwahati West (GW)) of the WRD and 7 No. Land Spurs to provide riverbank erosion protection over a 6.3 km length of riverbank

Figure 2.4 :Proposed Flood and Bank Erosion Protection Works at Palasbari Sub-Project Area



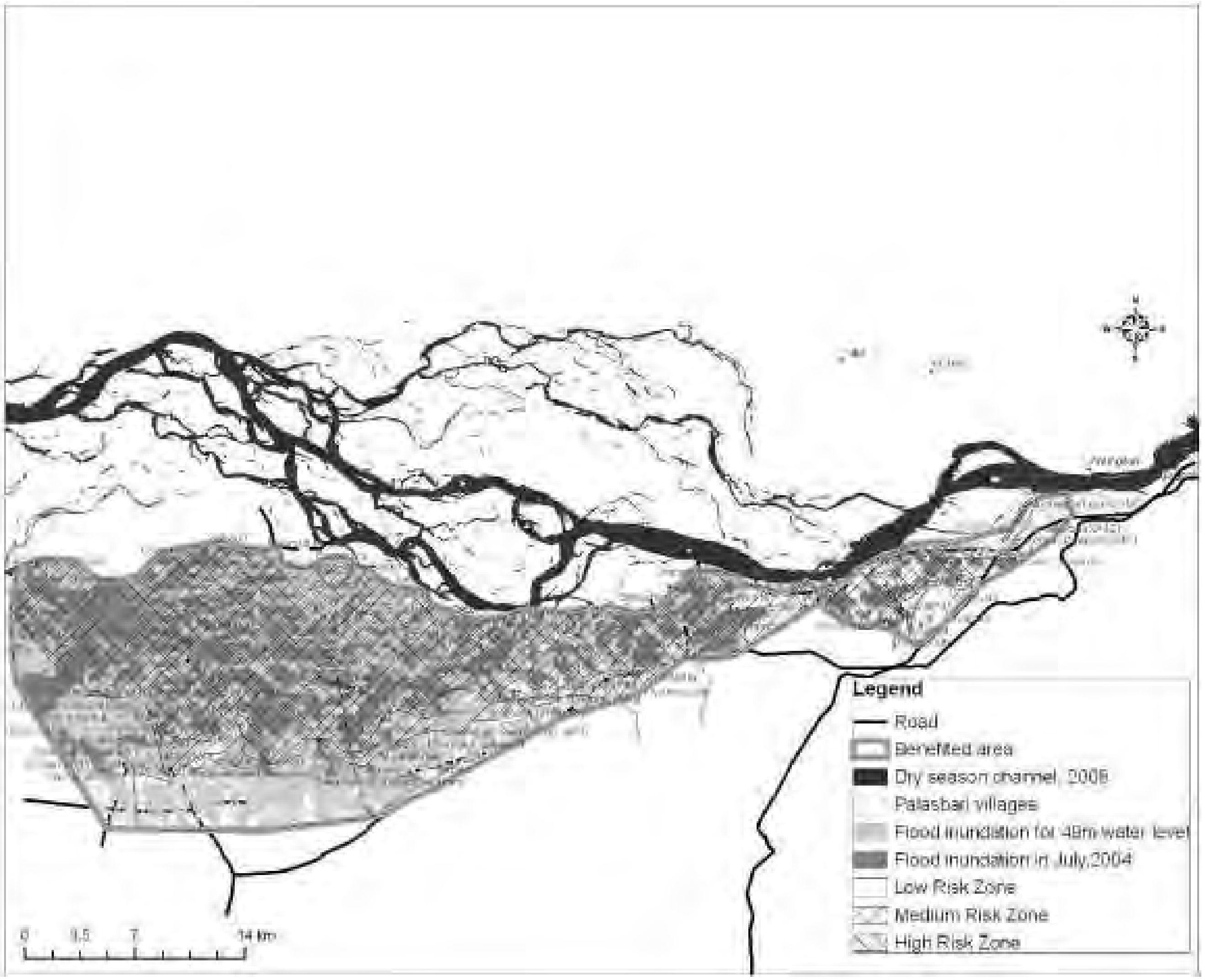


Figure 2.5 Palasbari Flooded Area at HFL (49 m) and Maximum Observed Flooding (July 2004)

2.4. Subproject Components and Activities[5]

2.4.1. Structural Measures

45. Works have been proposed to retire substantial portions of the existing embankment specifically in the upstream area near the airport. In total, around 15 km of retired embankment are to be constructed. In the downstream area towards Gumi and beyond the existing embankment provides sufficient protection, even though it does not have 1.5 m free board as required throughout. The design assumes a High Flood Level of 50 year return period.

46. Immediate protection consists of limited quantities of material dumped along the eroding bank at approximately low water level. The material is designed to launch down the slope during bed scour to provide a single layer of temporary coverage that is expected to last one or two seasons. This material would form the base layer for the follow-on comprehensive main protection.

2.4.1.1 Tranche 1, DPR year 1 to 3:

(i) **Retirement of 4.0 kilometers (km) of Brahmaputra dyke from Palasbari to Dakhala Hill (Rs65 million).** Bank revetment will be constructed between Palasbari and Dakhala Hill. Bank erosion has adversely affected the residents of the area by destroying their homes and land, by eroding the embankment. Local residents recall severe erosion for at least 50 years. Many have lost their land and have been forced to move repeatedly. Embankments in Palasbari have been retired several times because of erosion; any further efforts to upgrade and/or retire embankments in this area must be accompanied by effective erosion protection. The revetment works will be implemented in years 1–3.

(ii) **Revetment of 5.0 km length between Palasbari and Dakhala Hill (Rs440 million).** The embankment between Palasbari and Dakhala Hill will be retired where necessary, and strengthened. Large sections of this embankment have been completely eroded, while some sections require raising and strengthening. Flood protection works constructed in this area will protect valuable land, including Guwahati airport and the areas that are to form parts of an extension of the city. This work will be implemented in years 2–3.

(iii) **Gumi revetment (Rs12 million)**. Emergency bank protection will be constructed at Gumi (3 km), during Tranche1. The emergency protection will consist of (1) a launching heap of geo-bags, which will protect the bank toe from erosion, and (2) temporary wave protection in the form of geo-bags placed along the bank slope. Future work (Tranche 2) will include comprehensive bank protection. This work will be implemented in year 1 to year 2.

[5] The area on the west bank of Dhansiri River (a tributary of Brahmaputra River) is protected partly near the mouth by one embankment. This embankment is connected to one PWD road leading to NH 37. But on the eastern side of the said river, there is no embankment. Moreover, there is a branch river of Dhansiri, called Geelabeel river, flowing almost parallel to the Brahmaputra river (East-west direction), though Dhansiri river is flowing North-South originating from Mikir Hills in Karbi-Anglong State. During flood season, spilling occurs on the two sides of these rivers and full area is flooded. Therefore, flood embankments are necessary on the eastern side of Dhansiri river up to NH 37 along with one regulator across Geelabeel river for protecting the land from Dhansiri flooding.

The total estimated cost of tranche 1 works is Rs625 million.

2.4.1.2 Tranche 2 (years 4–6, subject to future verification):

(i) **Construction of two gated drainage sluices (Rs40 million).** These sluices will be placed in areas that experience local drainage congestion.

(ii) **Revetment of about 7 km between Majirgaon and Palasbari (Rs717 million).** This revetment is required to safeguard the embankment in this reach. The Brahmaputra River has flowed along the bank line for a number of years and is likely to continue so.

(iii) **Revetment and pro-siltation measures of 2.5 km at Taparpathar (Rs114 million).** This revetment is required to stabilize the embankment in places where the Brahmaputra River approaches the embankment

(iv) **Revetment and pro-siltation measures of 4 km at the Gumi area (Rs336 million).** This revetment is required to stabilize the embankment in places where the Brahmaputra River approaches the embankment

(v) **Rehabilitation and strengthening of three boulder deflectors near Gumi (Rs35 million).** The boulder deflector will continue protecting the existing bank from erosion after upgrading and strengthening.

The total cost of tranche 2 works is Rs1,242 million.

The total estimated cost for the subproject is Rs1,867 million. The work distribution over 6 years is estimated in Table 2.1.

Table 2.1 Summary of Tranche wise Work at Palasbari Subproject Site

Item	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
Palasbari embankment 4.9 km		50	50			
Palasbari revetment 4.0 km	50	30	20			
Gumi revetment 3.0 km	50	30	20			
2 gated drainage sluices					50	50
Majirigaon revetment, 7.1 km				50	50	
Taparpathar revetment, 2.5 km					50	50
Gumi revetment, 4 km					50	50
Gumi, 3 boulder deflectors				70	30	

Source: Water Resources Department, State Government of Assam.

2.4.2. Non-Structural and CBFRM Measures

47. **Land Use Guidelines**. Land use guidelines are aimed at ensuring that land use across the floodplain is consistent with the likelihood, risk, and hazard of flooding. For this purpose, current and likely future land use in flood-prone areas will be reviewed, especially the expected population growth and its impact on future flood risk and damage in higher-risk areas. In addition, the use of land use zoning to preserve wetlands and protect existing flood storage areas from further development will be assessed.

48. **Building and Development Guidelines*.*** While building and development controls are also not expected to provide a panacea for reducing flood risk and flood impacts in Assam, the flood proofing of public infrastructure is one area where improvements might be possible (to ensure it is ready and effective to return to service after a flood). The Program will assess flood damage to buildings and public infrastructure to identify possible improvements. The United Nations Development Program Sisaster Management Project

has had work undertaken on the design and construction of flood-resilient buildings, which will be reviewed.

49. **Flood Forecasting and Warning.** Flood forecasting is a means to an end—to provide timelier and more accurate flood warnings. It is the warning that is essential, rather than the forecast. While a variety of public agencies participate in the flood forecasting and warning (FFW) process in Assam, most villagers receive no formal flood warnings—they generate their own warning by watching the river during the flood season, taking into account local rainfall. The Program will review the elements of FFW process, paying special attention to warning needs of villages and possible improvements in communities and flood emergency management. An important element of an improved FFW system is anticipated to be the provision of local forecasts by the Water Resources Department, i.e., the translation of regional forecasts by Central Water Commission (CWC) into clear and easily understandable warnings to villages. Local communities will be centrally involved in this process.

50. **Flood Emergency Planning and Management**. Flood emergency planning includes prevention, preparation, response, and recovery activities. Flood emergency planning and management (FEPM) is and will remain a central plank of flood risk management in Assam—flooding is a regular recurring natural event that cannot be prevented or entirely eliminated by structural measures. Flood emergency planning will to be reviewed and probably strengthened at the village, district, and state levels (e.g., through the use of the army for evacuation).

51. **Community-Based Flood Risk Management (CBFRM).** CBFRM is one area where considerable opportunity exists to reduce the impacts of floods on village communities. Under the Program, comprehensive community surveys will be undertaken to address community concerns on flood risk management. Based on the responses, a CBFRM plan will be prepared, including raised platforms and associated facilities (e.g., permanent latrines, a raised tube-well for water supply, and permanent public buildings that are needed during flood emergencies, such as the local school and dispensary, and emergency shelter), along with community nonstructure programs, such as flood warning and flood education.

52. **Flood Education.** Villagers appear to be very aware of floods and highly flood resilient. The need for further flood education in villages will be assessed in the community surveys. Flood management in Assam is fragmented across many different agencies. The Program will promote cooperation and the exchange of ideas and information between the different agencies through workshops, seminars, etc. (a form of flood education).

53. **Financial Measures.** When in emergency accommodation during floods, flood-prone villagers cannot afford kerosene for cooking purposes. Relief payments—whether in cash or kind—are a financial measure (and a form of insurance) aimed at reducing the impacts of flooding. Under the Program, the system of flood relief payments, food, and stock fodder issue and other relief measures will be reviewed and possible improvements will be pursued

54. Typical sketch of proposed embankment to be done with design section with flood shelter on country side is shown at Figure 2.5. Where retirement is not possible due to the location of important town, industry, roads, railways and other important establishments and also land acquisition is difficult, the width of embankment may be marginally shifted towards countryside with flood berms / platforms on countryside. The typical sketch of this embankment is shown at Figure 2.6. As can be seen, in the design, the borrow areas have

been shown next to embankment towards country side. This will require effective management. This issue has been deliberated in detail under Chapter 5 on "**Environmental Impacts and Mitigation Measure**".

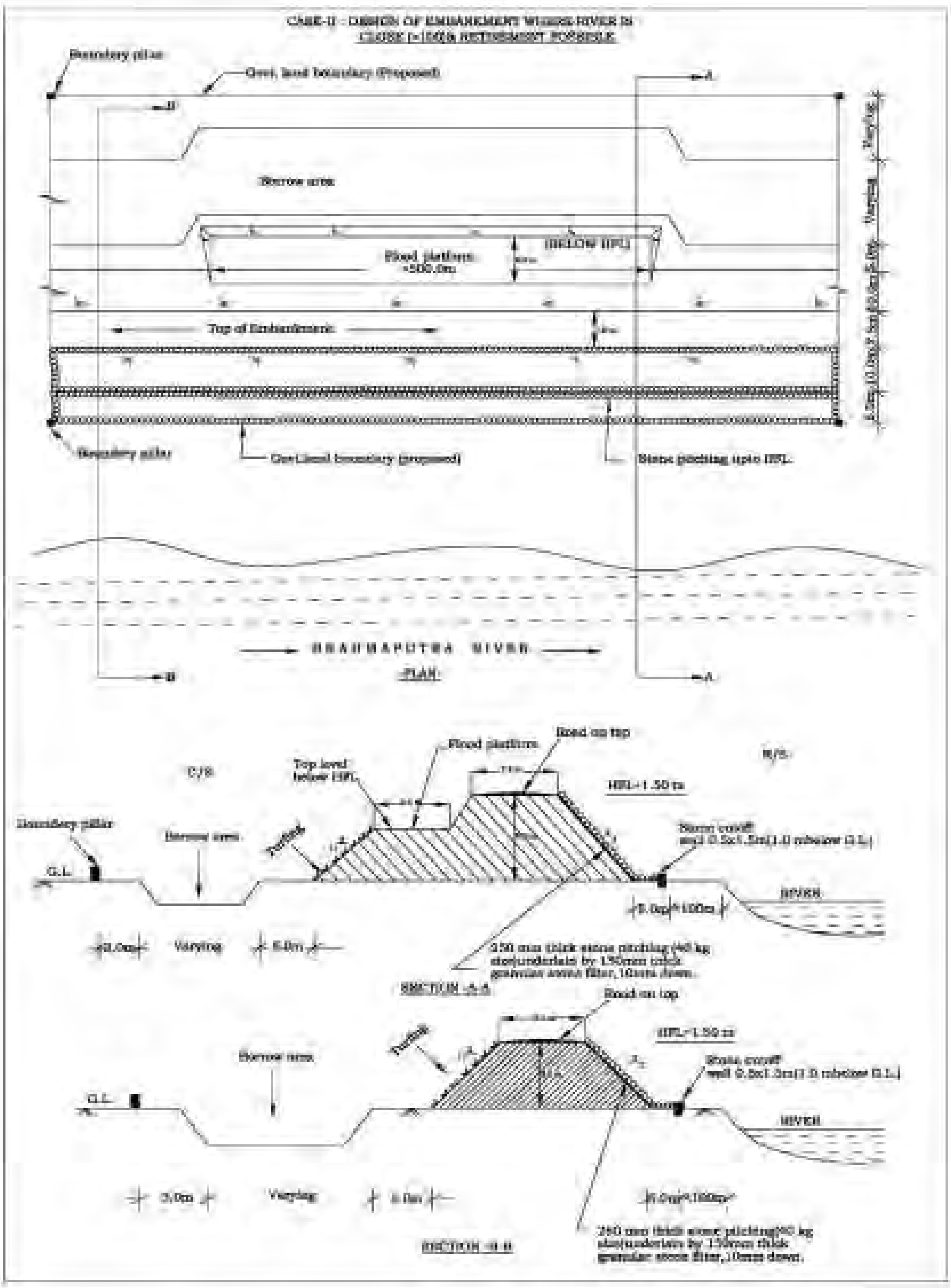


Figure 2.6 Flood Embankment near Riverbank

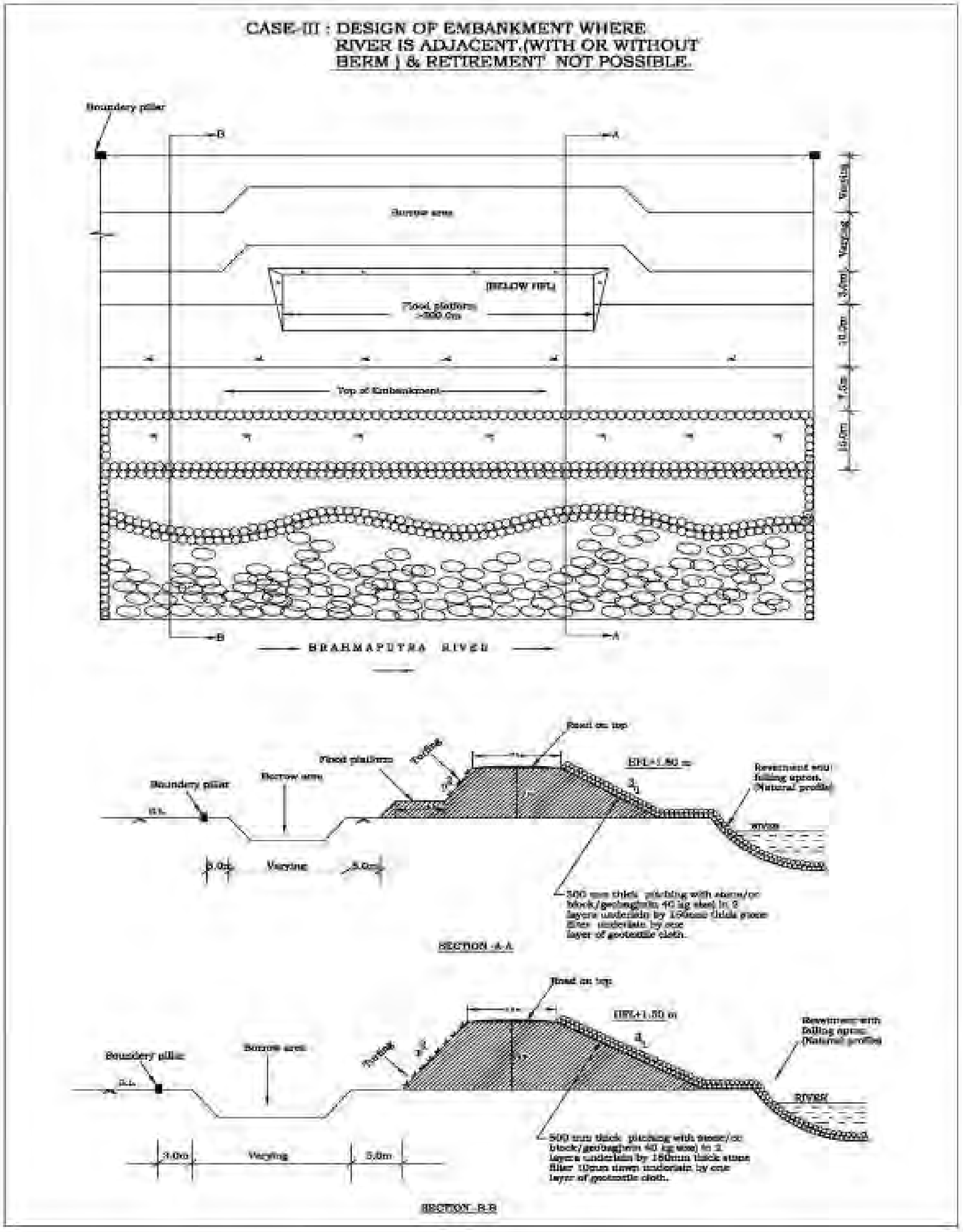


Figure 2.7 Flood Embankment Adjacent to Riverbank

2.4.3. Construction Material for Bank Protection

55. Use of inert or natural material is proposed. Geo-textile bags filled with sand shall be the preferred option. It is very stable material and used worldwide. The engineered bags life is considered to be much beyond 30 years, the economic life of the Project. Use of geotextile is considered beneficial even from aquatic fauna aspect. (Refer APPENDIX 2.1 which provides the extract of the research carried out by Hannes Zellweger on use of geotextile bags for river erosion control in Bangladesh).

2.5. Implementation Schedule and Project Cost

56. The project will be implemented over a period of six years and would seek Multi-tranche Finance Facility (MFF) which may comprise two sub-loans covering year 1-3 and 4-6, respectively. The total estimated cost of the sub-project for structural works is estimated as Rs. 1,867 Crores (i.e. US $ 39.63 Million).

57. The sub-project will provide improved flood and riverbank erosion risk management to achieve more stable living conditions for the existing population needs to be put into the larger context of land-use zoning to avoid future catastrophes. Understanding the risk of attracting more settlements on the risk prone flood plains, the Project incorporates a strong component of flood plain zoning, which will be the foundation of land-use zoning and building restrictions. There are no plans to reduce the existing embankment system or remove it. The benefit of flood protection can be demonstrated by comparing the inundated areas behind the embankments during the exceptional 2004 flood with a scenario without embankment area that was inundated in 2004 (Figure 2.4).

2.6. Regulatory Requirements

2.6.1. ADB's Environmental Categorization

58. The project was initially considered as environmental category A by ADB. With the structural works focusing on the sustaining the functions of the existing flood embankment systems through renovation of deteriorated embankments, provision of inner secondary embankment and sluice gates, and provision of riverbank protection works, the present EIA indicates that the subproject does not have significant adverse environmental impacts that are sensitive, diverse, or unprecedented, and affect an area broader than the sites or facilities subject to physical works.

2.6.2. Regulatory Requirements of the Government of India and Assam State

59. The Government of India has framed various laws and regulation for protection and conservation of natural environment. These legislations with applicability to this project are summarized below in Table 2.3 and approval and monitoring framework is depicted Figure 2.7. Only the Air and Water Acts are applicable to the IFRERM Assam Palasbari subproject.

Table 2.2 Applicability of Key Environmental Legislation at a Glance[6]

Legislation	Key Requirement	Applicability	Remark	Granting Agency	Reporting Requirement	Monitoring Agency
Air (prevention and control of pollution) Act, 1972 and rules there under	An Act to prevent and control of Air Pollution	Applicable	Applicable during construction stage for the operation of air polluting units like Hot Mix Plant	SPCB	Normally compliance monitoring report is to be submitted once in a year or as indicated in the consent letter	SPCB
Water (prevention and control of pollution) Act, 1972 and rules there under	An Act to Prevent and Control of Water Pollution	Applicable	Applicable during construction stage for discharge of waste from construction camps or maintenance of construction equipment	-do-	-do-	-do-
Environmental (Protection) Act, 1986 and rules there under including EIA Notification, 2006.	Requires prior environmental clearance for all River Valley projects for ≥ 25 MW hydroelectric power generation and ≥ 10,000 ha. of culturable command area	Not Applicable	The proposed project includes only activity related to existing river bank and embankment protection. No hydro power generation or new canal project having large culturable command area.	MoEF/ SEIAA	Once in six months	Regional Office of MoEF
Forest (conservation) Act, 1980 & rules there under	Restriction on the dereservation of forests or use of forest land for non-forest purpose	Not Applicable[7]	No diversion of forests land in the whole stretch	MoEF/ State Forest Department	Once in six months	Regional Office of MoEF/ State Forest Department

6 Time to amendments is an issued legislation in India. The environmental legislation applicability shall be established at the start of project implementation. Necessary clearance, if any becomes applicable shall be obtained from concerned authorities accordingly.

7 The land revenue records need to be verified again to ascertain if any forest land is require to be diverted. If yes then this ACT shall be applicable and necessary clearance for forest land diversion will have to be obtained.

Legislation	Key Requirement	Applicability	Remark	Granting Agency	Reporting Requirement	Monitoring Agency
Wildlife (protection) Act, 2002 & rules there under	No person shall destroy, exploit or remove any wild life including forest produce from a sanctuary/National park or destroy or damage or divert the habitat of any wild animal by any act whatsoever or divert, stop or enhance the flow of water into or outside the sanctuary, except under and in accordance with a permit granted by the Chief Wild Life Warden	Not Applicable	No wild life sanctuary/ National Park exist in the project area.	Chief Wildlife Warden	As per the consent letter	Concerned protected area office/ Chief Wildlife Warden

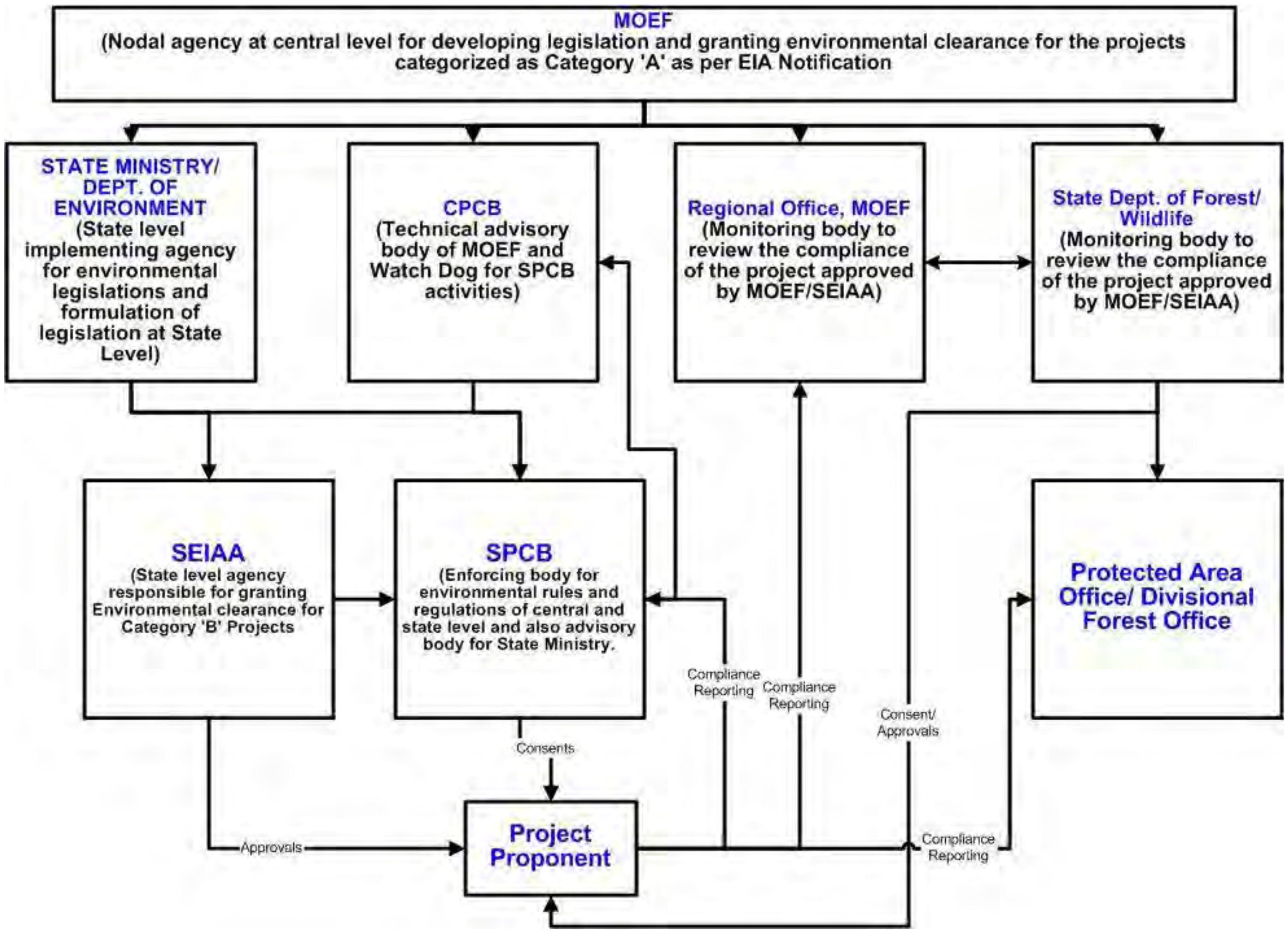


Figure 2.8 Legislative Interface between various Central and State Authorities

3. DESCRIPTION OF THE ENVIRONMENT

3.1. Introduction

60. It is necessary for the environmental assessment studies to establish baseline for valued environmental attributes that are likely to be affected by the proposed developmental activities. The study of the existing environmental conditions will establish the pre-project physical, biological and socio-economic conditions, and predict associated environmental impacts caused during the construction and operation phases of the project.

61. In this study, emphasis has been given to data collection on the physical environment, biological environment and socio-economic environment of the study area (i.e. 8 km buffer zone around the embankment). These data are important considering the nature and location of the proposed sub-project focused on the Palasbari Reach.

3.2. Description of Physical Environment

3.2.1. Climate

62. The climate of the region is sub-tropical with a hot, humid summer season dominated by the southwest monsoons from early-June to mid-September and a cool, dry winter from late October to the end of February. The pre-monsoon season starts in the early part of March until May marked by occasional thunderstorms and rising temperatures during the day. The post (retreating) monsoon season from last part of September to mid October generally represents fair weather conditions with declining rainfall as well as.

63. The Brahmaputra Valley in Assam forms an integral part of the subtropical monsoon regime of Eastern Asia receiving a mean annual rainfall of 230 cm with a variability of 15-20%. Distribution of rainfall over different river basins in Assam shows marked spatial variations, e.g. from as low as 175 cm in the Kopili basin located in the central part of the valley to as much as 410 cm in Jiadhol basin close to the Matmora reach in upper Assam. The isohyetal map of the Brahmaputra valley and adjoining highlands (based on IMD data) has been shown in Figure 3.1.

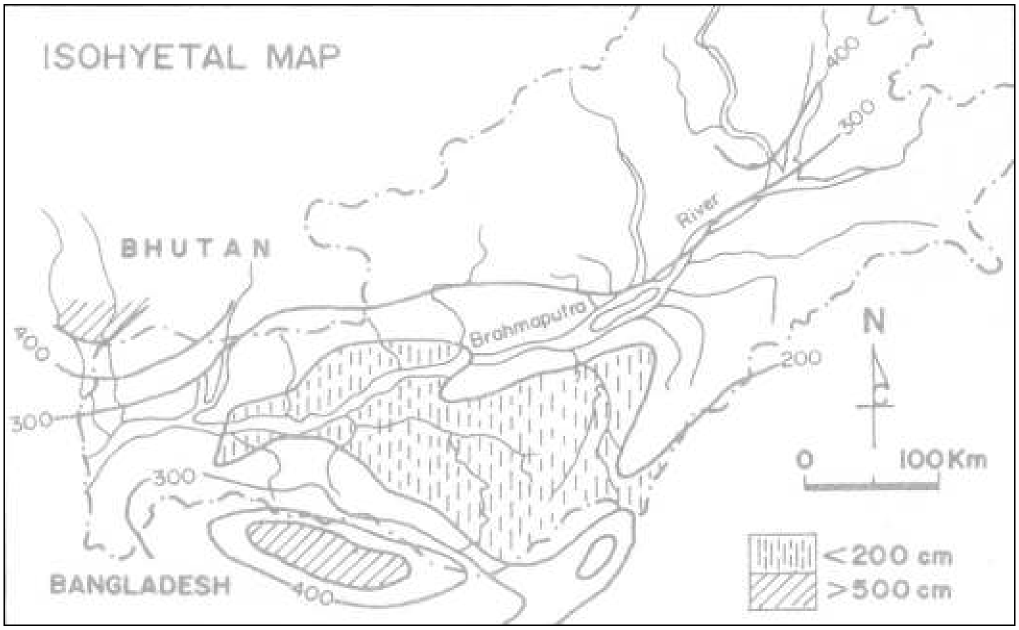


Figure 3.1 Isohyetal Map of the Brahmaputra Valley and Adjoining Highlands [8]

64. Monsoon rain from June to September account for 60-70 % of the annual rainfall in the region, while the pre-monsoon season extending from March to May provides 20-25 % of the rainfall, caused primarily by depressions moving from west and by local convectional storms. The pre-monsoon rains are primarily controlled by the position of a belt of depressions called the Monsoon Axis extending from North-East India to the head of the Bay of Bengal. In the course of its North-South oscillations in summer this axis moves closer to the foothills of the Himalayas resulting to heavy precipitation in Assam and adjoining highlands.

65. In the absence of any meteorological station in the Palasbari Reach, the meteorological data from IMD station at Borjhar (LG Bordoloi Airport, Guwahati), which is located at 5 km distance in the SE direction, has been used. Annual rainfall pattern of last 12 years (1995 - 2007) and mean monthly rainfall at Borjhar in Year 2007 are shown in Figures 3.1 and 3.2, respectively.

[8] Goswami, D.C. 1998. Fluvial regime and flood hydrology of the Brahmaputra River, Assam. *Memoir Geological Society of India*, No.41: 53-75.

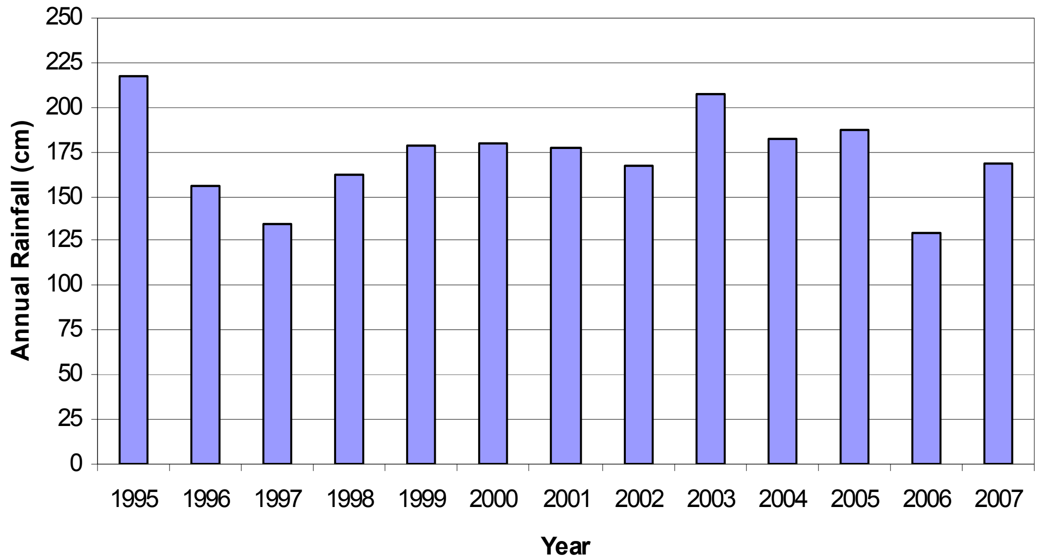


Figure 3.2 Annual Rainfall Pattern (1995 – 2007)

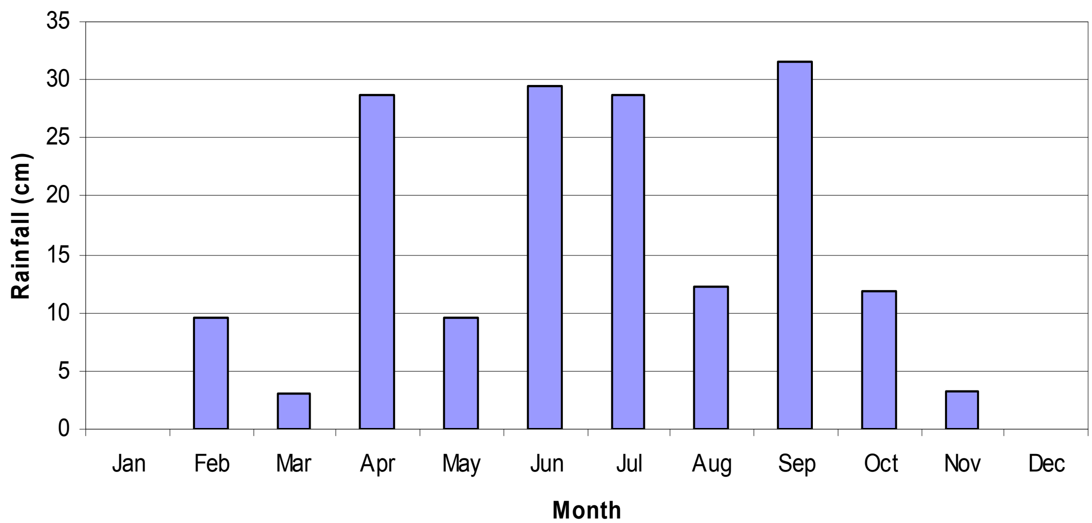


Figure 3.3 Mean Monthly Rainfall in Year 2007 at Borjhar Station

66. Mean monthly maximum temperature varies from 23°C to 32°C, whereas mean monthly minimum temperature ranges from 10°C to 25°C. The monthly variation of maximum and minimum temperatures at Borjhar Meteorological Station are shown in Figure 3.3.

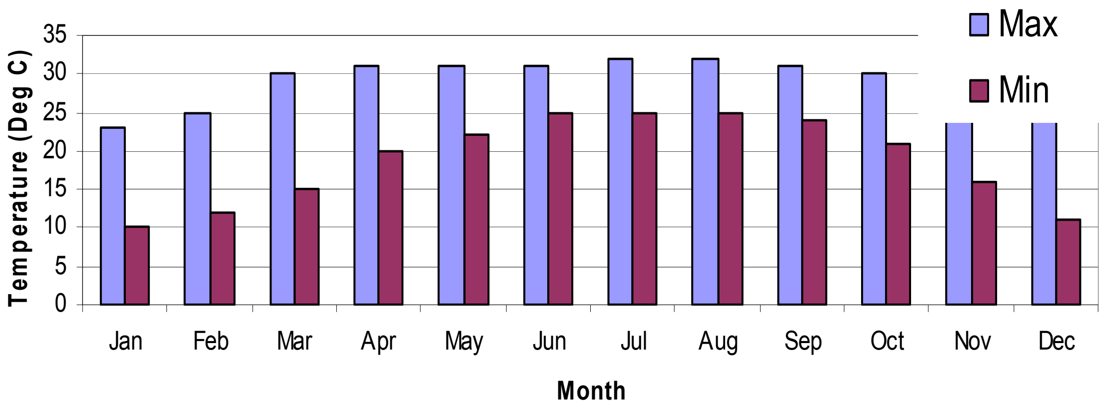


Figure 3.4 Mean Monthly Variation of Temperature

67. Powerful atmospheric systems called cloudbursts that trigger intense rainfall in limited areas causing flash floods of great fury, and destruction are being experienced in greater frequency along the foothill region of and in the immediate downstream areas in the Brahmaputra plains. The situation aggravates further if such extreme climatic events trigger landslide and slope failure in the upper watersheds or temporarily block river courses creating dams that subsequently break sending surging flood waves downstream. During the 1950 Assam earthquake, a massive landslide in Arunachal Himalayas blocked the Subansiri River – a major tributary of the Brahmaputra for days together creating a dam that was eventually released in a deluging flood that greatly devastated the downstream areas in Dhemaji and Lakhimpur districts of Assam. On 10th June 2000, a massive flood occurred in Arunachal Pradesh reportedly as a result of a sudden failure of a landslide-induced dam in the neighboring uplands of Tibet. Cloudburst and landslides related flash floods occurred in 2004 in the Manas and Beki rivers of Assam due to failure of landslide dam upstream of Kurichu hydel project in Bhutan that caused highly destructive flood and channel avulsion. On October 7 of the same year i.e. 2004, a flash flood in Jinari river of Assam was triggered by a cloudburst over Meghalaya that caused great havoc in the downstream areas in Assam.

3.2.2. Physiography and Topography

68. There is a good measure of homogeneity among the project areas in terms of their riverine location in active floodplain tract along the bank of the Brahmaputra River, their composition consisting almost entirely of young alluvial soil, and acute vulnerability to flood and erosion. However, in terms biodiversity, urbanization, socioeconomic base, minerals and industries, and infrastructure, there are considerable variations in each sub-project. The physiography of Assam consists of (i) Foothill Zone, (ii) Middle Plain of North Bank, (iii) Active Flood Plain, (iv) Middle Plain of South Bank, (v) Sub-mountain Zone, and (vi) Hills. These divisions are shown in Figure 3.4.

69. The Palasbari Reach, like the other three reaches under the NEIFREM project, is located in the active floodplain zone along the bank of the River Brahmaputra. The reach consists of a variety of landscape elements *viz.,* rivers, floodplains, wetlands (beels), swamps and occasional hillocks.

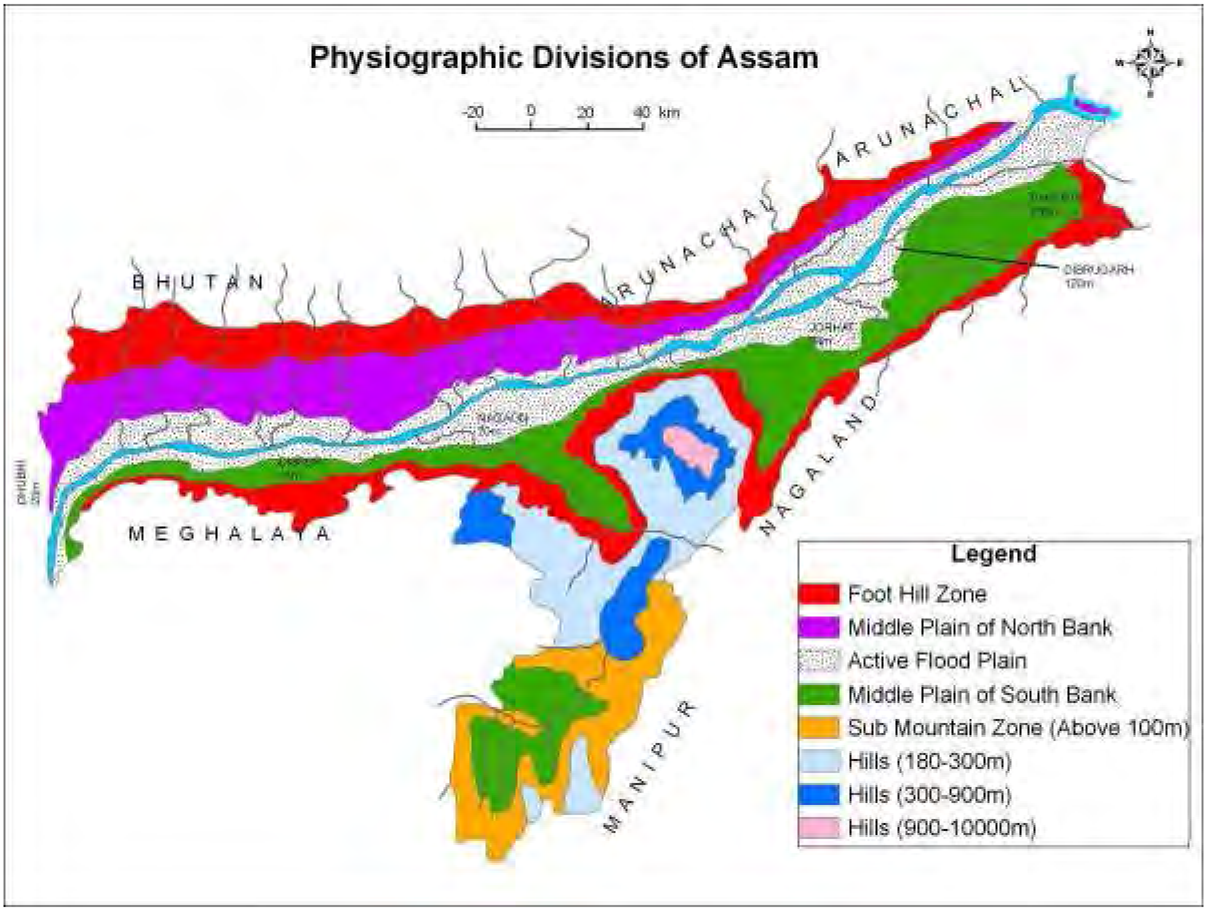


Figure 3.5 Physiographic Divisions in Assam

70. The Palasbari Reach extends along a 74 km length of the southern bank of the Brahmaputra River in Kamrup District, from the confluence of the Jaljali River in the west to the confluence of the Khanajan River in the east. The District of Kamrup extends across both sides of the Brahmaputra River. The southern portion of Kamrup comprises three major physiographic zones: a Southern Foothills Zone, which consists of the Khasi foothills; an Active Floodplain Zone, which lies adjacent to the Brahmaputra and contains many 'charlands'; and a Middle Plain, which covers the intermediate area containing many beels and swampy areas, and a number of pronounced 'hills', which represent more refractory rock outcrops. Two hills that are of relevance to the Palasbari Sub-project are Dakhala Hill and Nagarbera Hill, which respectively mark the break in the Brahmaputra embankment and the confluence of the Jaljali River and the Brahmaputra. (See Figure 3.4 for a diagram of the physiography and major drainage network of the area). The Palasbari Reach consists of a mix of active floodplain and middle plain zones, with elevations falling in a westerly direction from about 50 m around the village of Mazirgaon to about 40-45 m around the village of Nagarbera.

71. The immediate hinterland of the Palasbari Reach is consisting of largely of the middle plain zone characterized by beels, wetlands and hills. Drainage is often poor. To the west of Dakhala Hill, the main drainage system of the hinterland is the Kulsi-Deosila River, which has a combined catchment area of 3,770 km^2 and forms a complex system of interconnecting anabranches, distributaries, flood runners and beels. The Deosila River, which rises on the Meghalaya Massif, appears to be the dominant river of this system. Originally, the Kulsi River

formed the downstream reach of this system, flowing into the Brahmaputra to the west of Nagarbera Hill. However, riverbank erosion from the Brahmaputra has truncated the mouth of the Kulsi River into two separate channels, one of which now flows into the Brahmaputra to the north of Nagarbera Hill, the other joining the Jaljali River to flow into the Brahmaputra to the south of Nagarbera Hill (see Figure 3.6). A number of northerly flowing tributaries cross NH-37 to join the Kulsi-Deosila system. Over time, riverbank erosion from the Brahmaputra caused the River Khulsi to form two flood runners that delivered Brahmaputra floodwaters into the hinterland and across to the Jaljali River (again, see Figure 3.6). The Brahmaputra Embankments now prevent this behavior. Drainage congestion problems exist over much of the lower area of the Khulsi-Deosila System, especially where the various rivers and drainage channels come together to form the Jaljali River.

72. To the east of Dakhala Hill, the main drainage system of the hinterland is the Khanajan River, which is an outlet channel of Deepar Beel that joins the Brahmaputra close to the village of Mazirgaon, together with its anabranches, and tributaries. There is a sluice gate in the outlet channel of the Khanajan River that is used to regulate water levels in Deepar Beel. However, this sluice gate is only operational when the Brahmaputra is not in flood[9]. To the west of the Khanajan River, a drainage channel referred to as Kalbhog Channel flows to the Brahmaputra close to the town of Palasbari via a sluice gated outlet in the Brahmaputra embankment. This sluice gate is currently non-functional, but was used during the rainy season to irrigate agricultural fields in the hinterland (and provide water for fishing). Another sluice gate at Nahira is functional and is used for irrigation during the rainy season. Major Beels[10] in the hinterland are located along both of these drainage systems.

73. The topography of the project area is characterized by flat tract that forms a part of the active floodplain including the chars (sandbars) within the banklines of the River Brahmaputra. The valley as a whole slopes gently from the northeast at an average gradient of 13 cm/km. The gradient is about 17cm/km in its upper reach near Dibrugarh, which reduces to 10 cm/ km near Guwahati. The monotony of the floodplain lying at an average elevation ranging from 50 m to 120 m above MSL is broken at places by protruding arms of isolated hillocks of Archaen origin. The Dakhala hill (elevation 138 m) and the Nagarbera hill (167 m) are two such prominent hillocks located within this project area. Both these hillocks, made up of granite and genisses, are northerly outcrops of the Meghalaya plateau. The western part of the project area from Dakhala to Nagarbera presents a relatively low-lying tract due to their peculiar structural disposition in relation to the geology and tectonics of the highlands to the south.[11] The floodplain belt in this stretch is marked by large number of degraded wetlands, abandoned river channels, waterlogged and drainage congested areas. The relief map based on analysis of satellite data showing topography of the Palasbari Reach is presented in Figure 3.7.

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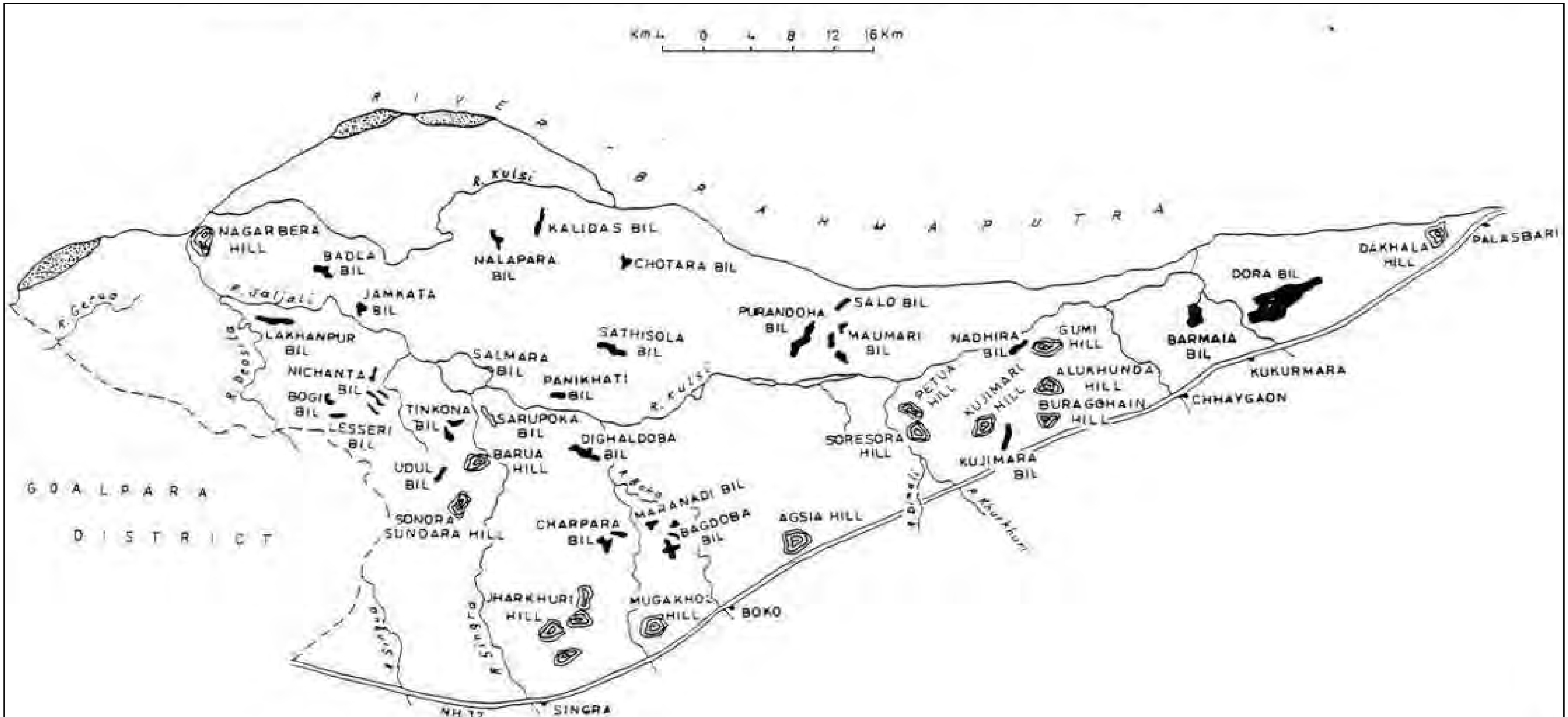
9 When the Brahmaputra River is in flood, water levels in the Brahmaputra are typically much higher than in Deepar Beel, causing flooding around the beel.

10 Deepar Beel is a wetland of national and international significance and a designated RAMSAR site.

11 Goswami, D. C. and Das, P. J., 2002: Hydrological Impact of Earthquakes on the Brahmaputra River Regime in Assam: A case study in exploring some evidences, Proc. 18th National Convention of Civil Engineers, Nov. 9-10, 2002, pp. 40 -48.



(Source: after Bordoloi, Neelkamal, 1995)[12]

Figure 3.6 Physiography and Drainage of the Palasbari Reach

[12] Bordoloi, Neelkamal (1995). Impact of the Brahmaputra Flood and Erosion Hazard on Floodplain Occupancy in the Palasbari – Nagarbera Tract of Kamrup District, Assam, Unpublished Ph. D. Thesis, Gauhati University

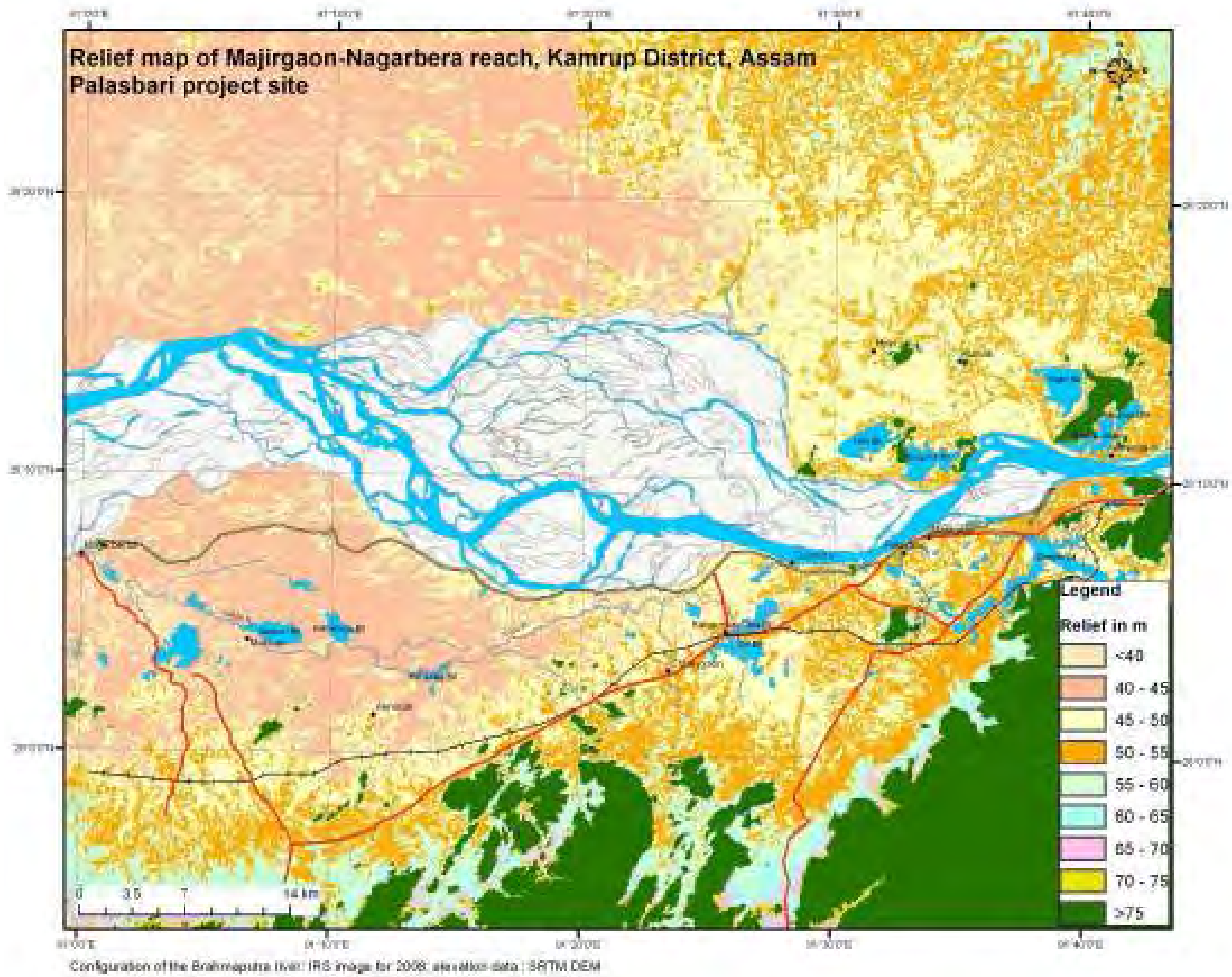


Figure 3.7 Palasbari Area: Topography

3.2.3. Water Environment

74. The State of Assam in general and the Brahmaputra valley in particular, is endowed with vast water resources potential. The Brahmaputra River and the 33 major tributaries joining it in Assam including the main trans-Himalayan tributaries of Subansiri, Jia Bharali, and Manas carry about 30% of the country's total water resources potential. Surface water bodies covering about 8,251 km^2 account for 10.5% of the total geographical area of the State. Of these, the river systems including waterlogged areas occupy 6,503 km^2. The annual surface water availability is over 53 million ha m. Besides, there are 3,513 wetlands in the Brahmaputra valley covering 1012.3 km^2 areas in Assam. Groundwater is also plentifully available at shallow depth in the valley and the utilizable ground water resources estimated at over 2 million ha m.

3.2.3.1 Surface Water

75. In the Palasbari Reach, the Kulsi River, a major south bank tributary of the Brahmaputra originating in the Meghalaya plateau to the south, drains a large area running westward parallel close to the Brahmaputra and eventually joining it through Jaljali River near Nagarbera hill. The important sub-tributaries originating in the Meghalaya hills that join the Kulsi River in the plains are the Boko River, the Singra River, the Kharkhari River and the Deosila River. The drainage map of the reach showing major tributary rivers and wetlands is presented in Figure 3.6.

76. The Kulsi River has a basin area of 750 km^2 with a maximum discharge of 191 cumecs and a minimum of 7.5 cumecs. The annual rainfall in the basin is about 167.2 cm. The river has suffered truncation of its course and diversion at several places since 1974 forcing it to take the present course, out falling into the Brahmaputra near Nagarbera.

77. Close to the starting point of the Palasbari Reach, the Khanajan River, which is an outlet channel of the **Deepar beel** – a wetland of national and international significance, designated as a Ramsar Site, meets the Brahmaputra River.

78. To the west of Khanajan, a small channel called Kalbhog flows across the embankment and joins the Brahmaputra near Palasbari (Ch. 4.9 km). A sluice gate at Palasbari discharges the landslide water and carries Brahmaputra water to the agricultural fields during the monsoon season. The sluice gate located near the embankment is presently non-functional. The local people consider water for irrigation along with the advantage derived for fishing during the flood season a great boon. Another sluice gate at Nahira is functional and used for irrigation during the rainy season. Truncation and diversion of the Kulsi near the embankment has created several wetlands like the Kalidas beel, Alikash beel, along with extensive drainage congestion in the downstream areas. The distribution of major wetlands and other water bodies in Palasbari Reach located within the 8 km buffer zone around the embankment is shown in Figure 3.8.

79. Water quality monitoring and analysis in regard to physico-chemical as well as biological parameters was carried out on samples collected from three locations in the project area. The locations of the sampling points are shown in Figure 3.9. The results of the analysis are presented in Table 3.1 and these are compared with the water quality criteria of designated best use given by Central Pollution Control Board (CPCB). (Refer Appendix 3.2).

80. The comparison of the surface water samples analyzed against the water quality criteria for designated best use shows that the water quality of the project area meets the criteria of Class ‘C’ “Drinking Water Source after Conventional Treatment.”

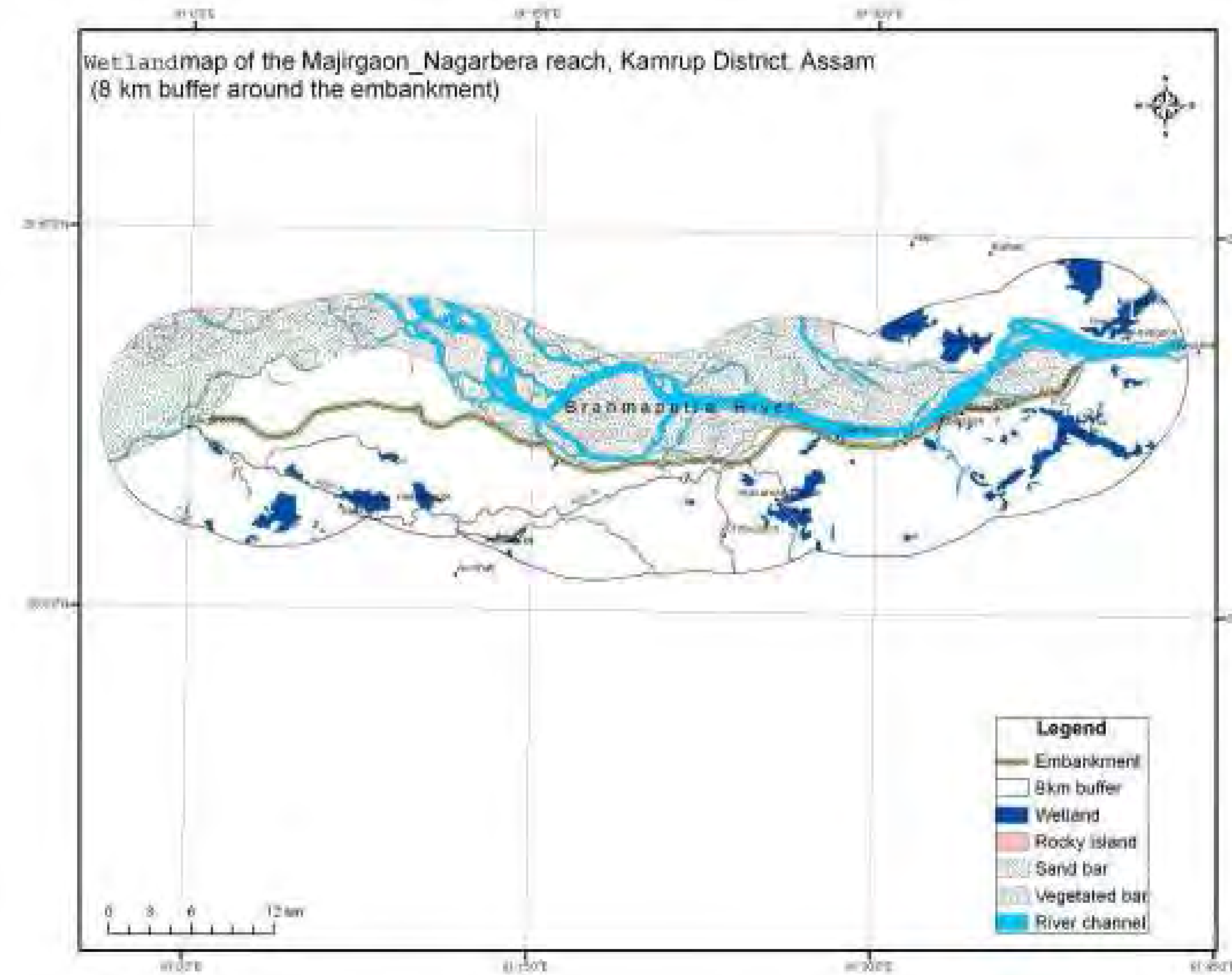


Figure 3.8 Wetland and other Waterbodies of the Palasbari Reach (8 km buffer around the embankment)

Figure 3.9 Sampling Locations of Water, Soil, Air and Noise

Table 3.1 Water Quality at Selected Locations in Palasbari Reach

Parameter	Unit	Drinking Water Quality Standard (IS 10500:1991)		Gumi	Palasbari	Khanajan
		Desirable	Permissible			
Colour	Hazen	5	25	Colourless	Colourless	Colourless
Odour	-	Unobjectionable	Unobjectionable	Nil	Nil	Nil
Temperature	(ºC)	-	-	19	22	24
pH	-	6.5 – 8.5	6.5 – 8.5	7.7	6.7	6.7
Electrical Conductivity	(mS/cm)	-	-	3.6	3.0	3.1
TSS	mg/L	-	-	229	183	193
TDS	mg/L	500	2000	18	16.9	17.4
Total Hardness	mg/L	300	600	50	48	52
DO	mg/L	-	-	10.54	9.73	7.41
BOD	mg/L	-	-	3.96	3.25	3.46
COD	mg/L	-	-	2.63	1.62	2.85
Chloride	mg/L	250	1000	26	27	27
Sulphate	mg/L	200	400	10	10	10
Nitrate	mg/L	45	100	BDL	3.26	3.14
phosphorus	mg/L	-	-	BDL	BDL	BDL
Calcium	mg/L	-	-	15.23	12.02	13.07
Magnesium	mg/L	-	-	34.77	35.98	38.93
Ammonical Nitrogen	mg/L	-	-	2.1	2.4	2.8
Total nitrogen	mg/L	-	-	4.5	3.8	3.62
Arsenic	ppb	0.05	0.05	0.002	0.001	0.004
Iron	ppm	0.3	1.0	0.9	1.12	1.84
Manganese	mg/L	0.1	0.3	BDL	BDL	BDL
Lead	mg/L	0.05	0.05	BDL	BDL	BDL
Floride	mg/L	1.0	1.5	1.37	1.46	1.27
Total Coliform	Coliform/100mL	10	10	11	9	9
Fecal Coliform	Coliform/100mL	0	0	1	0	1

(Source: Field monitoring and analysis done by Department of Environment Science, Gauhati University)
(Note: BDL – Below Detection Limit)

3.2.3.2 Hydrological and Morphological Aspects

81. The hydrological characteristics of the Brahmaputra valley, as a whole, are dominated by the intensely powerful monsoon rainfall region of the eastern Himalayas, the freeze and thaw cycle of Himalayan snow, and the immensely dynamic fluvial processes of the river and its tributaries. It is also influenced by the unique characteristics of the physical terrain and tectonic framework of the region. The estimated flood discharges of the river at Pandu based on Log Pearson Type III analysis for different return periods are presented in the Figure 3.10.

82. The river carries an average annual discharge of 19,830 m^3/s. The highest recorded daily discharge at Pandu upstream of the Palasbari stretch was 72,726 m^3/s (August, 1962). The summer high flows and winter low flows vary in certain years as much as 20 times. The annual flood of the river with a magnitude of 48,200 m^3/s has a return period of 2.2 years, while the maximum recorded flow has a return period of 133 years (Figure 3.10).

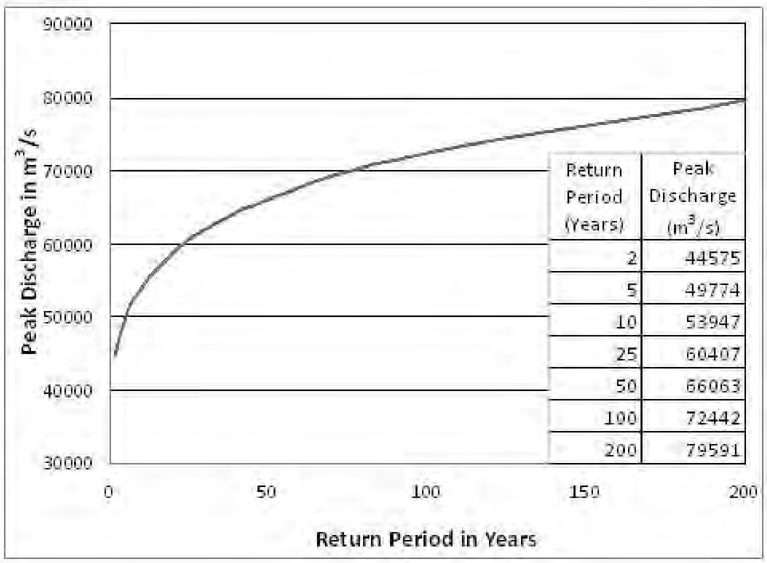


Figure 3.10 Flood Frequency of Brahmaputra River at Pandu

83. The water yield per unit area of its basin is highest among the large rivers of the world. The enormously large variations in the daily discharge are remarkable feature of its flow regime.

84. Brahmaputra is one of the most heavily sediment charged rivers in the world carrying an average annual suspended sediment load of 400 million metric tons at Pandu Station with an average daily rate of about 2.1 million tons during the raining season (May through October). Transport rates as high as 26 million tons per day has been recorded during the peak flow. The river carried significantly higher sediment loads during the period 1955-60, which may be related to the 1950 earthquake that caused enormous landslides in the Himalayan slopes generating large debris load for the river. The amount of sediment carried as bed load by the Brahmaputra at Pandu is estimated to be 5-15% of the total sediment load.

85. The river carries more water per unit area of its basin than any other river of the world and is second only to the Yellow River in China in terms of sediment yield. The pattern of sediment yield in the major tributaries of the Brahmaputra River in Assam is shown in Table 3.2. The high sediment yield in the tributary rivers as well as the mainstream of the Brahmaputra is attributed mainly to the extremely potent rainfall regime, easily eroded rock formations, frequent

seismic events causing massive landslides in the hill slopes, and human depredations in the watersheds through harmful land use practices like unorganized shifting cultivation, encroachment of water bodies, forest areas and hill slopes.

Table 3.2 Water and Sediment Yields of Selected Tributaries of the Brahmaputra River, Assam

River	Drainage area (km^2)	Water yield ($m^3 s^{-1} km^{-2}$)	Sediment yield (tons km^{-2} yr^{-1})
Brahmputra at			
Tsela d' Zang (china)	191222	0.0105	100
Pasighat (India)	244700	0.0231	340
Pandu (India)	500000	0.0306	804
Bahadurabad (Bangladesh)	580000	0.0331	1128
Dibang	12120	0.1066	3765
Lohit	22077	0.0709	1960
Subansiri	27400	0.0756	959
Jia Bharali	11300	0.0858	4721
Puthimmari	1787	0.0403	2887
Pagladia	383	0.1087	1883
Manas	36300	0.0232	1581
Kulsi	750	0.0797	135
Buridhing	4923	0.0788	1129
Desang	3950	0.0382	622
Dhansiri	10240	0.0184	379
Kopili	13556	0.0182	230

(Source: After Goswami, 1985)[13]

86. The flood inundation scenario in the Palasbari Reach based on analysis of satellite data is revealed in Figure 3.11. It shows the area affected during the flood of 2004, which is considered to be among the most severe ones to occur in this region. The area covered by inundation was 2,364.67 ha, which accounts for 18.27% of the geographical area in the 8 km buffer around the embankment.

Table 3.3 Pattern of Flooding in 8 km Buffer Zone of Palasbari Reach (as on July 13, 2004)

Particular	Area (ha)	Area (%)
Flooded Area – River Side	239.69	1.85
Flooded Area – Country Side	2124.98	16.42
Total Flooded Area	2364.67	18.27
Total Area in 8 km Buffer	12939.34	100.00

87. The morphology of the Brahmaputra River is characterized by intense braiding, bar formation, and extremely dynamic bankline and bed configuration. The morphology and behavior of the river undergoes drastic changes in response to variation in the flow regime and pattern of sediment transport and deposition in the river following the seasonal rhythm of the monsoon.

[13] Goswami, D.C.1985. Brahmaputra River, Assam, India: Physiography, basin denudation and channel aggradation. *Water Resources Research, Amer. Geophys. Union,* 21: 959-978.

88. The Jaljali River is the main tributary within the sub-project area, running north under National Highway 37 to near chainage 15 km of the Brahmaputra Dyke and then running roughly parallel to the Brahmaputra River, passing within a kilometer of Nagarbera Hill at km 60, where it confluences with the Brahmaputra River. Significant bank retreat has recently occurred downstream of Nagarbera Hill.

89. The general trend of south-bank tributaries, such as the Jaljali River, is for significant portions of the channel to run parallel to the Brahmaputra River for many kilometers. This is because the south-bank tributaries generally carry very little sediment and are thus diverted in the downstream direction by the heavy sediment deposition of the larger river. Therefore, when Brahmaputra bank erosion occurs at the mouth of these south-bank tributaries, the tributary's channel length can be shortened significantly. This in turn seems to have a destabilizing effect on the platform of the upper portions of the tributaries as they adjust to the new channel slope. This process has been observed within the Kaziranga sub-project area. The effect has not been documented along the Jaljali River. However, this may be because there is very little infrastructure near the Jaljali River.

90. Inundation of the Jaljali River floodplain has been documented from satellite images captured during periods of high flooding in the Brahmaputra River. It is not clear if this inundation is from high flows in Jaljali River and heavy rainfall alone, or if there is a backwater effect causing poor drainage during periods of high water in the Brahmaputra. The result is that significant portions of the floodplain are inundated during the flood season.

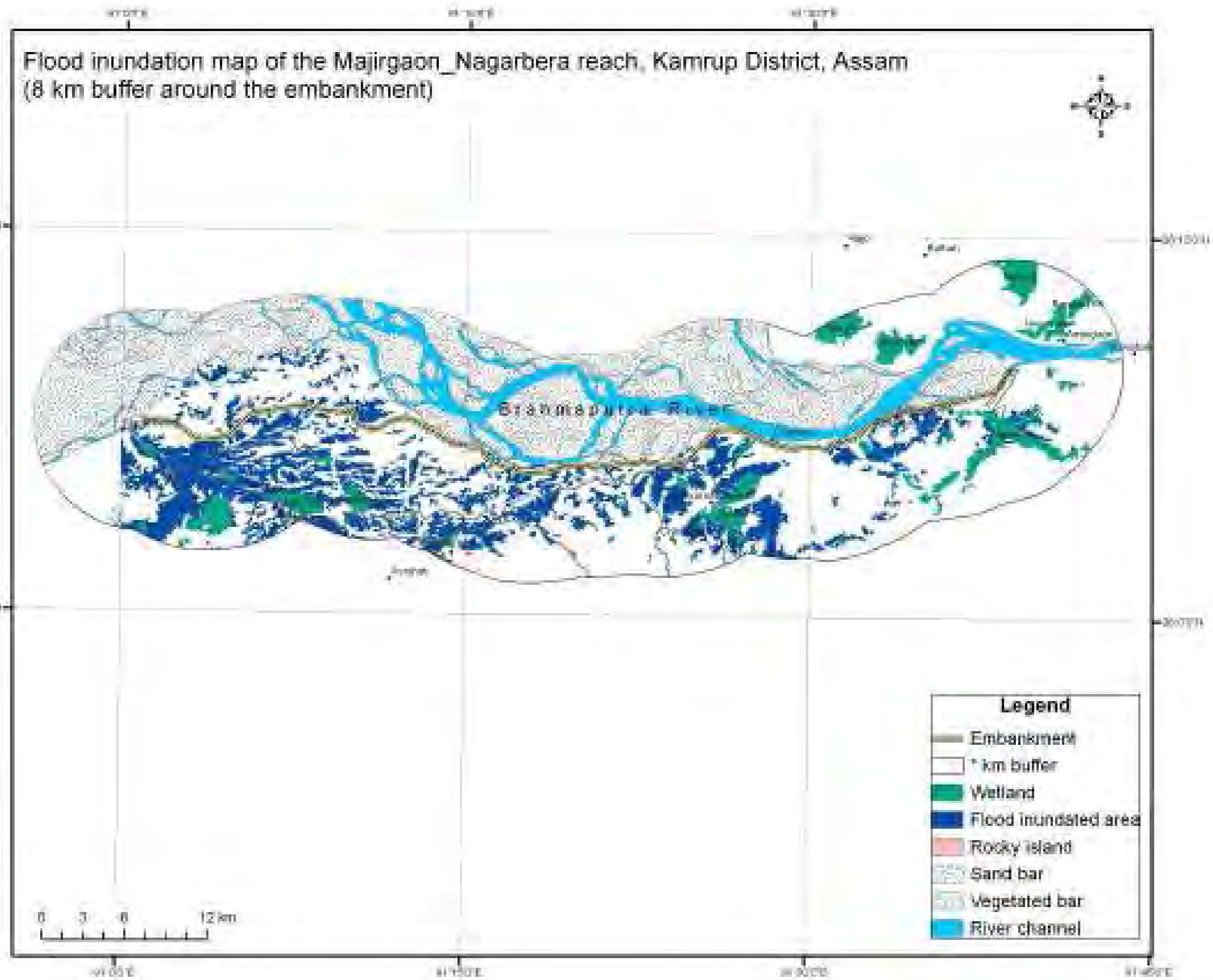


Figure 3.11 Flood Inundation Map of Palasbari Reach

91. The Brahmaputra is a classic example of a braided river – a river in which the channel exhibits successive bifurcation and rejoining of flow around sand bars and islands. In case of the Brahmaputra in its Assam reach, a combination of multiple factors, such as excessive sediment load, large and variable flow, easily eroded bank materials, aggradation of the channel have been identified as the possible underlying factors.[14] Further, the braiding mechanism is related to the presence of narrow sections (nodes) where the bank, are stable due to the existence of resistant rocks, like the one near Guwahati, in the immediate downstream of which the channel fans out developing an intricately braided channel as evidenced in the Palasbari reach.

92. Another striking feature of the river's morphology is the continuous shift of the thalweg (deep channel) from one location to another within the bankline of the river. Bank materials of the Brahmaputra consist mainly of varying proportions of fine sand and silt with only occasional presence of clay. There is a relatively fine-grained topstatum and a coarser substratum.

93. Bank failures are rampant in numerous locations like the Palasbari Reach. These failures are largely seen as a function of hydraulic character of the flow and engineering properties of bank materials. Shear failure in the upper bank materials is by far the most widespread mode of bank failure in the river. These are caused either by undercutting of the upper bank materials by channels during the high floods producing an overhanging cantilevered block that eventually fails or by over steeping of bank materials due to migration of the thaleng closer to the bank during the falling stages. The latter process seems to be more dominant in case of the Palasbari Reach.

94. The bed regime of the Brahmaputra is characterized by drastic changes in bottom configuration and occurrence of bed forms of greatly varying sizes ranging from small size ripples of few centimeters wavelength to giant size dunes and waves of dozens of meters. The dynamic pattern of the channel configuration and movement of the Brahmaputra in the Palasbari reach is demonstrated for different years based on the SOI topographical map of 1911 and the IRS satellite images for 1977, 1991, 2000, 2006, 2008 (Figure 3.12). The movement of the thalweg (deep channel) towards the south bank and its present position hugging the backline where existing protection measures viz. embankments and spurs are under serious threat is well evidenced in the succession of images presented. Fig 3.18 shows the pattern of erosion and accretion of the bank during the period 1911 to 2008 based on analysis of satellite as well as conventional data using GIS. The rates of erosion and accretion estimated from this analysis for the period 1911-2008 are 16,119.83 ha and 1831.08 ha, respectively, giving a net loss of around 14,288.75 ha of land.

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[14] Goswami, D. C., 2002. Channel Pattern, Sediment Transport and Bed Regime of the Brahmaputra River, Assam. In S. K. tendon and B. Thakur (eds.). Recent Advances in Geomorphology, Quarternary Geology and Environmental Geosciences: Indian Case Studies, Manisha Publications, pp. 143-156.

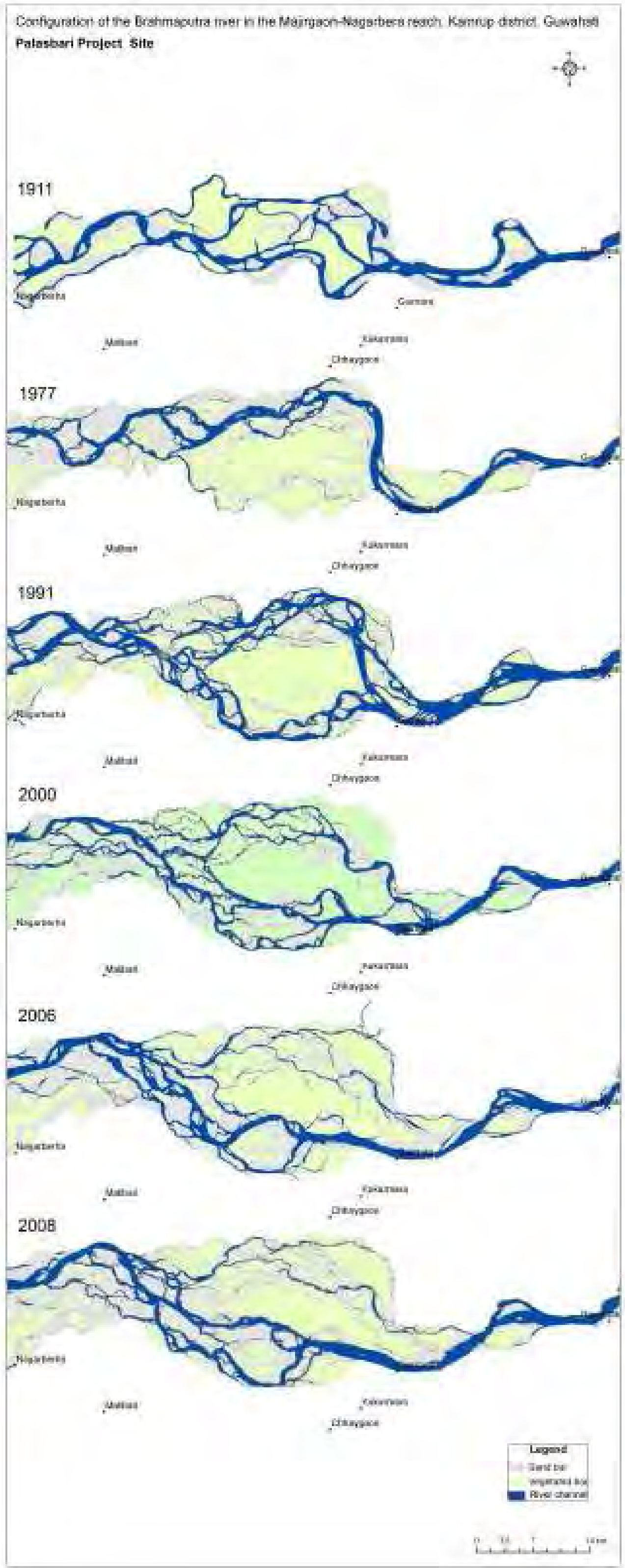

Figure 3.12 Pattern of Channel Configuration and Thalweg Movement of the Brahmaputra River in Palasbari Reach (Year 1911 through Year 2008)

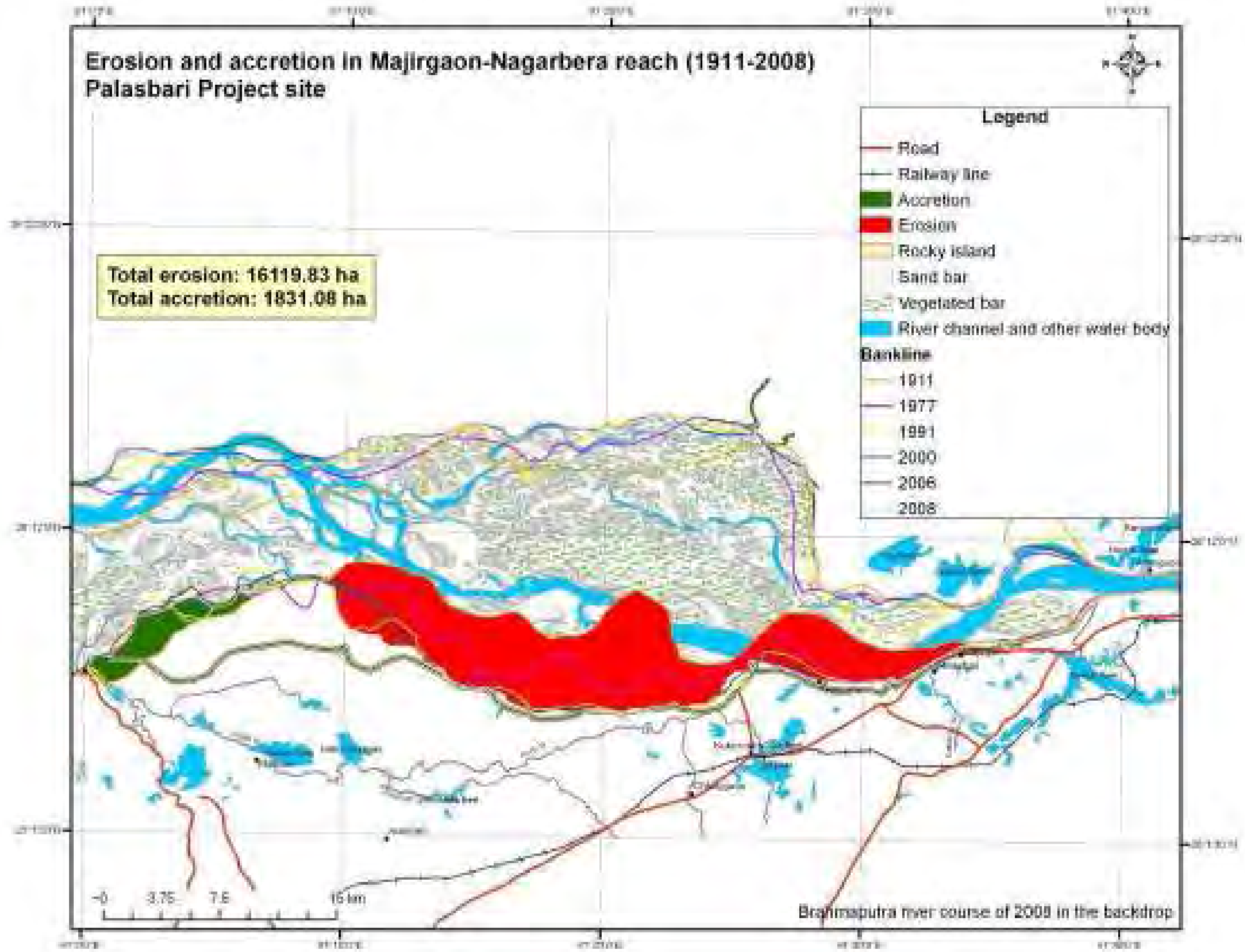

Figure 3.13 Pattern of Erosion and Accretion of the Brahmaputra Bank in the Palasbari Reach (1911 – 2008)

95. The pattern of bankline migration in the reach during different time periods is shown in Figure 3.14. There has been persistent regression of the backline in most of the locations where cross sections are taken although at varying rates (Table 3.4). The pattern of shifting of the bankline during the present decade as depicted on the map for the period 2000- 2007 shows regression in all the sections except a minor amount of progression (forward shifting) in one cross-section. In a similar study carried out in this reach during 1992 for different time periods indicated a maximum shift of 7.6 km in the bankline during the study period 1911-1988.[15]

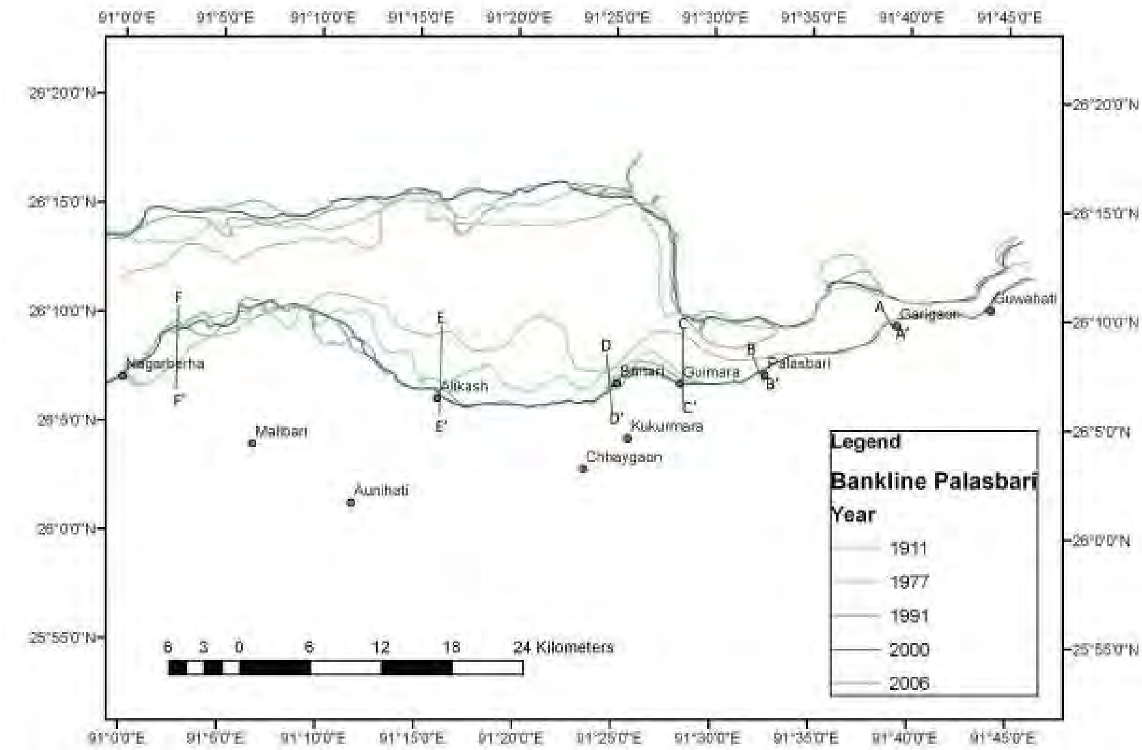

Figure 3.14 Bankline Migration (in m) of the Brahmaputra River in the Palasbari Reach at Selected Cross-sections during different Time Periods

Table 3.4 Rates of Bankline Migration (in m) at Selected Cross-sections in the Palasbari Reach during Different Time Periods

Cross-Section	Period			
	1911 – 1977	1977 – 1991	1991 – 2000	2000 – 2007
AA'	53	-81	42	-55
BB'	-1215	-55	23	-58
CC'	-3430	-354	-321	-23
DD'	-113	-1691	-137	-580
EE'	-4128	-710	-415	4
FF'	2770	821	-521	-298
Total	-6063	-2070	-1329	-1010

15 Goswami, D.C. 1992. Satellite monitoring of bankline migration of the Brahmaputra River at Palasbari, Assam. *Bulletin of NNRMS* (B)-15: 26-27.

3.2.3.3 Flooding Behavior

96. The two segments of the Sub-Project site – east of Dakhala Hill and west of Dakhala Hill are exposed to mainstream flooding from the Brahmaputra River, tributary flooding from both Deepar Beel (to the east of Dakhala Hill), and from the Kulsi-Deosila System (to the west of Dakhala Hill), and to local flooding from heavy rains.[16] These three types of flooding behavior, which can occur separately or in conjunction, can interact to exacerbate flooding impacts. Obviously, high water levels in the Brahmaputra serve to increase the level and duration of tributary flooding in Deepar Beel and in the Kulsi-Deosila River. It is noted that the outlet sluice on Deepar Beel is non-functional during Brahmaputra flooding, which raises the level and extends the duration of tributary flooding along this waterway, a situation that will be further exacerbated by local flooding. It is also noted that drainage congestion is widespread around the lower reaches of the Kulsi-Deosila system, a situation that will again be exacerbated by local flooding.

97. It has not been possible to obtain details of flooding behavior along the Palasbari Reach, although recent flooding experiences of two villages in the Palasbari Sub-project area are reported in 'Volume 1, Flooding in the Brahmaputra Valley of Assam' (NEIFRERM Project, July 2008). In 2008, several major floods occurred in Kamrup District. In mid-August, some 708 villages in the Kamrup Rural Sub-division and some 70 villages in the Kamrup Metro Sub-division were affected by flooding. The cause of this flooding is not stated, but given its widespread nature it was presumably mainstream or a combination of mainstream and tributary flooding. It is not known how many of these villages were in the Palasbari Reach. In September 2008, major flooding occurred in the Hajo and Rangiya Sub-Divisions of Kamrup (to the north of the Bramaputra) caused by tributary flooding when the Puthimari River (catchment area 1,790 km^2) breached embankments at a number of locations. Some 20,000 people in the Hojo Sub-division and a further 80,000 people in the Rangiya Sub-division were affected. National Highway NH-31 was cut for several days by floodwaters from the Puthimari River. Again, it is not known what occurred, if anything, along the Palasbari Reach.

3.2.3.4 Groundwater

98. The entire Brahmaputra valley especially its floodplain zone underlain by unconsolidated alluvial materials is a vast reservoir of groundwater. The dynamic resource of groundwater in the Brahmaputra valley is estimated to be of the order of 2.79 M.ha.m.[17] In the floodplain zone the depth of water is shallow, normally within 5 m below ground level. During the post monsoon period, in almost the entire flood plain area of the Brahmaputra valley, the water table lies within 2 m below the ground surface, caused mainly by the impact of monsoon rains and recharge to the groundwater aquifers. This situation leads to water logging in large areas of the floodplain.

99. Groundwater quality of sample taken from Palasbari New Market Area reveals that the quality within permissible limits based on drinking water quality standards under IS 10500:1991 and meets all the desirable requirements. The analysis of the groundwater quality is represented in Table 3.5:

[16] Interviews with villagers from Panikhaity and Jahirpu Villages, both in the Palasbari Sub-project area, indicated that tributary floods from the Kulsi River were less deep than mainstream floods from the Brahmaputra (see 'Volume 1, Flooding in the Brahmaputra Valley of Assam', NEIFRERM Project).

[17] Central Ground Water Board, 2005

Table 3.5 Ground Water Quality

S. No.	Parameters	Unit	IS 10500:1991 (Drinking Water Standard)		New Market
			Desirable	Permissible	
1	Appearance	-	-	-	Clear
2	pH	-	6.5-8.5	6.5-8.5	6.5
3	Conductivity	(µmho/cm)	-	-	143
4	Hardness as $CaCO_3$	(mg/L)	300	600	54
5	Calcium	(mg/L)	-	-	30
6	Magnesium	(mg/L)	-	-	24
7	NO_3-N	(mg/L)	45	100	0.11
8	Fluoride	(mg/L)	1.0	1.5	0.59
9	Arsenic	(mg/L)	0.05	0.05	0.00028
10	Total Iron	(mg/L)	0.3	1.0	0.16
11	Lead	(mg/L)	0.05	0.05	0.26
12	Copper	(mg/L)	0.05	1.5	0.01
13	Zinc	(mg/L)	5	15	0.057

(Source: Assam State Pollution Control Board, 2007)

3.2.4. Geology

100. The Brahmaputra valley is formed during the Pleistocene dating back to approximately 2 million years based from sediments derived from the Himalayas in the north, the Assam plateau in the south, and brought down by the Brahmaputra River and its tributaries. It is considered to be a tectono-sedimentary basin, 720 km long and 80-90 km wide, underlain by recent alluvium approximately 200-300 m thick consisting of clay, sand and pebble.[18] Most of the basin is underlain by very young and unweathered sedimentary formations with the result that the river carries mainly fine sand and silt with very little clay. The continuity of the flood plain is interrupted by some isolated hillocks of Archaean origin like the Dakhala Hill situated near Palasbari Reach. A dominant feature of the riverine landscape of the Brahmaputra is the large number of sandbars of varying shapes and sizes locally known as Chars that develop on the sandy bed of the braided channel. Although mostly transitory in nature, some of these chars are more or less permanent with a veneer of fertile soil on the top that support vegetation, crops and settlements.

[18] GSI. 1977. Contributions of geomorphology and geohydrology of the Brahmaputra Valley. Miscellaneous Pub. 32.

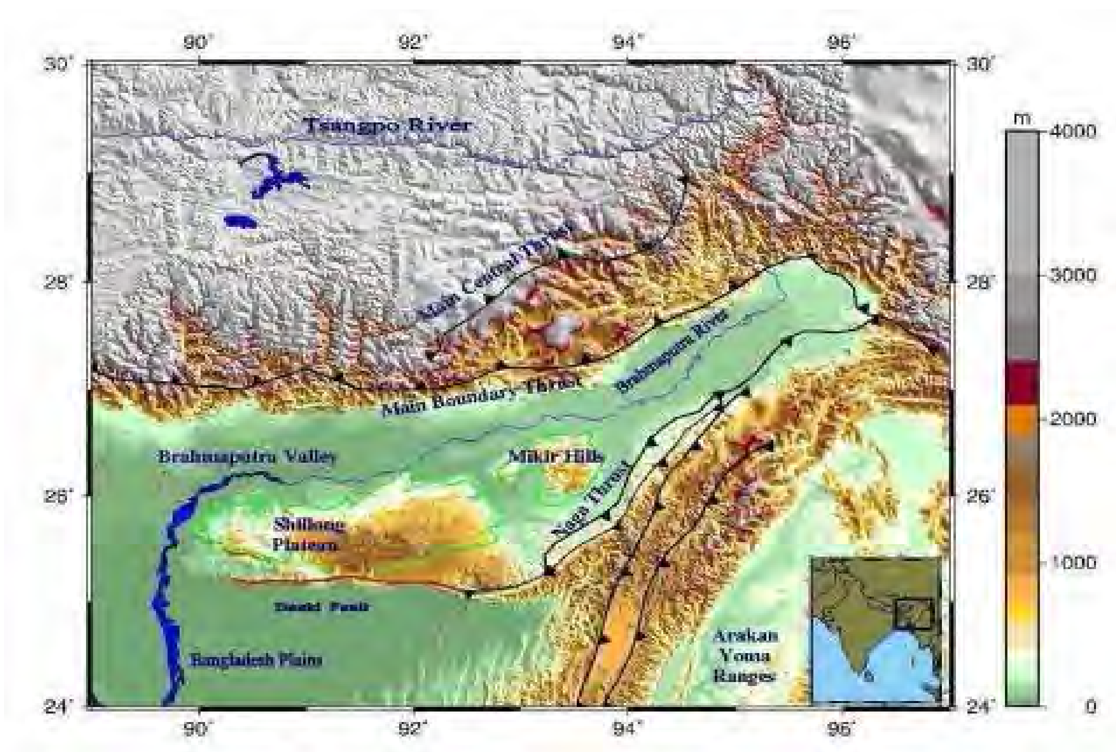

Figure 3.15 Geotectonic Map of Brahmaputra River Valley and its adjoining Highlands

3.2.5. Seismology

101. Due to their strategic location in regard to colliding Eurasia (Chinese), Indian and Burmese tectonic plate boundaries, the Brahmaputra valley and its adjoining hill ranges are seismically very unstable. The earthquakes have caused extensive landslips and rockfalls on the hill slopes, subsidence and fissuring of ground in the valley, and changes in the course and configuration of several tributary rivers as well as the mainstream. The geo-tectonic map of the Brahmaputra valley and its adjoining highlands is presented in Figure 3.15.

102. There appears to be phases of rapid aggradation of the Brahmaputra River associated with earthquakes, mainly as a result of deposition of sediments received from landslides, followed by relatively slower removal of accumulated debris over longer time periods. Active seismicity of the NE region has a very significant impact on the hydrologic regime and morphology of the Brahmaputra River including its host of tributaries and other water bodies (e.g. wetlands) strewn over the floodplains. Occurrence of these episodic events led to intensification of flood hazards, especially in the aftermath of the two great earthquakes of 1897 and 1950.

103. Based on the seismic zoning map of India, the entire project area falls in Zone V (very severe seismic intensity zone). The distribution of major earthquakes (above Richter magnitude 7.0) in the NE region since the 1897 Shillong earthquake is shown in Table 3.6. The seismicity map of Northeast India with respect to the magnitude of earthquakes is shown in Figure 3.16.

Table 3.6 Major Earthquakes in Northeastern India and Adjoinging Regions since 1897

Date	Epicenteral Area	Lat (^oN)	Long. (^oE)	Magnitude
12-06-1897	Shilong, Meghalaya	$26^o00'$	$91^o00'$	8.7
31-08-1906	India-Burma Border	$27^o00'$	$97^o00'$	7.0
12-12-1908	Kachim,Burma	$26^o30'$	$97^o00'$	7.0
09-09-1923	Jankaria,Meghalaya	$25^o12'$	$91^o00'$	7.1
02-07-1930	Dhubri,Assam	$25^o30'$	$90^o00'$	7.1
27-01-1931	Kachin,Burma	25^o36	$96^o48'$	7.6
04-08-1932	India-Burma Border	$26^o00'$	$95^o30'$	7.0
23-10-1943	Hojai,Assam	$26^o00'$	$93^o00'$	7.2
29-07-1947	Tammu,Arunachal Pradesh	$28^o30'$	$94^o00'$	7.8
15-08-1950	India-Burma-China Border	$28^o50'$	$96^o30'$	8.7
06-08-1988	Manipur-Burma-Border	$25^o14'$	$95^o12'$	7.2

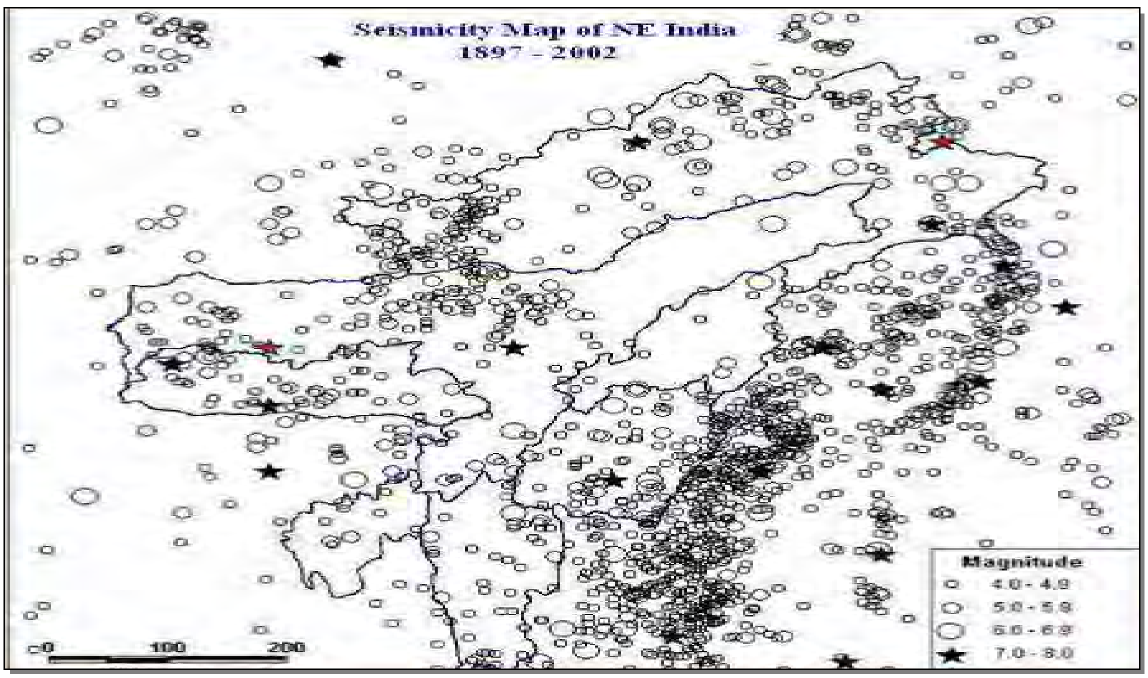

Figure 3.16 Seismicity Map of Northeast India (1897 – 2002)

104. As reported by Oldham (1899), the great Shillong earthquake of 1897 had several impacts on the hydrology of the Kulsi River causing severe floods after the earthquake leading to aggradation of the river bed thereby changing the river from one with deep pools to one with a shallow sandy bed.[19] The bed level of the river was reported to have gone up by more than three meters due to which several tributaries had been blocked leading thereby to inundation of adjoining areas. Subsidence of the ground near the Brahmaputra River created a number of depressed areas now occupied by swamps. The tectonic sensitivity of the south Kamrup region including the Palasbari is indicated by the distribution of major faults in the area in Figure 3.18.

[19] Oldham, D. 1899**.** *The Great Earthquake of 1897*. Geological Survey of India Memoir 29.

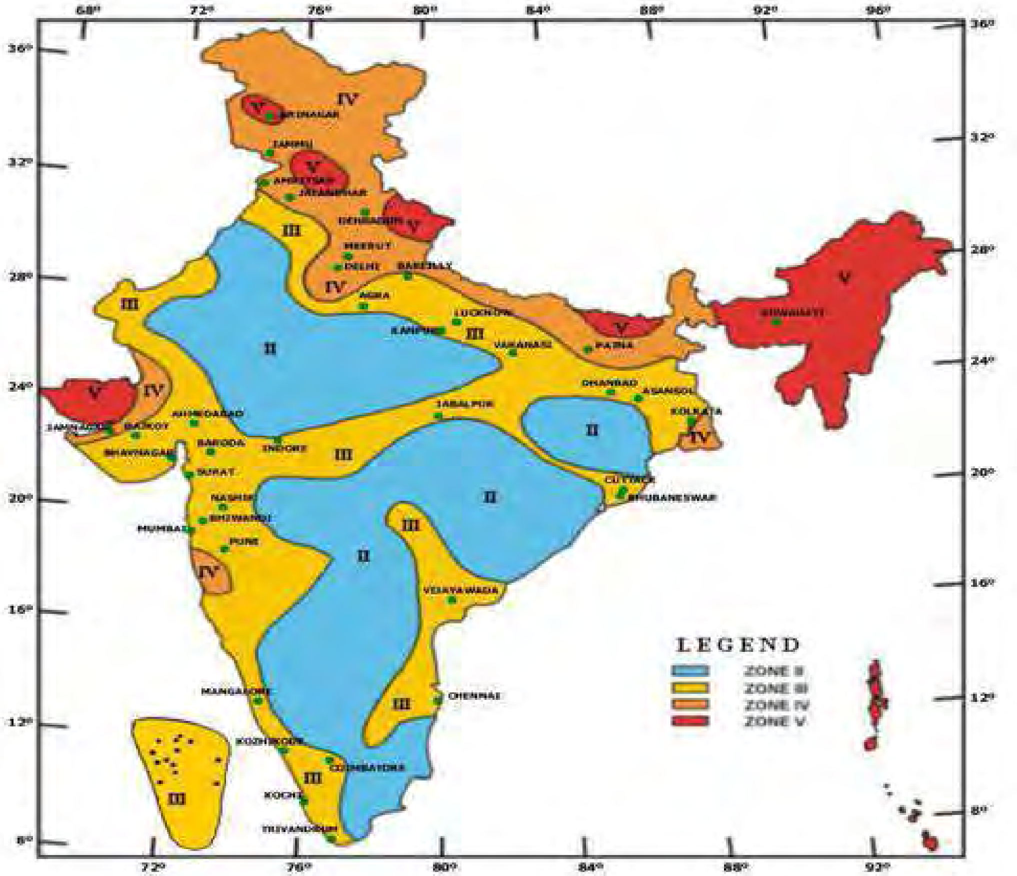

Figure 3.17 Seismic Zoning Map of India

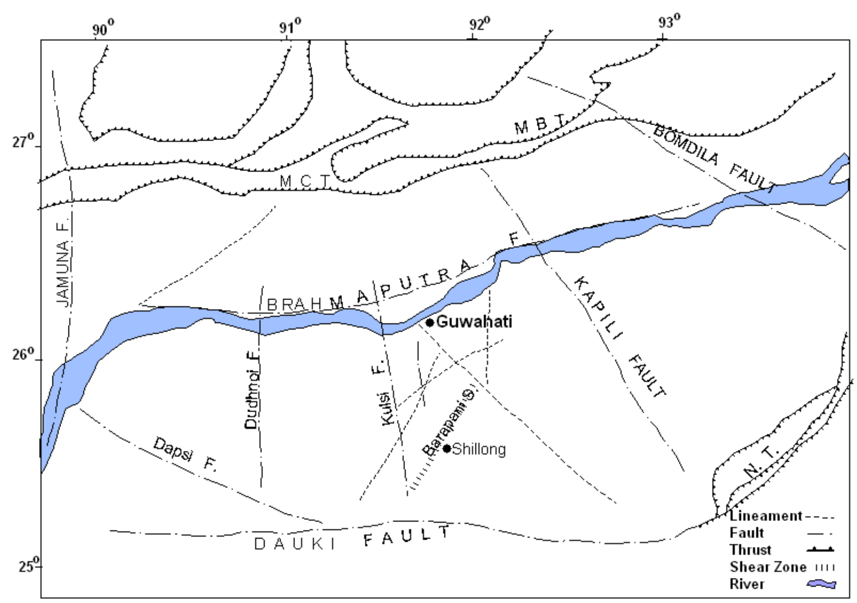

Figure 3.18 Tectonic Map showing Major Faults in South Kamrup Region including Palasbari Reach

3.2.6. Soil

105. The project area is almost entirely made up of alluvial soils formed on recent river deposits called new alluvium, which are also termed as Fluvisols or Fluvents. These are mostly composed of sandy to silty loams and are neutral to slightly acidic in reaction. In limited upland areas within the valley and in the foothill region, there are few isolated pockets of deeply weathered Pleistocene deposits of older alluvium. A study of the litho logs of the Quarternary sediments of the Brahmaputra valley extending down to more than 100 m reveals repeated sequence of clay, pebbles, and boulders.[20] In the hill areas, especially to the south of the Brahmaputra River, laterites and red loams are found. In the Palasbari Reach, besides the new alluvium, there are red ferruginous soils in the upland areas close to the southern hills and marshy soils in the perennially water logged areas. The distribution of soil types in Assam is shown in Figure 3.19.

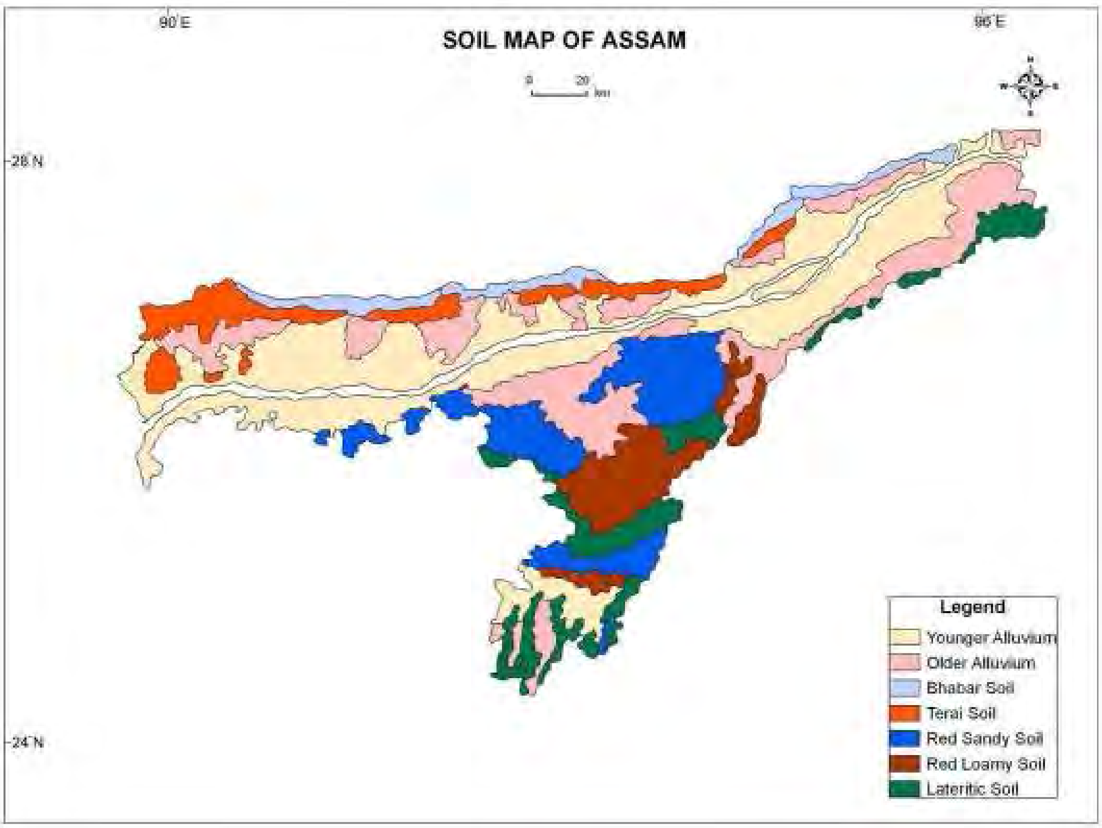

Figure 3.19 Soil Types in Assam

106. The soil quality of the project area was sampled and analyzed for two locations, namely Gumi and Palasbari. The sampling locations are shown in Figure 3.9 and the soil quality at selected locations in Majirgaon-Nagarbera Reach is given in Table 3.7.

Table 3.7 Soil Quality in the Study Area

Parameters	Unit	Gumi	Palasbari
Organic carbon	%	0.25	0.37
Organic matter	%	12.67	13.98

20 GSI. 1977. Contributions of geomorphology and geohydrology of the Brahmaputra Valley. Miscellaneous Pub. 32.

Available nitrogen	Ppm	18.71	21.7
Available phosphorus	Ppm	0.052	0.006
Iron	Ppm	0.053	0.036
Copper	ppm	0.015	0.005
Manganese	ppm	BDL	BDL
Lead	ppm	BDL	BDL
Chromium	ppm	BDL	BDL
Zinc	ppm	0.018	0.002
Mercury	ppm	BDL	BDL
Arsenic	ppm	0.002	0.004
Potassium	ppm	52	78
CEC		1.75	BDL
Textural Classes		Clay	Clay
Clay	%	55	37
Silt	%	28	33
Sand	%	17	30
Bulk Density	g/cc	1.59	3.17
Water Holding Capacity	%	29.36	33.31
Pore Space	%	42.5	43.4
Specific Gravity	%	1.14	1.03
Electrical Conductivity	dS/m	3.6	3.0

(Source: Field monitoring and analysis by Environmental Science Department, Gauhati University)

107. The soil quality in the Palasbari Reach shows low organic carbon, low available nitrogen, low available phosphorous and medium available potassium.

3.2.7. Land Use

108. The current land use pattern in the area is examined in three different scales and space dimensions keeping in view the nature and intensity of the potential impact of the different project elements. On a broader scale, an 8 km buffer around the line of intervention i.e. the embankment is chosen and the land use pattern within the zone is delineated from satellite images using GIS. The size of the buffer is decided based on the consideration of topography (up to the edge of the hilly region in the south) and the location of the major wetlands of the area specially the Deepar Beel, the outlet of which joins the Brahmaputra in the eastern extremity of the reach. The land use map of the buffer zone is presented in Figure 3.20 and the area covered by different categories of land use is presented in Table 3.8.

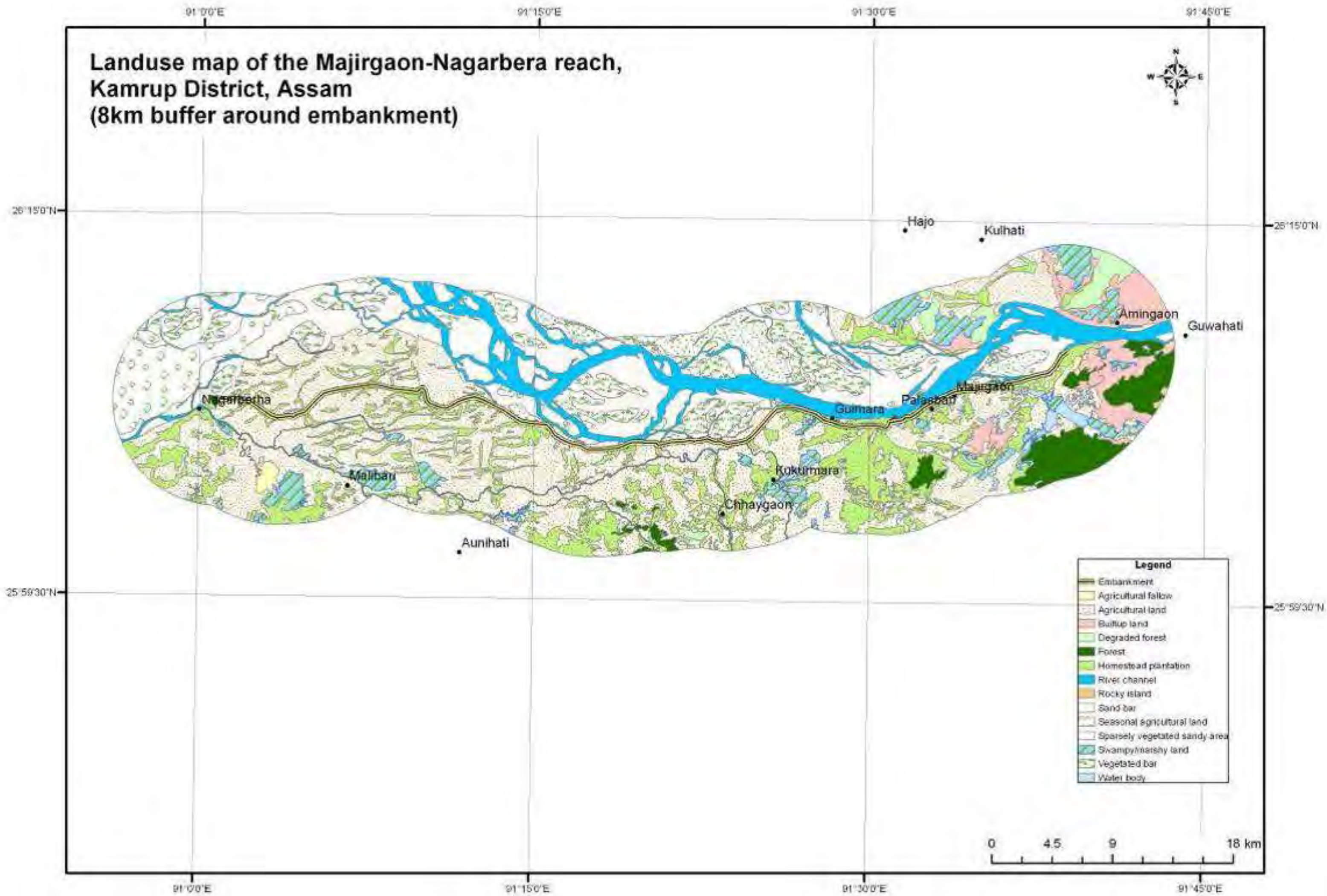

Figure 3.20 Land use Map of Palasbari Reach (8 km buffer around embankment)

Table 3.8 Land use in the Study Area (8 km buffer around embankment)

Category	Area (ha)	Area (%)
Agricultural fallow	457.8	0.3
Agricultural land	45457.7	35.6
Built-up land	4700.1	3.7
Forest	4547.1	3.6
Homestead plantation	18727.5	14.6
River channel	11398.3	8.9
Rocky island	4.0	0.0
Sand bar	19610.5	15.4
Seasonal agricultural land	4174.4	3.3
Sparsely vegetated sandy area	4556.7	3.6
Swampy/marshy land	5436.7	4.3
Vegetated bar	7377.3	5.8
Water bodies	1191.6	0.9
Total	127639.7	100

(Data source: IRS-P6 data for Year 2008)

109. Out of the total study area of 119,042.3 ha, agricultural land occupies 45,457.7 ha accounting for 35.6%, followed by sand bars (15.4%), and homestead plantations (14.6%).

110. The project area, especially towards the country side of the embankment is dotted with a large number of wetlands. These are mostly formed from abandoned channels of the Kulsi and other rivers. Few of these are created due to course truncation of the Kulsi River as a result of construction of the dyke system in 1974. The total area covered by river channels including Brahmaputra River, Kulsi River, and its tributaries in the country side of the embankment are about 11,398.3 ha whereas other water bodies including wetlands occupy about 1191.6 ha area (0.9%) of the 8 km buffer up to the foothills of the Meghalaya plateau. The sandbars (chars) on the river side of buffer zone occupy another 19,610.5 ha of the buffer.

111. Land use pattern is also examined in a 100 m direct impact zone on either side of the embankment using satellite remote sensing and GIS. The dimension of the direct impact zone is decided based on field observations as well as discussions with technical and administrative officials of the Government. The 100 m direct impact zone for the entire reach is shown in Table 3.9. The land use data for the direct impact zone is presented in Figure 3.21. It indicates that the agricultural lands occupy highest portion of the area followed by homestead plantation, water bodies, sandbars, agricultural fallow land, sparsely vegetated sandy areas, swampy/ marshy land, etc.

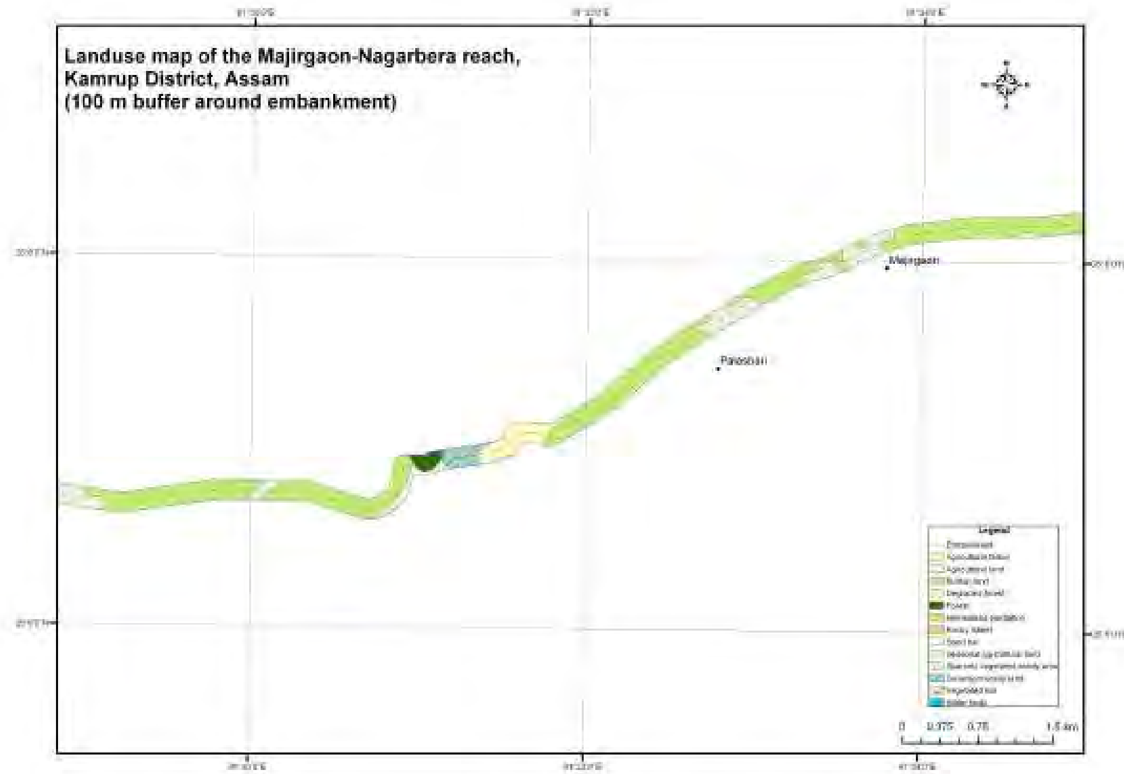

Figure 3.21 Land use Map of Palasbari Reach (100 m buffer around embankment)

Table 3.9 Land use of Palasbari Reach (100 m buffer around embankment)

Category	Area (ha)	Area (%)
Agricultural fallow	15.9	1.1
Agricultural land	822.1	57.8
Forest	5.8	0.4
Homestead plantation	445.6	31.3
River channel	55.6	3.9
Sand bar	29.8	2.1
Seasonal agricultural land	11.8	0.8
Sparsely vegetated sandy area	14.8	1.1
Swampy/marshy land	14.5	1.1
Vegetated bar	5.6	0.4
Total	1421.5	100

112. The land use pattern in the zone lying between the bank and the embankment was also mapped using satellite data and GIS. The result of this analysis is shown in Figure 3.22. The land use data of the zone presented in Table 3.10 show that agricultural land dominates the land use accounting for more than 69% of the total area followed by homestead plantations (26%).

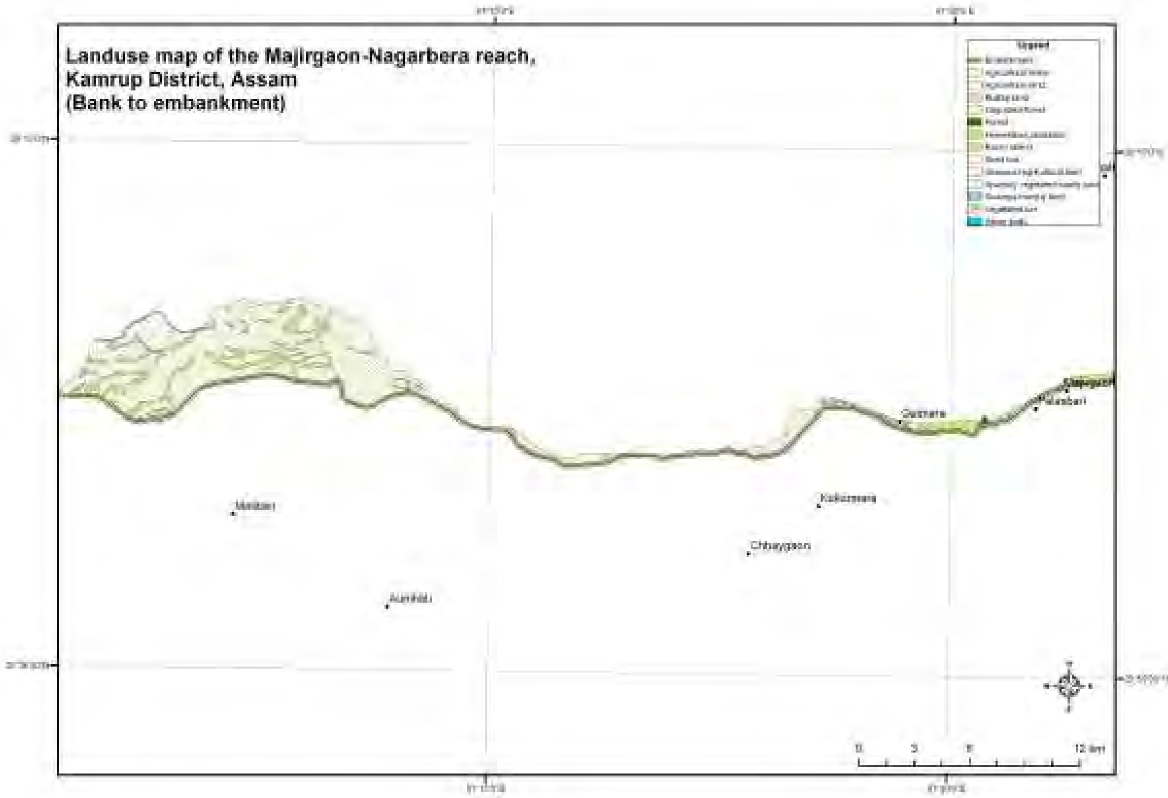

Figure 3.22 Land use Map of Palasbari Reach (bank to embankment)

Table 3.10 Land use of Palasbari Reach (bank to embankment)

Category	Area (ha)	Area (%)
Agricultural fallow	33.6	0.1
Agricultural land	20048.9	69.2
Forest	19.2	0.1
Homestead plantation	7540.2	26.0
River channel	1067.7	3.7
Seasonal agricultural land	58.1	0.2
Sparsely vegetated sandy area	88.2	0.3
Swampy/marshy land	89.2	0.3
Water body	25.2	0.1
Total	28970.3	100

3.2.8. Air Quality

113. The Palasbari reach being rural in character with limited economic development and infrastructure, the ambient air environment is relatively undisturbed. However, in order to scientifically establish the baseline air quality status as required in this assessment and in view

of its future relevance, ambient air quality was monitored at two locations in the field as indicated in Figure 3.9. The results of ambient air quality monitoring in the reach are presented in Table 3.11. The ambient air quality results have also been compared with the National Ambient Air Quality Standards (NAAQS) for Residential and Rural Areas in India.

Table 3.11 Ambient Air Quality

S. No.	Parameter	Unit	NAAQS for Residential and Rural Areas	Majir Gaon	Khanajan
1.	Suspended Particulate Matter (SPM)	μg/m^3	200	66.3	71.3
2.	Respirable Suspended Particulate Matter (RSPM)	μg/m^3	100	47.5	56.0
3.	Oxides of Nitrogen (NOx)	μg/m^3	80	4.5	7.8
4.	Sulphur Dioxide (SO2)	μg/m^3	80	3.6	3.2
5.	Lead (Pb)	μg/m^3	1.0	0.045	0.062
6.	Carbon Monoxide (CO)	μg/m^3	2000	120	174
7.	Hydrocarbons (HC)	μg/m^3	-	1250	870

(Source: Field monitoring, Dept. of Env. Science, Gauhati University, March 2008)

114. It is evident from the comparison that all the air quality parameters are found well within the permissible limits as per the NAAQS for residential and rural areas. The National Ambient Air Quality Standards in India are shown as Appendix 3.3.

3.2.9. Noise Environment

115. Ambient noise levels along the Palasbari Reach have been monitored at Gumi, Palasbari, Majir Gaon and Khanajan during day and nighttime. In the absence of any major source of noise pollution in the immediate vicinity of the impact corridor, the noise levels observed were well within the standards for residential areas. The ambient noise levels during day and nighttime are presented in Table3.12. The National Ambient Air Quality Standards in respect of noise are shown as Appendix 3.4.

Table 3.12 Ambient Noise Levels in the Study Area

Location	AAQS in respect of Noise for Residential Area		Day Time [dB(A)]			Night Time [dB(A)]		
	$L_{eq(day)}$	$L_{eq(night)}$	L_{max}	L_{min}	$L_{eq(day)}$	L_{max}	L_{min}	$L_{eq(night)}$
Gumi	55	45	58	42	47	56	37	45
Palasbari			52	37	45	52	41	43
Majirgaon			55	48	51	53	37	42
Khanajan			57	48	51	55	32	44

(Source: Field Monitoring, Dept. of Env. Science, Gauhati University, March 2008)

3.3. Terrestrial Ecology

116. The River Brahmaputra has structured the terrestrial and aquatic ecosystem of the floodplain zones. People living in the floodplain of the river depend on the ecological supports of the Brahmaputra River and its monsoon flood. Almost every year, river water inundates the entire low-lying areas of the floodplains and thus rejuvenates the land with natural fertilizer and biodiversity components.

117. The river has created large numbers of wetlands in the floodplain within a range of 10 km distance from the major river system. These wetlands have supported numerous aquatic biodiversity resources including ecologically and commercially important butterflies, moths, fishes, amphibian, reptiles, mammals, birds and economically important aquatic plants, ornamental plants, medicinal plants etc. and created life support systems of the traditional peoples living in the floodplains.[21,22,23] The major human dependable biodiversity resources, which have regularly been supported the human livelihood management of the rural folks are supported by the river created wetland ecosystems. These wetlands were formed due to continuous interaction of land and water, so without water sources, no wetland ecosystem would exist in the floodplain zones.

3.3.1. Methodology of Baseline Data Collection

118. To collect the baseline data for the Palasbari Reach from the mouth of Khanajan River through Sontoli Bazzar and village Nagarbera near Jaljali river outfall (total length around 74.10 km) area was divided into two basic zones, based on the investment project design:, (1) from Ch. 0.0 km to Ch. 2.4 km (Khanajan river mouth to Dakhola hill), and (2) from the downstream of Dokhola Hill up to Nagarbera Hill near Jaljali River outfall ch 60.0 Km.[24] In many places, the embankment was found to be obliterated by the people through the activities like earth cutting and house constructions beyond Sontoli Bazaar up to Nagarbera village.

119. The Sub-zone (A) covers the countryside from the embankment. The width of this zone was fixed at 100 m where impacts may occur during embankment project. The Sub-Zone (B) covers the 100 m or less (as per the existence of terrestrial zones near riverside) between the embankment and Brahmaputra River. The assessment was carried out from 11 February 2008 and continued till April, 2008**.** During field survey, the available primary information was collected by direct sighting method and the secondary information was collected from field during survey based on the interrogation with the local inhabitant and published materials to gather the additional data. Also, the present threats of the terrestrial and aquatic ecosystems were monitored and the mitigation measures were analyzed.

3.3.2. Terrestrial Ecology

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[21] Saikia, P. K. and P. C. Bhattacharjee 1995. Status, and decline of waterbirds in Brahmaputra Valley, Assam, India. Pp. 20-27, in Verghese, A. S., Sridharand, A. Chakravarty, K. [ED.]. Proceedings: Published by Zafar Futhehaly, Bird Conservation Strategies for the Nineties & Beyond. OSI, OSI Liaison Officer, No. 10.Vishnuchittam, Sirur Park Road, Seshadripuram, Banglore-560020, India.

[22] Mani, M. S. 1986. Butterflies of the Himalaya. Oxford & IBH Publishing Co., New Delhi.

[23] Mani, M. S. 1974. Ecology and Biogeography in India. Dr. W. Junk B.V. Publishers, The Hague.

[24] In Ch. 60.0 km at Nagarbera hills, the local People have illegally demoralized the hills and its peripheral zones by collecting big boulders and stones for commercial purposes. The people also collected boulders that laid for the bank erosion management purposes.

120. The vegetation compositions of the terrestrial zones were comprises of Ajar-*Lagerstroemia flosrganae*, Ahot Goch -*Ficus religiosa*, Bor Goch-*Ficus bengalensis*, *Tamarix dioica*, *Orozylum indicum*, Atlas-*Annona squamosa*, Buwal-*Cordia dichotoma*, Bogori-*Zizyphus mauriciana*, Bhimkol-*Musa balbasiana*, Bholuka Banh-*Bambusa balcooa*, Bijuli Banh-*Bambusa pallida*, Dewa Cham-*Artocarpus lacusha*, Satiana or Devil tree-*Alstonia scolaris*, Dimoru-*Ficus glomarata*, Khohota Dimoru-*Ficus lipidosa*, Gamari-*Gmelina arborea*, Helos-*Antidesma ghaesembilla*, Jati Banh-*Bambusa tulda* (trees were categorized based on height; e.g. >15 feet), Jamuk-*Syzygium fruiticosum*, Khokon-*Duabhanga grandifolia*, Katia Khongal Dimoru-*Ficus tinctoria*, Kathal-*Artocarpus heterophylus*, Karas-*Pungamia pinnata*, Krishnasura-*Delonix regia*, Kadam-*Anthocephalus cadamba*, Kolajamun-*Syzygium cumini*, Moder-*Erythrina indica*, Mokal banh-*Bambusa pallida*, *Bauhinia spp*, Mango-*Mengifera indica*, Narikol-*Cocos nucifera*, Owtenga-*Dillenia indica*, Palas-*Butea monosperma*, Poma-*Toona cialita*, Cascabela thevetia, Pakori-*Ficus rumphii*, Purakol-*Musa spp,* Simul-*Bombax ceiba*, Siris-*Albizzia lebbek*, Sisso-*Delbergia sisso*, Sonaru-*Cassia fistula*, Segun-*Tectona grandis*, Suwalu-*Litsea monopetala*, Soom-*Persea bombiciana*, Silikha-*Terminalia chebula*, Tamul-*Areca catechus*, Tora Goch-*Alpinia allughas*, Tambul- *Areca catechu*, Velew -*Trtramelos nudiflora* etc.

121. The other important terrestrial plants included *viz.*, Jati Bet- *Calamus erectus*, Dubari Ban- *Cynodon dactylon*, Locosa Ghanh- *Hemarthia compressa*, Birina- *Vetiveria zizanoides*, Ekora- *Saccharum ravanae*, Khagori- *Phragmites karka*, Ulukher- *Imperata cylindrica*, Hankher-*Pollinia ciliata*, Kahua- *Saccharum sponteneum* and Borota Kher- *Saccharum elephantinus* etc. Other important plant species of the area have been eliminated due to regular flood and changing scenario of soil characteristics. The major climber species comprises *Stephania harnondifolia* (Tubuki lata), *Zanthoxylum hamiltonianum* (Tej-muri), *Cuscuta reflexa* (Akashi Lata), *Illegeria khasiana* (Kerkeri lata), *Dioscorea hamilttoni* (Bonoria alu), *Smilax macrophylla* (Tikoni boral), *Calamus erectus* (Jati bet), *C. gracilis* (Wahing bet), *C. latifolius* (Motha bet), *Pinaga gracitis* (Raidang Bet), *Pothos cathcartii* (Hati-poita) and *P. scandens* (Kawri Lata) etc. (Appendix 3.5 and Appendix 3.6).

122. The vegetables/ pulses /jutes etc. available in the project sites are Paleng, Mithi, Dhania, Lai Sak, Khesari, Podina, Potatoo, Bhendi, Bengena, Bilahi, Jolokia, Phulkabi-*Brassica oleracea var,* Morapat-*Corchorus capsularis,* Amita-*Carica papaya,* Ghehu-*Triticum aestivum* and Rice etc*.*

123. Study revealed the presence of 223 avian fauna, 19 mammalian fauna, 32 reptilian fauna from Khonajan Ch. 0.0 km to Polasbari Ch. 0.0km, Majirgoan 0.0 km to Dokhola hill 4.9 km, Dokholahill Ch. 0.0 km to Gumi Ch. 22.0km, Ch 22.0 km to Ch. 60.0 km (Nagarbera village and hills).(Appendix 3.7, Appendix 3.8, and Appendix 3.9)

124. The study has reported altogether 11 amphibian fauna in Majirgoan-Nagarbera embankment site which include: Rana tytlery**,** *Rana typiensis, Haplobtrachus tigerina, Rana syanophylectes, Rana leptoglosus,* Fezerzerya pieri**,** *F. synhendrense, F. terai, Mycrohyla ornate, Polypedatus leucomystes and Buffo melanostictus* (Table 3.13).

Table 3.13 Amphibian Fauna Reported in Mazirgoan-Nagarbera Project Sites (based on present absent data)

Amphibian Species	Present absent data/Sample sites													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Rana tytlery	1	1	0	0	0	0	0	0	0	0	1	1	1	1

Amphibian Species	Present absent data/Sample sites													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Rana typiensis	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Haplobtrachus tigerina	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Rana syanophylectes	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Rana leptoglosus	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Fezerzerya pieri	1	1	1	1	1	1	1	1	1	1	1	1	1	1
F. synhendrense	1	1	1	1	1	1	1	1	1	1	1	1	1	1
F. terai	1	1	1	0	0	0	0	0	0	0	0	1	1	1
Mycrohyla ornata	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Polypedatus leucomystes	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Buffo melanostictus	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Abbrebriation: 1: (0 point):Dharapur ; 2: Darapur; 3: Jangrabari; 4: Alutalibari; 5: DBHcm; 6: DBH; 7: DBH; 8: DBHin; 9: Spur 7th; 10: Majguri; 11: Goroimarialikash; 12: Borakhat; 13: Bejisuti-Kalidas; 14: Nagarbera Hillside (1: Present;0: Absent).

125. Diversity Index[25] and Species Richness[26] of Amphibian Fauna, Reptilian Species, Avian Fauna and Mammalian Fauna have been given in Appendix 3.10.

126. Rarefaction analysis of species richness of Amphibian Fauna shows higher richness in Gumi Reach at Spur 7th (Ch. 22.3 km), Majgur (Ch. 24.0 km), Goroimari Alikash (Ch. 26.0 km to 37.0 km), Borakhat , Bejisuti, Kalidas Beel area (Ch. 37.0 km to 42 km) and Nagarbera hillside (Ch. 58.0 km to 60.0 km), where richness value was 11.0.

127. Rarefaction analysis of species richness of Reptilian Species shows higher richness in Khonajan “0” point to Dhuptala Bazar (Ch. 0.0 km - Ch. 2.4 km); Gumi reaches at Spur7th (Ch. 22.3 km), Majguri (Ch. 24.0 km), Goroimari alikash (Ch. 26.0 km to Ch. 37 km), Borakhat, Bejisuti, Kalidas beel area (Ch. 37 km to 42 km) and Nagarbera hillside (Ch. 58.0 km to Ch. 60.0km) than the others.

128. The area is rich in avifaunal point of view. Study of avian species in Palasbari Reach exposed the subsistence of 223 avian species belong to 43 different families. The aquatic migratory birds have been observed from the Khonajan (Ch. 0.0 km to Ch. 2.4 km; Ch. 2.4 km to Ch. 9.5 km); from Majirgoan (Ch. 0.0 km) to Dokhola hill (Ch. 4.9 km and up to Ch. 19.5 km). The area ranging from Gumi (Ch. 22.0 km) to Nagarbera (Ch. 60.0 km) has no migratory waterfowl available owing to very shallow river channels and the riverbank was running comparably longer distance from the existing Brahmaputra Dyke. People reside in those areas have regularly been capturing the migratory birds for commercial purposes. Rarefaction analysis of species richness also shows higher richness in inside the embankment than outside (Richness Value: Inside: 222.9; Outside118.9).

129. Altogether 19 species of mammalian fauna has been recorded in the study site from Khonajan Ch. 0.0 km to Ch. 2.4 km; Ch. 2.4 km to Majirgoan 0.0 km; Majirgoan Ch. 0.0 km to

25 In ecology, diversity index is a statistic which is intended to measure the biodiversity of an ecosystem.
26 The species richness is the number of species present in an ecosystem.

Dokhola Hill Ch. 4.9 km; Satrapara to Land Spur No. 7 (Ch. 4.5 km to Ch. 19.3 km); Ch.20.0 km to Ch. 60.0 km.

3.3.3. Faunal Behavior Pattern and their Land River Interface

130. There were altogether two river confluences found in the project site, one at Dharapur "0" point and other at Palasbari Boatghat area. In the river confluence of Khonajan – Brahmaputra (near Dharapur "0" point) and Palasbari outlet Channel-Brahmaputra (near Palasbari Boatghat; Coordinates: 26°07′88″N-91°35′24″E) dolphins were came to forage and playing during winter and monsoon. It is a deep channel even during dry season. The other land river interfaces were completely blocked during 1974 embankment from Ch. 20.0 km - Ch. 60.0 km Gumi - Nagarbera site.

3.3.4. Migratory Route of Terrestrial Fauna

131. There is no live migratory route of terrestrial fauna in the Palasbari Reach, however, one wild elephant was reported to have reached the riverside habitat near Dharapur "0" Point (Latitude 26°09′49″N & Longitude 91°39′01″E), but it could not be marked as a migratory route.

3.3.5. Dolphin and its Behavior Patterns

132. River Dolphins came to the embankment site throughout the deepwater channels during Monsoon season, but the most important areas are the Palasbari Boatghat Ch. 0.0 - 4.9 km (26°07′88″N-91°35′24″E) and Dharapur "0" Point Ch. 0.0 km (Coordinates: 26°09′49″N-91°39′01″E) up to Sluice gate, in which the Dolphins were frequently visited for playing, breeding and foraging purposes (Ref Figure 3.23). Earlier, the Dolphins extended their range up to Deepar beel[27], which is connected by the Khonajan River from Brahmaputra. But the Sluice gate is the main barrier of this species extended up to Deepar beel (3 km distance from the Dharapur "0"point).

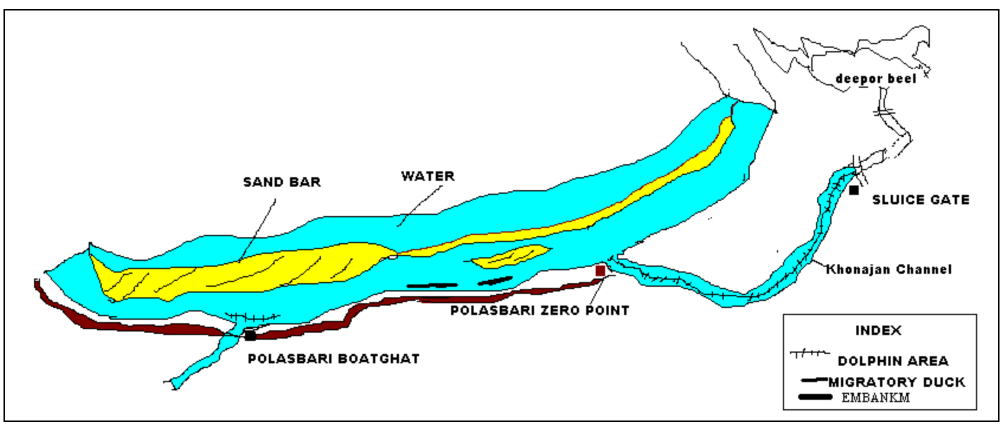


Figure 3.23 Important Dolphin Areas in Palasbari Reach

[27] Deepar beel is the only Ramsar site of Assam, situated about 3 km Arial distances from the Khonajan mouth. Khonajan is the only outlet of this important wetland of Kamrup district. Although it has connection with river Brahmaputra, the embankment did not hamper the beel, as the proposed embankment did not harm the connection of Khonajan. The garbhanga RF is adjoined with the Deepar beel, but it is far away from the embankment and is a different strand of south bank ecosystem.

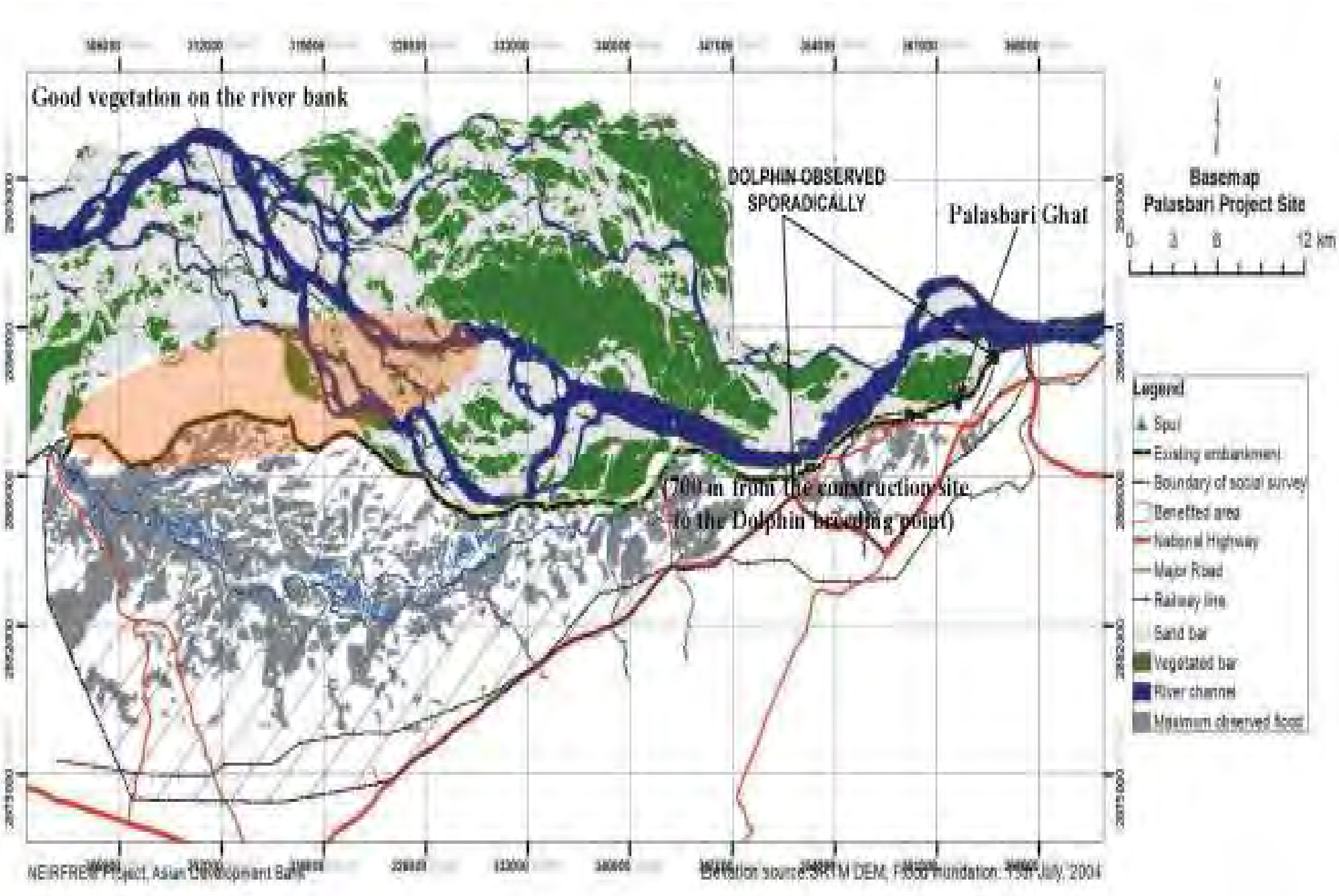


Figure 3.24 Distance of Dolphin Breeding point from the Embankment

133. However, the Dolphins were not seen during winter when water level recedes. Nonetheless dolphins were still sighted at 'Dharapur "0" point' area outside the embankment (Ref Figure 3.24). Therefore, there will be no effect on Dolphin by this embankment. Also, the migratory waterfowls were seen from Dharapur "0" point' to Majirgoan Ch. 0.0km during winter season. This area is important for the migratory waterfowl.

3.3.6. Identification of Areas of Eco-Sensitivity

134. The area near Khonajan "0" point Ch. 0.0 km of Dharapur project site and the Khanajan channel up to Sluice gate is the eco-sensitive area (Lat/Long. 26°09′49″N - 91°39′01″E). Bird nests holes were also observed in this point. The Brahmaputra river channels from the Dharapur "0" point up to Dhuptala bazaar Ch. 2.4 (Coordination: 26°09′49″N-91°39′01″E to 26°08′38″N-91°37′28″E) is the important site for migratory waterfowl during winter season. Also, the area near Palasbari Ghat (Latitude 26°07′88″N & Longitude 91°35′24″E) (Ch. 0.0 to Ch. 4.9 km up to Dokhola hill) is the most important eco-sensitive area for River Dolphin (mammal) and *Bagarius bagaris* (fish species) particularly during monsoon. Both the species reported to be breed and playing in this site.

3.3.7. Identification of Endangered, Globally Threatened and Endemic Species

3.3.7.1 Endangered Reptilian Fauna

135. A total of 9 endangered species of Reptilian fauna were recorded in the project site during survey (Schedule-I of Wildlife protection Act 1972). (Table 3.14 3.14).

Table 3.14 Endangered Reptilian fauna in Project Site (Under Indian Wildlife Protection Act, 1972)

S. No.	Common Name	Scientific Name	Status (IWPA)
1	Burmese Python	Python molurus bivittatus Kuhl, 1820	Schedule-I
2	Yellow Monitor Lizard	V. flavescens	Schedule-I
3	Indian Roofed Terrapin	Kachuga tecta (Gray)	Schedule-I
4	Khasi Hill Terrapin	K. sylhetensis (Jerdon)	Schedule-I
5	Spotted Black Terrapin	Geoclemys hamiltoni (Gray)	Schedule-I
6	Indian Mud Turtle	Lissemys punctata Lacepede	Schedule-I
7	Peacock Softshell	Trionix hurum (Gray)	Schedule-I
8	Khasi Hill Terrapin	K. sylhetensis (Jerdon)	Schedule-I
9	Ganges Soft-shell Turtle	Trionix gangeticus	Schedule-I

3.3.7.2 Endangered Mammalian Fauna

136. Altogether there were 4 endangered mammalian fauna have been reported from the site. The Asiatic Wild elephant has been reported to reach the Dharapur area during heavy flood of 2004. Among all 4 endangered mammalian fauna, one species the *Platinista gengeticus* is the aquatic mammals (Table 3.15).

Table 3.15 Endangered Mammalian Fauna Reported in Project Site

S. No.	English Name	Scientific Name
1	Indian Elephant*	*Elephas maximus*
2	Barking Deer*	*Muntiacus muntjak*
3	Chinese Porcupine*	*Hystrix brachyuran*
4	River Dolphin	*Platinista gengeticus*

* Secondary information

3.3.7.3 Endangered and Globally Threatened Avian Fauna

137. There were altogether 16 endangered species of avian fauna under Indian Wildlife protection Act, 1972 and 17 globally threatened species recorded in the study sites during survey period. Among all the globally threatened species, two species were recognized as critically endangered, one was endangered and seven species were each in vulnerable and near threatened category (Table 3.16).

Table 3.16 Endangered Avian Fauna in Palasbari Reach

S. No.	Scientific Name	English name
1	*Pelecanus philippensis*	Spot-billed Pelican
2	*Leptoptilos javanicus*	Lesser Adjutant Stork
3	*L. dubius*	Greater Adjutant
4	*Dendrocygna bicolour*	Fulvous Whistling Teal
5	*Aythya baeri*	Baer's Pochard
6	*Pandion haliatus*	Osprey
7	*Haliaeetus leucoryphus*	Pallas's Sea Eagle
8	*Pellorneum palustre*	Marsh Babbler
9	*Falco chicquera*	Red-necked Falcon
10	*Falco peregrinus*	Peregrine Falcon
11	*Besra*	Accipiter virgatus
12	*Eurasian Sparrowhawk*	A. nisus
13	*Besra*	Accipiter virgatus
14	*Grey-headed Fish eagle*	Ichthyophaga ichthyaetus
15	*Gyps bengalensis*	Whiterumped Vulture
16	*G. indicus*	Longbilled Vulture

Table 3.17 Various Categories of IUCN Red Data Book and Globally Threatened Species of Birds in Palasbari Reach

S. No.	Scientific name	English name	Category
1	*Gyps bengalensis*	Whiterumped Vulture	CR
2	*G. indicus*	Longbilled Vulture	CR
3	*Leptoptilos dubius*	Greater Adjutant	En
4	*Pelecanus philippensis*	Spotbilled Pelican	V
5	*Leptoptilos javanicus*	Lesser Adjutant Stork	V
6	*Haliaeetus leucoryphus*	Pallas's Sea Eagle	V
7	*Dendrocygna bicolour*	Fulvous Whistling Teal	V
8	*Aythya baeri*	Baer's Pochard	V
9	*Pellorneum palustre*	Marsh Babbler	V
10	*Eurynorhynchus pygmeus*	Spoonbilled Sandpiper	V
11	*Anhinga melanogaster*	Oriental Darter	NT
12	*Ephippiorhynchus asiaticus*	Black-necked Stork	NT
13	*Aythya nyroca*	Ferrugineous Duck	NT
14	*Ichthyophaga ichthyaetus*	Greyheaded Fish Eagle	NT
15	*Sarcogyps calvus*	Redheaded Vulture	NT
16	*Circus macrourus*	Pallid Harrier	NT
17	*Sterna acuticauda*	Black-bellied Tern	NT

Note: Category: CR: Critically Endangered; EN: Endangered; V: Vulnerable; CD: Conservation Dependent; NT: Near Threatened and DD: Data Deficient)

3.3.7.4 Endangered Amphibian Fauna

138. The frog species *Rana tytleri* is the only **IUCN RED DATA** category specie reported present in the site. This endangered fauna inhabits paddy field ecosystem with excessive aquatic vegetation, hence, no effect on this species in anticipated by the proposed embankment.

3.3.8. Protected Area, Restricted Area, Legislative and Others

139. No protected areas or restricted areas found throughout core zone of Palasbari Reach.

3.3.9. Wildlife Habitat, Reserved Forests, Sanctuaries, their Core Zones, Buffer Zone, Working Restrictions

140. Wildlife habitat, reserved forests, sanctuaries, their core zones, buffer zone, working restrictions are not found throughout the length of the project site in Palasbari Reach.

3.3.10. People's Dependence on Flora and Fauna

141. The local people of Khonajan from Ch. 0.0 km to Ch. 2.4 km up to Dhoptola bazaar area primarily dependent on the selling bamboos, winter crops (vegetables), and collection of wild waterfowl for their livelihood. Most of the people depend on their livelihood on those activities, whereas, the people of Gumi from Ch. 20.0 km up to Nagarbera hill area Ch. 60.0 km depend mainly on agriculture, and gathering of forest products (timber, dry leaves, and wild flowers), fishery, and minerals (granite stones from the hills, and riversand).

3.3.11. Tree Counting

142. The survey recorded altogether 271,124 individuals of trees inside the embankments and 239,092 trees outside the embankments that were counted in a belt of 200 m width from the middle of the embankment from Khonajan Ch. 0.0 km to Majigoan Ch. 0.0 km; Dokhola hill Ch. 0.0 km to Nagarbera 60.0 km (Table 3.18). These tree species will likely to be affected during project intervention as per the departmental design. Among the entire tree species bambusa species, Khokon trees, Sisso trees, and Segun trees are valuable. The embankment site has not sustained any types of medicinal plants.

Table 3.18 Tree Counting Inside and Outside the Embankments in Palasbari Reach

Tree species	Total inside the Embankment	Total Outside the embankment
Devil tree-Alstonia scolaris	0	140
Dew Cham-Artocarpus lacusha	0	196
Simul-Bombax ceiba	1736	2072
Sonaru-Cassia fistula	0	140
Tamul-Areca catachus	0	728
Khokon-Duabhanga grandifolia	0	56
Poma-Toona cialita	0	336
Bhim kol-Musa balbiciana	280	196
Bholuka banh-Bambusa balcooa*	117600	148400

Tree species	Total inside the Embankment	Total Outside the embankment
Cascabela thevetia	0	56
Atlas-Annona squamosa	476	784
Segun-Tectona grandis	112	252
Jati banh- Bambusa tulda*	145600	84000
Mokal banh-Bambusa pallida	1120	1120
Satiana-Alstonia scolaris	112	420
Bauhinia spp.	0	28
Zizyphus mauritiana	0	168
Sisso-Delbergia sisso	1036	0
Purakol-Musa spp.	700	0
Ahot-Ficus religiosa	868	0
Bor-Ficus bengalensis	112	0
Tamarix dioica	1120	0
Orozylum indicum	56	0
Zizyphus mauriciana	196	0
	271,124	239,092

Note: Data were taken 100 meters width from either side; numbers in bold are valuable compare to others
*Not in bunch but individual numbers (1 bunch=80-100 individuals)

143. This study identified a total of 40,855 individuals of economically important plants outside embankment and 17,922 individuals of economically important plants inside the embankment (Table 3.19).

Table 3.19 Economically Important Tree Species in Palasbari Reach

Tree species	Total trees Outside the Embankment	Total trees inside Embankment	Importance
Gamari-Gmelina arborea	2100	1200	Valuable timber
Bijuli banh-Bambusa pallida	3000	2400	Good market Value
Jati banh- Bambusa tulda	28200	12000	Good market Value
Kathal-Artocarpus heterophylus	1680	1080	Commercialy valuable fruit is produce
Segun-Tectona grandis	4200	0	Class-I Timber
Atlas-Annona squamosa	1200	1200	Fruit has good market value
Kadam-Anthocephalus cadamba	300	0	Fuel wood
Kolajamun-Syzygium cumini	120	0	Valuable fruits
Bholuka banh-Bambusa	55	0	Good market value

Tree species	Total trees Outside the Embankment	Total trees inside Embankment	Importance
balcooa			
Khokon-Duabhanga grandifolia	0	42	Valuable timber
Total	40,855	17,922	

3.3.12. Changes in River Ecology from Last Few Years & Its Effect on Terrestrial Ecology

144. In Palasbari Reach, a large stretch of terrestrial ecosystem had merged into the river water near Majirgoan Ch. 0.0 km to Ch 4.9 km area and Dokhola hill Ch. 0.0 km to Ch. 20.0 km. In last 40 years, an area of approximately 5 kilometers width of land has been lost from downstream of Majirgoan (from Palasbari) to Gumi Spur no. 1 due to soil erosion both during pre- and post- flood season. There was around 3 kilometers width of terrestrial ecosystem, which has been lost along the sides of Dharapur-Palasbari-Semina -Guimara area in last 20 years. During late 90's, a dense forest patch and potential biodiversity area exists from Dokhola Pahar area to Guimara, but after 17-18 year, this area has been lost to soil erosion.

145. The river ecology also has changed tremendously in Gumi Ch. 19.5 km from 7th No. Spur to Kalidas beel area due to blockage of natural river during 1974. Extensive deposition of river sands and reduction of wetland encourage reducing ground water level that hampers the terrestrial ecosystem.

3.3.13. Wetlands around Project Sites

146. There are very few perennial wetlands available near Palasbari Reach. The existing wetlands are Deepar Beel[28], Mora Kulsi (near Ch. 21.0 km), Jahirpur, Alikash, and Bejisuti-

[28] Deepar beel is a large natural wetland having great biological and environmental importance besides being the only major storm water storage basin for the Guwahati city. The beel is endowed with rich floral and faunal diversity. In addition to huge congregation of residential water birds, the Deepar ecosystem harbours large number of migratory waterfowl each year. Deepar beel has been designated as a Ramsar Site in November 2002. It supports threatened species of birds like spotbilled pelican, lesser adjutant stork, greater adjutant stork, blacknecked stork, and large whistling teal. The lake is one of the staging grounds on the migratory flyways for several species. The diversity and concentration of indigenous freshwater fish species is very high. Natural breeding of some of these species takes place within the beel itself. Phytoplankton is one of the major components of the lowest level of the producers in the Deepar beel ecosystem. The dominant species are represented by Oscilatoria sp and Microcystis sp. A total of 18 genera of phytoplankton are reported only from the core area of the Deepar beel ecosystem. The dominant aquatic plants include Eichhornia crassipes, Pistia stratiotes, Ottelia alismoides, Lemna minor, Potamogeton crispus, Vallisneria spiralis, Hydrilla verticillata, Ipomoea reptans, Azolla pinnata, Spirodela polyrhiza, Eleocharis plantaginea, Nymphaea albea, N.rubra and Sagittaria sagittifolia. The giant water lily Euryale ferox also grows here. The lake shore vegetation includes Eupatorium adoratum, Achyranthes aspera, Cyperus esculoentus, Phragmites karka, Vitex trifolia, Accium basilium, Saccharum spontaneum and Imperata arundinacea. Dominant tree species in the nearby deciduous forests include Tectona grandis, Ficus bengalensis and Bombax malabaricum. Altogether 21 genera of zooplanktons were identified in Deepar beel, the dominant species were from the groups of Cladoceran, Copepod, Rotifers and Protozoans, such as, Paramecium sp. The important benthic fauna in the Deepar beel ecosystem includes Tubifex sp., Nais sp., Pheritima sp., Dero sp., Limnodrillus sp., Chironomus sp., Bellemya sp., Bortia sp., Chaoborous sp., Culicoids sp., Dragon flylarvae, Cybister larvae, Pila globosa, Unio sp., etc. Wild Asian elephants (Elephas maximus) still visit the beel despite its proximity to Guwahati. Preliminary surveys have revealed the presence of at least 20 amphibians, 12 lizards, 18 snakes and 6 turtle and tortoise species in Deepar

Kalidas Beels. The Deepar beel wetland is situated about three kilometers south-east from the Khonajan (Ch. 0.0) area. Although, the Deepar beel ecosystem has a direct connection with the river Brahmaputra by Khonajan channel, this Khonajan channel is located outside the project boundary and has a sluice gate near Dharapur-Garigoan area. Also, from Gumi to Nagarbera project site, the wetlands are found along the stretches of land outside the embankment. Kalidas Beel (26°07'58" N and 91°01'04") support large number of fish and amphibian species, which breeds during pre-monsoon and monsoon season.

3.4. Aquatic Biology

3.4.1. Identification of Aquatic Fauna

147. All the aquatic fauna were collected from 12 different study zones. The whole stretch of river bandh was surveyed in these 12 different points *viz.* Khanamukh (9.5 km-upstream), Palasbari-Majirgaon (Ch. 0.0 Km), Gumi (Ch 22.0 Km), Last 7 spur (Ch. 11.70 Km), Majgumi (Ch 26.0 Km), Zahirpar (Ch 32.0 Km), Alikash-Taparpathar (Ch 37.0 Km), Asalpara Barakhat (Ch 39.0 Km), Bejisuta-Kalidas beel (Ch 40.0 Km), Sontoli (Ch 42.0km), Hill side (Ch 57.0 Km), Nagarbera (Ch 60.0 Km) were selected randomly for detailed observation. The details of survey points are given in Table 3.20. Some of the points were adjacent to fishing communities. The variability and number of each species in all study zones are found to be varied based on the ecological variations in these areas. As these areas are flood prone, tremendous scope of diversity of aquatic fauna is expected. The major fisheries of these areas are *Gudusia chapra, Hilsa ilisha, Salmophasia bacaila, Barilius spp etc.* Migratory fishes like *Hilsa (Tenualosa) ilisha* and *Anguilla bengalensis*, an endangered species are also encountered in the Palasbari Reach.

Table 3.20 Survey Points of Aquatic Ecology

S. No.	Survey Points	GPS Position	S. No.	Survey Points	GPS Position
1.	Khanamukh (9.5 km-upstream)		2.	Palasbari-Majirgaon (Ch. 0.0 Km)	
3.	Last spur 7 (Ch. 11.70 Km)	N: 26°05'48" E: 91°20'52"	4.	Gumi (Ch 22.0 Km)	N: 26°05'59" E: 91°22'12"
5.	Majgumi (Ch 26.0 Km)	N: 26°05'42" E: 91°19'34"	6.	Zahirpar (Ch 32.0 Km)	N: 26°05'31" E: 91°18'36"
7.	Alikash-aparpathar (Ch 37.0 Km)	N: 21°05'58" E: 91°16'25"	8.	Asalpara Barakhat (Ch 39.0 Km)	N: 26°05'38" E: 91°14'52"
9.	Bejisuta-Kalidas beel (Ch 40.0 Km)	N: 26°07'58" E: 91°01'04"	10.	Sontoli (Ch 42.0km)	N: 26°07'58" E: 91°20'52"
11.	Hill side (Ch 57.0 Km)	N: 26°05'25" E: 91°01'12"	12.	Nagarbera (Ch 60.0 Km)	N: 26°06'54" E: 91°00'40"

beel. Deepar beel harbours a large number of terrestrial and aquatic birds species, most of which are either endemic, threatened or endangered. Altogether 219 bird species have been recorded, of which 70 species are waterfowl.

148. In these areas some of the benthos e.g. Tubifex, Chironomus etc. are also found during the investigation. Presence of turtle like *Kachuga sylhetensis*, *Aspideretes gangeticus* has also been observed. Dolphins are reported to be frequently seen by the local villagers and fishermen. Besides that, Dolphins were frequently encountered at several points Including Palasbari, Gumi, Majgumi, and Jaljali River. Surfacing of Dolphins was observed in the main channel of the river.

149. The sluice gate of the Khanajan is serving the flood control measure without destroying the habitat. The Khanajan river mouth is found to be very important for fish richness and local migration of fish for breeding in the Deepar beel areas. Because of fish richness the river Dolphin[29] used to come either for foraging or breeding.

3.4.2. Aquatic or Macro-invertebrates Ecology

150. The aquatic fauna under macro-invertebrates, such as crabs, molluscs, snails, lizards, amphibians and other aquatic mammals (River Dolphin & Otter) gives a rich diversity in the project area. Besides this phytoplankton, zooplanktons were also found in abundance. The details of Fish Species, Macro-Invertebrates, Crabs, Turtles & Tortoises, Lizards, Snakes, Mammals, Plankton, Chlorophyceae, Myxophyceae, Zooplankton and Benthos observed in Palasbari Reach have been given in Appendix 3.11:

3.4.3. Fish Species Diversity

151. Total 65 species of fish belonging to 23 families has been identified in the study area. Diversity of fishes in different sites gives different results. *Salmostoma, Garra, Gadusia* etc. species are predominant in the Palasbari Reach. Hilsa is found to be more dominant in the flood seasons because it migrates through main channel of the Brahmaputra River. In winter season also Hilsa is found to migrate in a lesser number. Other fish species like minnows are found to be less in diversity in some points.

3.4.4. Faunal Behavior Pattern

152. The existing wetland at Deepar Beel at Khanamukh area, having direct connection with the Brahmaputra River, has given a rich commercial fishery in and around the Palasbari area. Kalidas Beel also supports large number of fish and amphibian species, which breeds during pre-monsoon and monsoon season. The river Dolphins also breed and play in the river water adjacent to all sites. Dolphins used to come to the connecting channels for feeding the fish where fishes are found in plenty. Other species like turtles and tortoises prefer to breed only in sandy ground near bank of the river having land river interface.

3.4.5. Migratory Route of Aquatic Fauna

[29] The Gangetic Dolphin (*Platanista gangetica)*, an extremely docile and graceful creature is an endemic species of the Brahmaputra river. Commonly known as 'Shihu' in Assam, the Gangetic Dolphins are among the four freshwater Dolphins found in the world - the other three are the Baiji found in the Yangtze river in China, the Bhulan of the Indus in Pakistan and the Buto of the river Amazon in Latin America. The presence of river dolphin in a river system signifies a healthy ecosystem. Since the river dolphin is at the apex of the aquatic food chain, its presence in adequate numbers symbolises greater bio diversity in the river system. IUCN (World Conservation Union) declared river dolphins as endangered in 1996, following which the Ganges river dolphin has been included in the Schedule - I of the Indian Wildlife Protection Act, 1972.

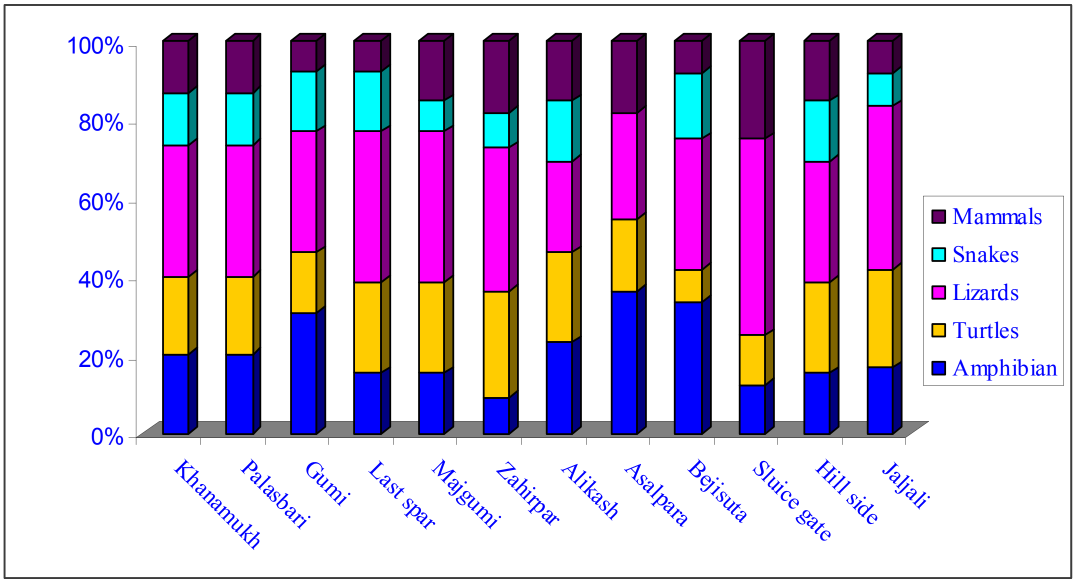
153. The migratory fish species like Hilsa and Anguilla, which have been encountered show anadromus and catadromous migratory behavior, respectively, migrating through the main channel of the river to the deeper zones of the river. Therefore, the proposed dyke construction will not have adverse effects on the migratory route. Other fish species like *Crossocheilius,* and *Tor* show only local migration from upper to lower reaches of the river.

(Source: Unpublished Ph.D. Thesis of Gauhati University submitted by M.Rahman, 2007)

Figure 3.25 Migratory Route of Hilsa

3.4.6. Areas of Eco-sensitivity/ Protected Area/ Restricted Area/ Legislative and Others:

154. No such eco-sensitivity areas, protected area, restricted area, and legislative areas were found in the project sites but the areas between coordination of 26°07'58" N, 91°01'04" E and 26°07'58" N, 91°20'52" E supports comparatively very good vegetation types on the bank of the proposed project areas. Therefore, the bank of the river having sandy beds should not be disturbed during the project intervention. Special care should be taken to keep the breeding habitats in their natural conditions.



(Source: Field Survey)

Figure 3.26 Abundance of Different Aquatic Vertebrates other than Fish

3.4.7. Identification of Endemic/ Threatened and Endangered Species

155. 4 fish species are found under endangered category, namely *Anguilla bengalensis, Tor tor, Garra gotyla stenorhynchus, and Laguvia shawi.* Besides fish, Turtles, few amphibians, and Dolphins are also under Schedule-I endangered species.

3.5. Socio-Economic Environment

3.5.1. Demography

156. Palasbari sub project area lies in Kamrup district. It is located in the south west part of Assam state with 14 revenue circles and 17 blocks. There are 1393 villages in the district and out of which 332 villages were located in the sub project area. The Palasbari reach falls in 6 Revenue Circles as per the land records, namely, Goroimari, Chaygaon, Chamaria, Nagarberra, Boko, and Palasbari. These circles consist of a total of 332 villages along the reach in the core and buffer zones. The general details of demography of the Palasbari reach are given in Table 3.21.

Table 3.21 Palasbari: General Details

Revenue Circle	Area (ha)	Villages	No. of Households	Total Population	Population Density (persons/km^2)
Goroimari	17340	75	16771	103084	594.5
Chaygaon	13249	53	13588	73583	555.4
Chamaria	14681	60	16147	99919	680.6
Nagarberra	10961	28	10743	61514	561.2
Boko	17677	64	11636	61832	349.8

Revenue Circle	Area (ha)	Villages	No. of Households	Total Population	Population Density (persons/km^2)
Palasbari	14765	52	20883	113598	769.4
Total	88673	332	89768	513530	585.1

Source: Census of India 2001

157. In the subproject areas, people are always vulnerable to physical risks – i.e., displacement by erosion and flooding, which further produces social and economic vulnerability. As a result, the subproject areas have more BPL houses (compared to national average of 26%). Then there are cases of female-headed households and elderly. In the context of erosion, many households fall within the multiple vulnerability category. The subproject location is marked by the presence of the people belonging to General, OBC, SC and ST categories. Nearly 50% of those surveyed are either landless or marginal farmers due to loss of land to the river. Around 25% live on daily wages, including those who earn a living as migrant worker (i.e., *hajira*) and others are dependent on agriculture and livestock.

158. The economy of Kamrup district and sub project area was mainly agriculture, livestock and timber market.

159. As revealed by the dataset in the succeeding Table, the population density in the revenue circles ranges from 349.8 persons per km^2 in Boko to 769.4 persons per km^2 in Palasbari. The average population density in the study area is 585.1 persons per km^2. The population profile of the revenue circles along the Palasbari reach with respect to male, female, schedule castes (male and female), schedule tribe (male and female) have been given in Table 3.22.

Table 3.22 Palasbari: Population Profile

Revenue Circle	Total Pop'n.	Male	Female	SC	S C_M	SC_ Female	ST	ST_M	ST_F
Goroimari	103084	53112	49972	2314	1176	1138	256	143	113
Chaygaon	73583	37816	35767	4074	2071	2003	15018	7671	7347
Chamaria	99919	51907	48012	11980	6324	5656	357	190	167
Nagarberra	61514	31837	29677	7825	4105	3720	83	38	45
Boko	61832	31514	30318	2280	1148	1132	34237	17386	16851
Palasbari	113598	58297	55301	12951	6614	6337	1277	640	637
Total	513530	264483	249047	41424	21438	19986	51228	26068	25160

Source: Census of India 2001

160. The percentage distribution of population with respect to General, SC and ST male as well as female population in the different revenue circles of the area are illustrated in Figure 3.27.

Figure 3.27 Percentage Distribution of Population by Social Groups

3.5.2. Education

161. Based on 2001, 74.16% population was literate in the district, ahead of Assam state average of 63.25%. The education facilities in the region are distributed mainly in the form of

Primary, Middle, Secondary and Senior Secondary schools mainly. Out of 332 villages, 296 villages have any form of educational facility within their boundary. As many as 6 Colleges, 12 Adult Literacy Centers and 12 other education facilities are also available in the region. The details of education facilities in the revenue circles have been presented in Table 3.23. The pattern of distribution of these facilities, revenue circle-wise, is illustrated in Figure 3.28

Table 3.23 Education Facilities in the Palasbari Reach

Revenue Circle	Villages with Educ. Facility	No. of 1° School	No. of Middle School	2° School	Sr. 2° School	College	No. Adult Literacy Class/ Centers	Other Educ. Facilities
Goroimari	59	127	33	16	1	1	0	0
Chaygaon	50	97	25	13	2	1	0	0
Chamaria	53	89	27	5	0	2	11	11
Nagarbera	27	84	24	7	1	0	1	1
Boko	62	101	34	13	0	2	0	0
Palasbari	45	98	29	14	3	0	0	0
Total	296	596	172	68	7	6	12	12

(Source: Census of India 2001)

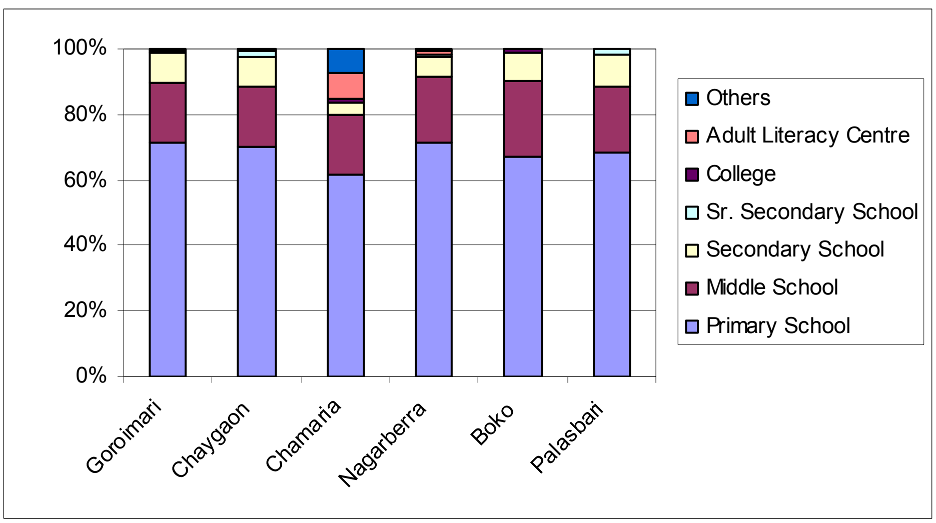


Figure 3.28 Distribution Pattern of Education Facilities in Revenue Circles

3.5.2.2 Peoples Dependence on Aquatic Fauna

162. Almost 55% people are dependent on fishing in the surrounding areas of Gumi, Majgumi, Alikah, and Bejikhuta. There are several beels used for fishery activity. Most of the households maintain their own fish ponds and almost one third of the households are involved in fishery activity. Besides fishing most people depend on the river Brahmaputra for bathing and irrigation in paddy field.

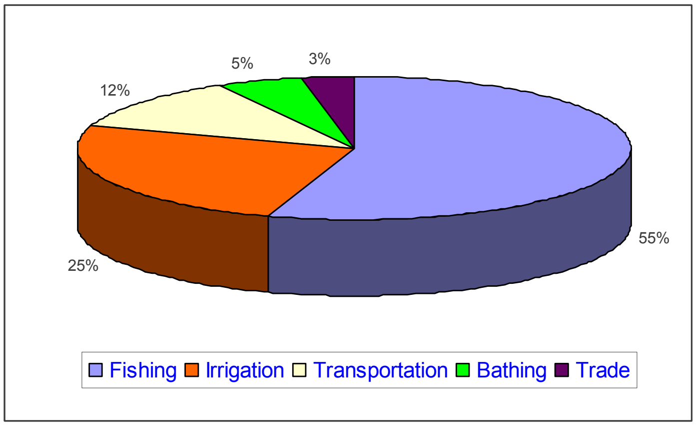


Figure 3.29 Dependency on Aquatic Fauna

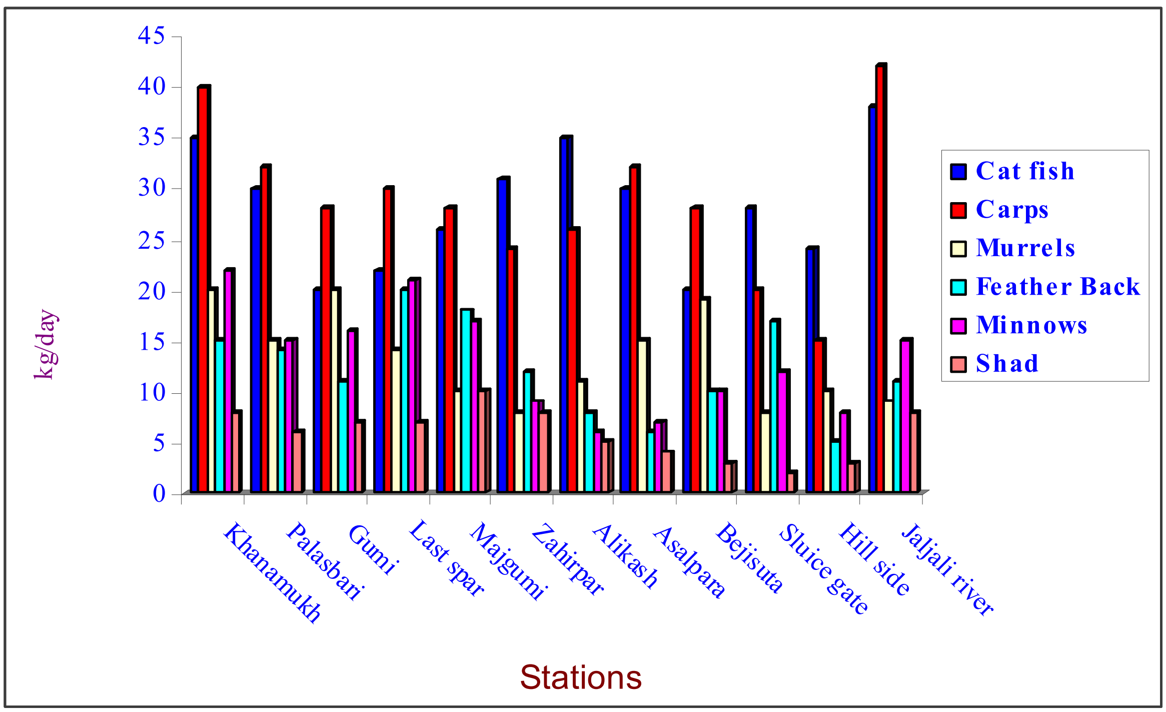


Figure 3.30 Average Fish Landing in Different Stations along the Palasbari Reach

(Source: Market Survey)

3.5.3. Industries

163. The entire area along the Palasbari reach does not have any major industry. People are mainly dependent on fishing and agricultural activities for their livelihood. A few small scale/ household industries are present in the area, which are mainly focused on manufacturing of Gunny Bags, Jute Products, Bricks, Pat Muga, and production of Species and Mustard Oil. The

distributions of these industries in various revenue circles along the Palasbari reach are given in Table 3.24.

164. Timber furniture was popular activity in the area with huge market potential in Guwahati and nearby urban areas.

Table 3.24 Palasbari Reach: Industrial Profile

Revenue Circle	Gunny bags	Jute products	Spices	Mustard oil	Bricks	Pat Muga	Others
Goroimari	0	0	0	0	0	0	0
Chaygaon	0	0	0	0	0	0	0
Chamaria	9	10	0	1	0	0	20
Nagarberra	0	6	1	0	0	0	7
Boko	0	0	0	0	0	0	0
Palasbari	0	0	0	0	1	1	2
Total	9	16	1	1	1	1	29

Source: Census of India 2001

3.5.4. Connectivity

165. The villages in the 6 Revenue Circles are mostly connected through paved roads. Also, the connectivity is through unpaved (mud) roads, footpaths, navigable river as well as waterways other than river. Poor accessibility from village settlements to the amenities and facilities was experienced in every rainy season due to the water stagnation and flooding for at least four months. The details of the connectivity has been shown in Table 3.25:

Table 3.25 Palasbari Reach: Connectivity

Revenue Circles	Total No. of Villages	Approach Paved Road	Approach Mud Road	Approach Footpath	Approach Navigable River	Approach Waterway other than River
Goroimari	75	60	71	0	0	0
Chaygaon	53	52	53	6	0	0
Chamaria	60	53	21	1	7	1
Nagarberra	28	17	24	0	14	2
Boko	64	59	61	0	0	0
Palasbari	52	36	47	3	4	2
Total	332	277	277	10	25	5

3.5.5. Power Facilities

166. Power facility in the Palasbari Reach area is not available in all the villages. Only 73.5% villages have electrical connections. Mostly, power is available only for domestic usage. Only in 4 villages, power is also available for agricultural activities.

Table 3.26 Palasbari Reach: Power Facilities

Revenue Circle	Total Number of Villages	Villages having Power Supply	Villages with Power for Domestic Use	Villages with Power for Agricultural Use	Villages with Power for Other Uses
Goroimari	75	40	37	0	0
Chaygaon	53	45	42	0	1
Chamaria	60	40	40	3	0
Nagarberra	28	15	15	1	1
Boko	64	57	57	0	0
Palasbari	52	47	47	0	3
Total	332	244	238	4	5

Source: Census of India 2001

3.5.6. Drinking Water Supply

167. Main source of drinking water in the entire Palasbari reach is groundwater. Water is available through wells, tube wells, hand pumps, and river. An inventory of the drinking water facilities throughout the year in the villages of Palasbari Reach are given in Table 3.27.

Table 3.27 Drinking Water Facility

Revenue Circles	TAP	WELL	TANK	TUBEWELL	HANDPUMP	RIVER	OTHER
Goroimari	1	61	0	57	13	24	0
Chaygaon	12	46	3	35	18	0	0
Chamaria	2	12	0	40	19	15	6
Nagarberra	7	22	4	5	23	3	0
Boko	4	38	13	35	26	5	0
Palasbari	15	31	0	18	28	17	1
Total	41	210	20	190	127	64	7

Source: Census of India 2001

168. During summer season, out of 332 villages, drinking water is available from tube wells, hand pumps and wells in 107, 80 and 87 villages, respectively. Tap water is available only in 9% villages. The distribution of drinking water sources in different revenue circles is illustrated in Figure 3.31:

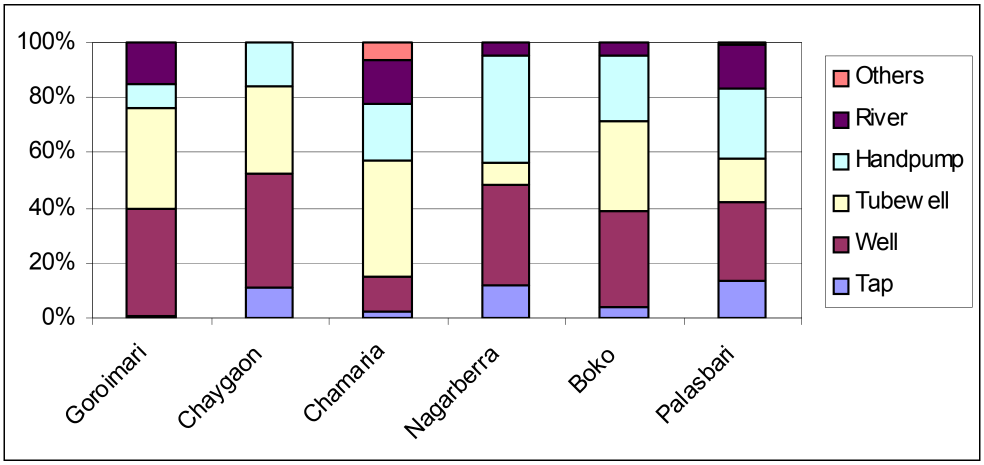


Figure 3.31 Distribution of Drinking Water Sources in Different Revenue Circles

Table 3.28 Sources of Drinking Water during Summer Season in Palasbari Reach

Revenue Circle	Total Number of Villages	Tap Water	Tube Well	Hand Pump	River	Well	Tank
Goroimari	75	1	30	4	3	33	0
Chaygaon	53	9	15	11	0	16	2
Chamaria	60	1	29	19	4	7	0
Nagarberra	28	6	3	9	0	10	0
Boko	64	3	19	18	0	13	10
Palasbari	52	10	11	19	1	8	0
Total	332	30	107	80	8	87	12

Source: Census of India 2001

169. There are public water supply schemes in some villages. The local bodies are operating the schemes. In town areas, about 50% households have latrines. The villages and other urban settlers however, practicing open defecation. There is no formal drainage system in the villages.

3.5.7. Medical and Health Facilities

170. Illness such as skin diseases, malaria, diarrhea, and dysentery were prevalent in the subproject area. Skin diseases were reported as major concern as it stricken almost every household member in all villages. In case of illness, most of the households consult faith healer available in the village. Some households consult Ayurvedic doctor in the village in nearby places. If the illness is not remedied by the local faith healers or Ayurvedic doctors, the patient then avail of services of local health centers about 2-5 km from the villages

171. The primary medical facility is available in most of the villages falling in the study area along the Palasbari Reach. The details of the health care facilities are given in Table 3.29.

Table 3.29 Medical Facilities

Revenue Circle	AD	AyD	MCW	MH	CWC	HC	PHCs	PHsC	FWC
Goroimari	0	0	0	0	0	0	0	6	13
Chaygaon	2	0	0	0	16	0	3	9	7
Chamaria	1	0	10	0	9	0	1	6	3
Nagarberra	2	0	0	0	2	0	2	6	6
Boko	7	1	3	1	10	0	3	9	7
Palasbari	7	0	0	0	1	0	6	2	9
Total	19	1	13	1	38	0	15	38	45

Note: AD- Alllopathic Dispensaries
AyD – Ayuverdic Dispensaries
MCWC – Maternity and Child Welfare Center
MH – Maternity Homes
CWC – Child Welfare Centers
HC – Health Centers
PHC – Primary Health Centers
PHsC –Primary Health Sub-Centers
FWC – Family Welfare Center
Source: Census of India 2001

172. Due to widespread impact of floods on amenities such as sanitation and water, the communities often experience outbreak of diseases such as malaria, diarrhoea, cholera, jaundice and other water borne diseases. During the floods, accessing medical facilities become very difficult due to the unavailability of means of transport. Also, with lack of work (during floods, as shared above) many people don't go to the doctor for treatment due to the unavailability of money. Within the Government organised flood camps, much medical facilities are not available. In the past, many people used to die of diseases post-flood in the area, but with better medical facilities while the situation has improved it still needs to be catered to. The community shared that in instances of child birth, local "dais" (midwives) carry out the delivery during the flood times on the raised platform called "*saang.*

3.5.8. Land use

173. As per the revenue records, the areas under different land use categories in the villages falling under the core/ buffer zone of Palasbari reach are given in Table 3.30.

Table 3.30 Landuse

Revenue Circle	Forest Land (ha)	Land without any Irrigation Facilities (ha)	Land with Irrigation Facilities (ha)	Culturable waste land (ha)	Area not Available for cultivation (ha)	Total land area (ha)
Goroimari	0	9813	521	1003	5996	17340
Chaygaon	6	6832	3182	1530	1692	13249
Chamaria	0	10693	254	1723	2006	14681
Nagarberra	1145	5315	1023	2482	994	10961
Boko	3326	9599	728	1820	2205	17677
Palasbari	38	8060	273	2760	3628	14765
Total	4515	50312	5980	11317	16521	88673

Source: Census of India 2001

174. The pattern of land use is further illustrated with the help of pie graph in Figure 3.32. It shows that the land without any irrigation facilities occupy about 56% of the geographical area.

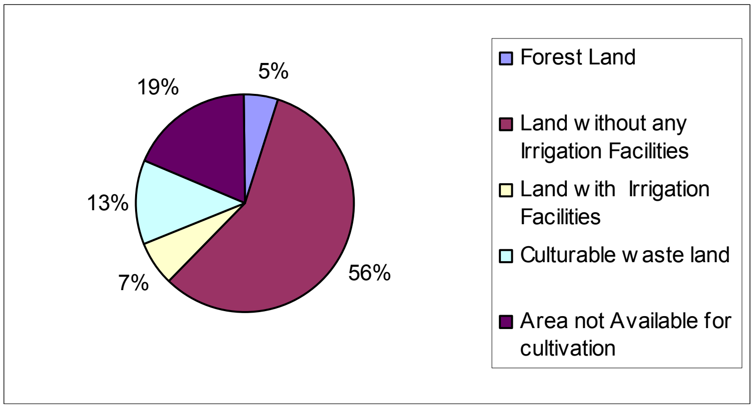


Figure 3.32 Distribution of Land use

175. The locations of various types of educational, social, religious and other institutions of social importance within the 100 m direct impact corridor around the embankment were obtained using a handheld GPC and the data were subsequently plotted on the satellite image of the tract with the help of GIS. The distribution of the institutions is shown in Figure 3.33, while the data are presented in Table 3.31.

Table 3.31 Establishments Located within 100 m Impact Zone

Facility	Majirgaon-Dakhala		Dakhala hill- Gumi		Gumi-Nagarbera	
	CS	RS	CS	RS	CS	RS
Education Facility						
L.P.school	2	Nil	2	Nil	9	1
M.E.school	1	Nil	Nil	Nil	4	Nil
High School	1	Nil	2	Nil	4	Nil
Madrassa	Nil	Nil	Nil	Nil	3	Nil
Relegious and Cultural Heritage Facilities						
Temple	3	Nil	2	Nil	Nil	Nil
Namghar(prayer Hall)	2	Nil	2	Nil	1	Nil
Mosque	Nil	Nil	2	Nil	9	1
Graveyard	Nil	Nil	Nil	Nil	1	Nil
Cremation ground	1	Nil	Nil	Nil	Nil	Nil
Id-gah maidan	Nil	Nil	Nil		1	Nil

Source: Field Survey

3.5.9. Distribution of Land use

176. The baseline survey which covered 10% of the villages in the Palasbari Reach revealed the proportion of households in each of the land holding category. About 18% households have

land holding above 2 ha while the remaining are either marginal holders or landless. Due to erosion, landowners are displaced which increases the number and proportion of marginal and landless households. About 600 hectares is loss due to erosion annually in the Palasbari Reach.

Table 3.32 Distribution of Land Holding by Category: Palasbari Reach

Class	Land Holding Category	Category as defined by Government of India	% of households in each category
A	Large Land Holder	Land owned more that 7.01 ha.	1.64
B	Medium Land Holder	Land Owned 4.01 ha to 7.00 ha	6.09
C	Small Land Holder	Land Owned 2.01 to 4.00 ha.	10.77
D	Marginal Land Holder	Up to 2.00 ha	26.25
E	Land Less	Household without land holding	55.25

177. In the past years, WRD built embankments for flood control in the subproject area. Retired embankments had to be built due to breaches and/or failure of existing embankments during high floods. The embankments provided substantial benefits to the local communities in terms of protection against loss of crops, assets and displacement. However, those affected by land acquisition for flood control embankments did not receive compensation as provided in the Assam Land (Requisition and Acquisition) Act of 1964 Compensation remained an outstanding issue for households who lost land due to construction of embankments. In Palasbari subproject 8 major LA case are pending from 1984 to 2000, which is now being addressed by WRD in the context of preparing the subproject proposal under the IFRERM Assam.

3.5.10. Occupational Pattern

178. The baseline survey revelade that more than 50% households in the Palasbari Reach were involved in agriculture, livestock, and fishing activities in a small land holding that are not economically viable to feed a large size households. This indicates that at least one member of each household has migrated to Guwahati for day labor. This migration of workers is considered as a major source of household livelihood. It was also estimated based on the survey that about one third of the working population was engaged in service sector – job with government or private sector. Remaining households were involved in activities such as timber, marketing, business, transport and other artisan activities.

179. Agriculture and wage/day labor are principal occupations in the area. While 52% are involved in agriculture, nearly 22% are engaged in daily labor activities. The incidence of landless is high in both the subproject locations. On an average, nearly 40% of the population in the subproject area are poor. After losing their land to erosion and floods in the past, majority of the households are now involved in doing "*haajira" (wage labor)* to meet their daily subsistence needs. However, during floods, the area is all flooded with water, with no means of transportation; people are not able to go to work and stay at home. Flood means no work for them, making it even more difficult for households to take care of household expenses and meet basic needs.

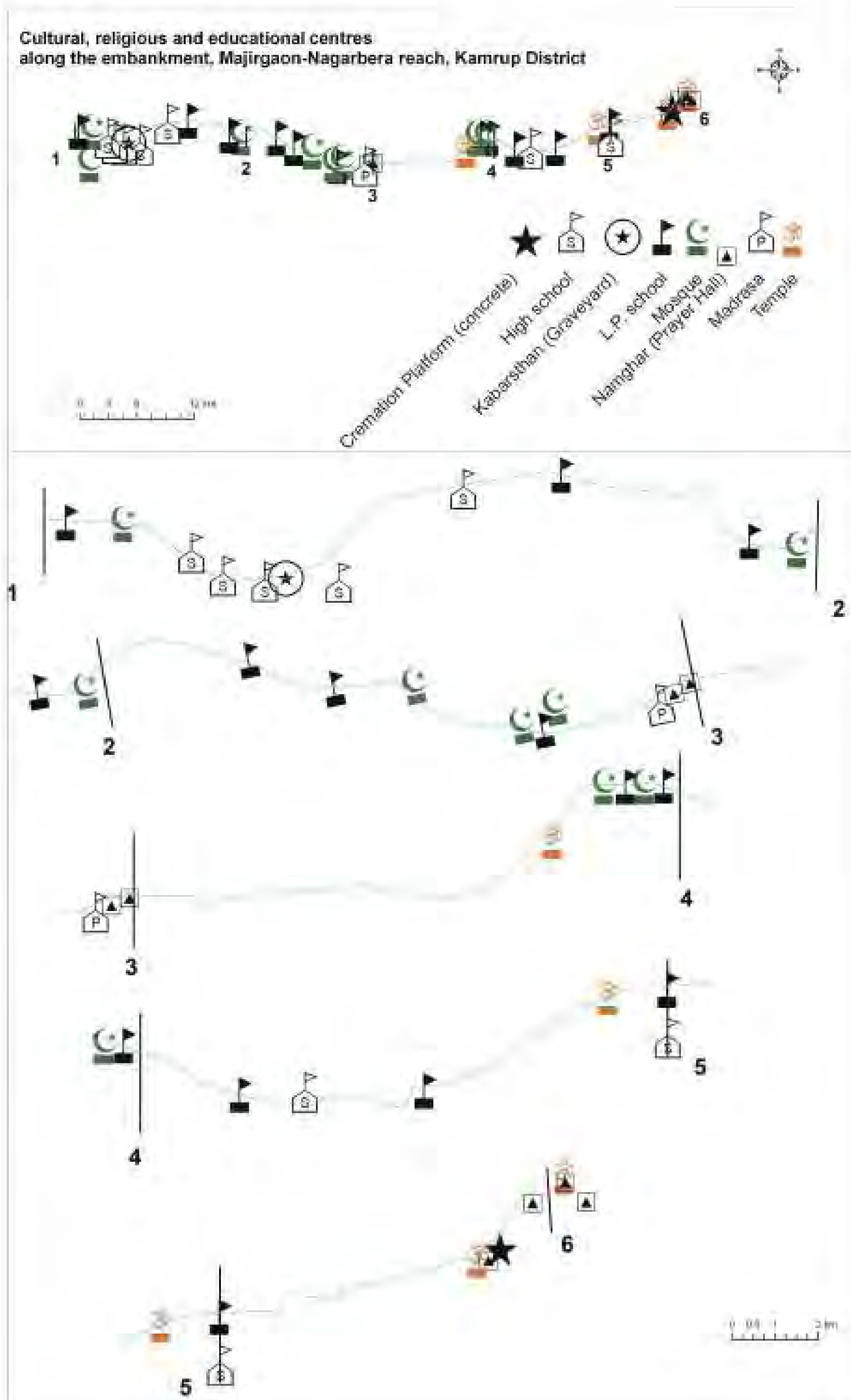


Figure 3.33 Social Establishments in 100 m Impact Corridor

4. ALTERNATIVE ANALYSIS

180. The analysis of alternative is an effective tool to examine the number of options (locational & technological) and establishing most environmentally favorable alternative which cause minimum environmental loss to the natural and social environment. However, since the suproject is site specific, i.e., aims to sustain the functions of the existing flood embankment systems protecting a large number of people and landmass from frequent devastating flooding and riverbank erosion of the Brahmaputra River, the scope for assessing alternatives to the project is limited. It includes the retirement of 4.9 km of Brahmaputra dyke from Majirgaon to Dakhala Hill, revetment of 4.0 km length in this section and 3km of revetment in Gumi area (tranche-1), revetment of a total of 13.6km sections in Majirigaon, Tarparpatha, and Gumi, construction of 2 gated drainage sluices, and rehabilitation of 3 boulder deflectors.

4.1. Alternatives to the Project

181. Under the alternative assessment, the "without project" option was considered and compared against the "with project" option as an alternative analysis. In addition, an intermediate option of continuous or repeated embankment retirement in response to the progress of riverbank erosion was considered as another alternative, as opposed to providing riverbank protection works under the "with project" scenario. Within the "with project" option, various revetment options, such as cement slabs, geo-textiles, sand bags, and porcupines, were assessed from its environmental suitability perspective and the most cost-effective option suitable for the river environment was adopted.

4.1.1. 'Without Project' Option

182. **Physical Environment**. In the ‘without project’ scenario, loss of precious land at the rate of about 90.1 ha/year will continue due to river bank erosion. Siltation of land due to flood will result to reduced productivity or loss of single crop. No effect on ambient air and noise quality is anticipated. The sedimentation level in wetlands and river bank may continue to increase due to erosion or flood.

183. **Biological Environment**. In the ‘without the project’ scenario, the present species composition of the vegetation, fisheries and wildlife is expected to remain unchanged. In normal conditions (no flood scenario), no change is anticipated in fish productivity of wetlands, pond fisheries, or productivity of agricultural land. However, loss of vegetation or loss of agricultural productivity, loss of pond fisheries productivity would be high during floods.

184. **Socio-economic Environment**. Without the project, large number of population will remain vulnerable to flood effect. Even the current rate of erosion to the tune of about 90.1 ha every year is a big loss of agricultural land and settlement areas. Flood also causes many linked socio-economic and health problems.

4.1.2. 'With Project’ Option

185. **Physical Environment**. In the ‘with project’ scenario, no change is expected in air, soil and water conditions. The air pollution and noise levels are likely to increase during construction phase but will be confined within the close vicinity of construction sites and will be temporary in nature. The bank protection measures will prevent loss of about 90.1 ha/year of productive land and will prevent increase of sedimentation load to river equal to 53.82 ha/year of land area.

186. **Biological Environment** In the ‘with project’ scenario, there is likelihood of improved fish productivity from wetland and pond fisheries. No significant impact is expected in terms of increase in sedimentation level or fish productivity during construction stage. With the implementation of mitigation measures the overall impact of the project is likely to be nil or positive on the biological environment except in terms of loss of trees which will be minimized and also regenerate over a period of time due to proposed tree plantation program.

187. **Socio-economic Environment**. The ‘with project’ scenario is also likely to bring stability to the economy of the area. It will facilitate conservation of large area from erosion (90.1 ha/year), which means increased agricultural produce. Farmers will be able to plant three crops, instead of two crops in a year. Wetlands and pond fisheries productivity will improve due to reduce siltation load and improved fishery practices. The project will also provide better commuting opportunities to fishermen and people of the area through the paved road on the embankment, which means reduced commuting time to reach the markets. The flood protected environment may also promote agro-based industries in the area. The post-project scenario will enhance overall economy of the area.

4.1.3. 'Repeated Embankment Retirement’ Option

188. **Physical Environment.** This option involves the retirement of flood embankments in response to the riverbank erosion process, with the acquisition of land and compensation to the affected people. In this scenario, loss of land at the rate of about 90.1 ha/yr (reaching 2,703 ha in 30 years) will continue due to riverbank erosion. There is also a possibility of frequent flood inundation in the subproject area, unless the retired embankment can be constructed before the existing embankment is breached due to the river bank erosion.

189. **Biological Environment.** In this option, the eroded land will turn into a river channel turning into an aquatic environment. The environment of floodplain and wetlands during the monsoon season will depend on the timing of constructing the retired embankment against the breach of existing embankment due to erosion. For other seasons, no change is anticipated in fish productivity of wetlands, or productivity of agricultural land.

190. **Socioeconomic Environment.** Since this option involves continuous river erosion, there will be displacement of people associated with 2,703 ha of land in 30 years to be lost due to river erosion, of which agriculture productivity will be lost. The similar economic benefits may be delivered in case of timely construction of retired embankment prior to the breach of existing embankment due to river erosion. However, there is a risk of failure given the lengthy procedures for land acquisition and opposition from the concerned population in the subproject areas (when compared with the ‘with-project’ option), in which case there will be repeated flood damages, affecting the confidence of local population on the reliability and effectiveness of FRERM systems leading to much less positive socio-economic impacts as compared with the ‘with-project’ option.

4.1.4. Repeated Embankment Retirement vs With Project (riverbank renovation, plus minimum retirement)

191. A comparative synthesis of the two options, i.e., "repeated embankment retirement" vis-à-vis "with project" (riverbank renovation with minimum retirement) is shown below.

Table 4.1 Analysis of Environmental Impact Parameters for the Shifting Vs Renovation of Embankment

Environmental Parameters	Repeated Embankment Retirement		With project (riverbank renovation, plus minimum retirement)	
	Type of Impact	Mitigation	Type of Impact	Mitigation
Natural Environment				
Land Use	The land use will change in the area of dkye retirement[30] Land loss due to erosion at Palasbari is estimated at 90.1 ha/yr of which 53.8 ha/yr is agricultural land and corresponding economic lost of Rs 1.83 million.	It will be permanent change and can not be mitigated.	No change, except cutting of tree construction. Security from flood will increase the cropping intensity and productivity, which may lead to increase use of agriculture chemicals.	Farmer training on the proper use of agriculture chemicals, and integrated pest management.
Soil Erosion and Siltation	Will be controlled, but sudden erosion progress may breach the dyke and cause siltation.	Erosion prediction, and longer set-back distance between bank line and dyke is needed	Will be controlled.	-
Hydrology /Flooding	No change in hydrology. Flood will be controlled. The vulnerability to erosion-caused breach and flood would be higher.	-	No change in hydrology. Flooding will be controlled.	-
Drainage Congestion	No change compared with the present condition	-	No change compared with the present condition	-
Landscape	Will change to the extent of embankment width. The need of borrow earth will be more. The borrow pits will change the landscape of the area	The effect can be minimized by rehabilitation of borrow areas and planting more trees. Earth can also be borrowed from existing embankment	No change except cutting of some trees and borrowing the earth for renovation and strengthening	The effect can be minimized by rehabilitation of borrow areas and planting more trees
Ecological Parameters				
Fisheries, Wild Life, Wetlands, Forests,	No change except loss of some homestead ponds.	Ponds can be built again	No change	-

30 The data show that the homestead plantations cover the largest areas ranging from a maximum of 33.24 ha in the strip covered by the Panchayat bundh (ch. 2.40 km – 9.50 km) followed by 15.26 ha in the strip from ch 9.5 (0.00 km) to 14.40 km (4.90 km) to a minimum of 8.84 ha in the ch. 0.00 km to 2.40 km. There is also agricultural land ranging in area from 2.28 ha to 3.22 ha in the entire 50 m wide strip. Beyond 50 m, it is mostly agriculture land and homestead plantation

Environmental Parameters	Repeated Embankment Retirement		With project (riverbank renovation, plus minimum retirement)	
	Type of Impact	**Mitigation**	**Type of Impact**	**Mitigation**
Endangered species, Beels, Water bodies	Wider areas will become river course.			
Tree Cutting	Yes involved, but number of trees to be cut would be more, due to the frequent embankment retirement requirement.	Tree loss can be compensated with aforestation plan, but with higher cost compared with "with project" conditions.	Since most of the trees are located close to embankment, within 50m strip, the tree loss is unavoidable. However trees loss will be less as backward shifting will be minimal.	Tree loss can be compensated with aforestation plan
Environment Pollution				
Air pollution, Surface & Ground Water Pollution, Noise & Vibration, Soil Quality Contamination, Waste Disposal	The pollution on all these components will occur primarily during construction stage. During operation stage also air pollution and accidental soil contamination may occur due to increased traffic on paved road on embankment top. The significance will be more, due to the more frequent construction works.	The impact can be minimized by adopting appropriate control technology and plantation of trees	The pollution on all these components will occur primarily during construction stage. During operation stage also air pollution and accidental soil contamination may occur due to increased traffic on paved road on embankment top.	The impact can be minimized by adopting appropriate control technology and plantation of trees
Social Environment				
Homestead Loss, Land Acquisition, Income loss,	Much more significant since more land acquisition will be involved, and much more land will be lost due to erosion. People residing close to the embankment will have to shift, along with people living on the land to be eroded.	Compensation for people on the land acquired for shifting the flood embankments. For people whose land will be lost due to river erosion, support needs to be arranged for them to restore the livelihoods.	Some people who are residing on the embankment or close to embankment will have to shift	Due to compensation, loss can be mitigated
Historical and Cultural Loss, Navigation and Water Transport	Some facilities may be lost due to progress of river erosion.		Not Affected	

Environmental Parameters	Repeated Embankment Retirement		With project (riverbank renovation, plus minimum retirement)	
	Type of Impact	**Mitigation**	**Type of Impact**	**Mitigation**
Health and Safety, Road Accident	Not affected. However health issue may develop if sanitation is not maintained at construction camp. Incident of accident may occur during operation stage due to increased traffic speed on paved road on embankment top	With appropriate sanitation measure in the construction camp and speed control these impacts can be minimized	Not affected. However health issue may develop if sanitation is not maintained at construction camp. Incident of accident may occur during operation stage due to increased traffic speed on paved road on embankment top	With appropriate sanitation measure in the construction camp and speed control these impacts can be minimized
Infrastructure Development, Road Transport, Industries	Will improve. There would be some stress on rural road during construction stage but it will be short lived.	-	Will improve. There will be some stress on rural road during construction stage but it will be short lived.	-
Split of Communities, Ethnic Minorities and Indigenous People	Not affected as no such issues involved		Not affected as no such issues involved	

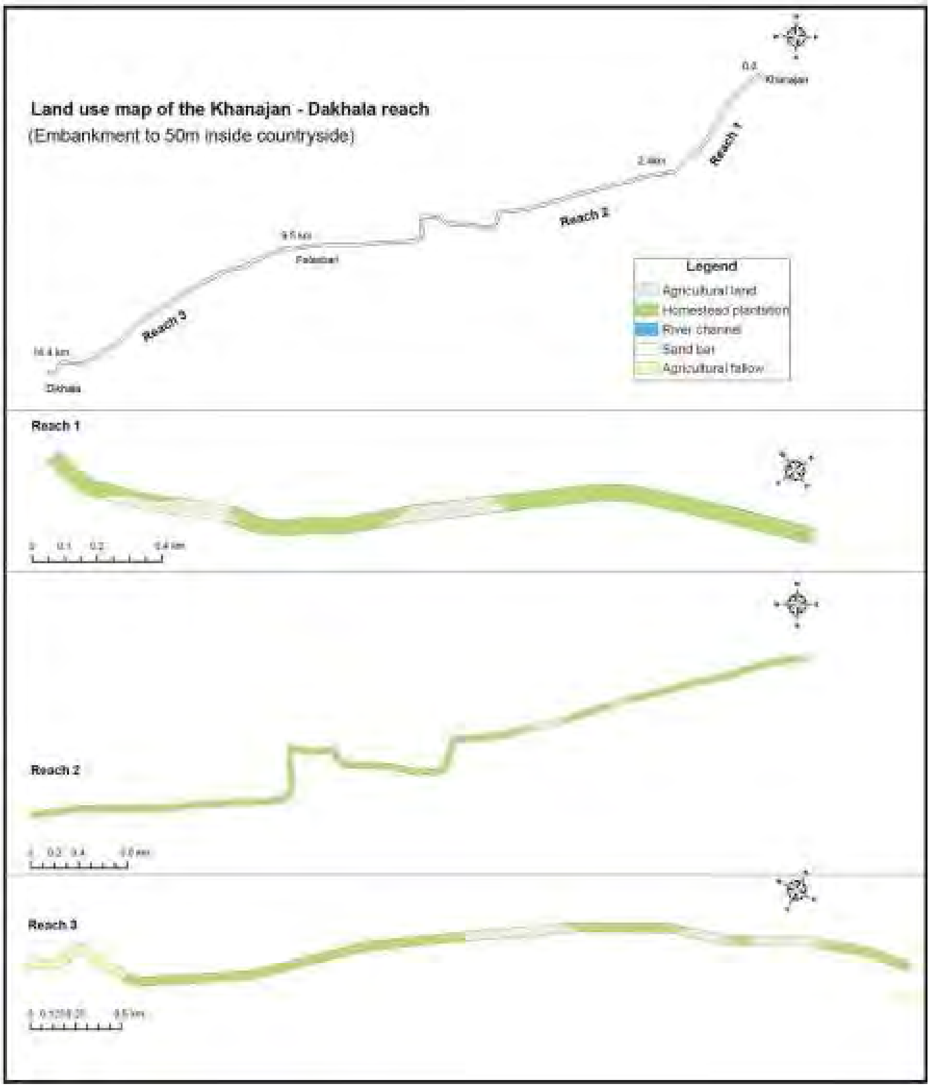


Figure 4.1 Land use Map (Khanajan to Dakhala) (Embankment to 50 m inside country side)

Table 4.2 Land use in Khanajan to Dakhala (embankment to 50 m inside country side)

Class	Area (ha)	Area (%)
Homestead Plantation	57.3417	79.03008
Agricultural Land	12.0868	16.65837
Agricultural Fallow Land	3.1162	4.29489
River Channel	0.0121	0.016655
Sand Bar	0.0001	0.000171
Total	72.5569	100

4.1.5. Conclusion

192. During the EIA, a number of public consultations have also been carried out with the local communities and stakeholders. The overall findings of the meetings are that most of the people consider riverbank erosion as the major threat to their livelihoods causing severe social and economic hardships let alone environmental disbenefits. They are strongly in favor of the 'with-project' option with riverbank protection measures against 'without-project' option. As to the comparison of 'with-project' and 'embankment retirement' options, local people are opposing the latter option, in view of the severe displacement impacts of the affected people in the riverine areas at large, saying that there is not enough land within the project area to resettle people displaced by the riverbank erosion.

193. Under the circumstance, and in light of the assessment of the available alternatives as shown above, the 'with-project' option is deemed as the optimal solution, as far as its feasibility and sustainability during its project life and beyond can be ascertained. It will generate overall positive social, environmental, and economic impacts and their negative impacts can be mitigated through appropriate safeguard measures as defined under the EIA and the social safeguards assessments. Strong ownership was also shown by the concerned local stakeholders in terms of their willingness to participate in the planning, implementation, and post-implementation stages of the suggested interventions. These will be pursued with the necessary participatory and institutional strengthening arrangements included in the design of the IFRERM Assam.

194. Considering the above analysis, the renovation and strengthening option is environmentally preferred, but technically not stable. However, from embankment stability purposes, if retirement option will be considered, the same can be preferred provided social issues are well addressed. The other related environmental issue like tree loss etc can be duly compensated through compensatory tree plantation.

5. ANTICIPATED ENVIRONMENTAL IMPACTS AND MITIGATION MEASURES

195. Based on the compiled information, attempts have been made to assess the present environmental status of the Palasbari Reach and identification of Valued Ecosystem Components (VECs). Preliminary environmental surveys along the Palasbari Reach was conducted coupled with detailed study of flood patterns, erosion, available topographic maps, satellite imageries, collection of baseline data from primary and secondary sources, etc. During the survey, a number of discussions were held with the people in the localities including those presently living along the various stretches of the Palasbari Reach. Some NGOs working in the areas were also consulted. The details of public consultation are furnished in Chapter 8. The ADB's Rapid Environmental Assessment (REA) checklist for irrigation projects[31] was used for identifying the valuable ecosystem components in the region. (Refer APPENDIX 2.2)

5.1. Valuable Ecosystem Components

196. The VECs identified in the Palasbari Reach are as follows:

- Land
  - Soil erosion
  - Change in land use
  - Soil compaction & Soil Contamination
- Hydrology & Morphology
  - Upstream & Down stream Effect
  - Flood Effect
  - Effect on river water levels/flow velocity/discharge intensities
  - Effect on drainage system
  - Silt Disposition and Bed level Changes
  - Effect on Wetland & Beels
  - Water Quality
- Climate
- Air
  - Change in air quality
- Noise
  - Change in ambient sound pressure levels
- Terrestrial Ecology:
  - Disturbance to Vegetation
  - Habitat fragmentation and destruction
  - Animal distribution & Migratory routes
  - Endangered species
- Aquatic Ecology
  - Effect on fish Activity & Productivity

[31] Under ADB Environmental Assessment Guidelines 2003, only following 16 REIA checklists have been defined: (i) Irrigation, (ii) Fisheries, (iii) Forestry, (iv) Hydropower, (v) Thermal Power Plants, (vi) Power Transmission, (vii) Agro Industrial Projects, (viii) Chemical-based Industrial Projects, (ix) Petrochemical Industrial Projects, (x) Urban Development, (xi) Water Supply, (xii) Solid Waste Management, (xiii) Sewage Treatment, (xiv) Airports, (xv) Ports and Harbors, (xvi) Roads and Highways, (xvii) Governance and Finance. Taking into consideration all the REA checklists, "Irrigation REA checklist" was found the most closer to the nature of IFRERM project activities.

    - Effect on spawning and breeding ground
    - Effect on pond fisheries
- Socio-economic
    - Effect on Establishments
    - Effect on Archaeological sites
    - Water Supply & Sanitation
    - Socio economic Impacts
    - Accident & Safety
    - Navigation

5.2. Potential Environmental Impacts

197. Potential environmental impacts associated with the proposed project at Palasbari Reach are classified as: (i) impacts during design and construction phase and ii) impacts during operation phase. Qualitative and quantitative techniques have been applied for direct and indirect impact identification. Impacts are classified as being insignificant, minor, moderate and major. The mitigation measures have been presented along with the impacts required.

5.2.1. Land use

5.2.1.1 Land Use Change due to Project Activities and Borrow Area

<u>Design and Construction Phase</u>

198. **Impacts**. The proposed project activities involve in total retirement of about 15 km embankment and about 19 km of bank protection works to prevent further erosion of the embankments, strengthening existing works, revetment/ pro-siltation measures are proposed in about 14 km of length, construction of 2 gated drainage sluices and rehabilitation, and strengthening of 3 boulder deflectors. Since a total of 15.1 km of embankment will be retired, the landuse change would be equivalent to an area of about 75 ha. However, this is needed for the strengthening of embankment and is the best suited engineering option.

199. For construction of river embankment of about 5 m height above the ground level with a top width of 7.5 m and a side slope of 1:2 to 1:3 that is estimated to provide protection against 100-year flood return period, substantial quantity of earth is required along the Palasbari reach. It is proposed that the demands for earth will be fulfilled by excavating borrow pits in the vicinity of the river embankment. The unplanned selection of borrow areas/ no rehabilitation of borrow areas may lead to loss of productive use of the land. The transportation of borrow earth may also cause air pollution, if transported in uncovered trucks. Due to such construction activities along the river bank, the land use of about 100 m buffer (37 m for embankment plus borrow areas towards country side) around the embankment is likely to be effected or changed. Based on satellite imagery and GIS interpretations, the Palasbari Reach has about 819.9 ha land (57.7%) of buffer area used as agricultural land and about 447.7 ha (31.5%) area as homestead plantation. (Refer Figure 3.21).

200. The access to the embankment construction site is mostly through the single lane rural roads (paved and unpaved both). These roads would require strengthening to sustain the heavy trucking load. In addition 4-5 construction camps throughout the 74.1 km long Palasbari Reach are likely to be located at a distance of about 10 - 15 km apart, close to the embankment. This will also temporarily change the land use of the area.

201. Due to the proposed interventions, most of the agricultural land and homestead plantation around the embankment site and construction camp areas may be affected adversely. Loss of topsoil is one of the most potential impacts with respect to borrowing of earth from country side of the embankment. Besides this compaction of soil along the haulage route may also take place, if proper mitigation measures are not employed.

202. **Mitigation Measures**. Since the impact zone around the embankment covers productive land, which is used by the villagers for cultivation, diversion of land for project purposes shall be minimized to the maximum extend feasible. The option of backward shifting of embankment shall be preferred. Adjacent cultivable lands, shall not be occupied for storage and/or handling of construction materials. Construction camps shall preferably be located on uncultivated area. All requisite facilities (drinking water supply, sanitation, domestic solid waste collection & disposal, fuel supply) shall be provided at these camps. The land used for construction camp shall be made reusable/cultivable after closure of construction camp. No construction debris shall be deposited on agricultural land. Loss of crops for construction camp area shall be compensated to the landowners.

203. **Borrow Area Location and Rehabilitation:** The borrow pits shall be on river side since borrow pits on the river-side to get silted up in the course of time whereas on the country-side remain a permanent disfiguration. Further the borrow pits next to embankment on the country side can be a cause of inducing seepage to the foundations. Borrow pits on the country side away from embankment shall be preferable even at the expense of comparatively long hauls. If sourcing earth from country side is unavoidable, the preference to be given for the following options:

- Waste land or excavating or enlarging existing lank or any humps above general ground level
- Earth from retired embankment.
- Land which farmers wants to either convert into a fish pond or lowering the agriculture field level to increase its water retention capacity
- No land acquisition shall be made for borrow areas
- Exploring the suitability of using dredge material from river Kulsi/Jaljali- which otherwise also require desiltation to increase its water carrying capacity
- Exploring the option of using combination of soil and sand in embankment construction. Means using soil as outer cover and sand as filler in between.
- Exploring technical feasibility of using soil from sandbars existing away from the bank.
- Follow the WRD guidelines for locating borrow pits close to the embankment if at all it is to be located next to embankment. All efforts shall be made that no tree loss takes place due to borrowing. The trucks shall be covered while transporting the earth.

204. While borrowing the earth top soil shall be preserved. The Borrow pits shall be rehabilitated after borrowing. The WRD guidelines for locating/rehabilitation of the pits shall be strictly followed. The Indian Road Congress (IRC):10-1961 guideline may also be referred for selection of borrow pits. In all cases good engineering and construction practices shall be followed. The construction contractor or DPR consultant shall submit the borrow area identification details along with borrow area rehabilitation plan in advance.

205. WRD Guidelines with respect to borrow area location and rehabilitation:

- For high embankments no excavation shall be done within 45 m of the river side toe of the embankment. From 45 m to 60 m the borrow pits must not be more than 1.8 m deep and from 60 m to 90 m not more than 2.4 m deep and beyond 90 m they can be of any depth.
- If earth is to be taken from land-side of the embankment, no borrow pits shall be excavated within 24 m of the land–side toe of the embankment. The depth of excavation in 24 m to 36 m shall not be more than 0.6 m.
- For low embankments the borrow pits on the river-side and on the land-side shall not be located at less than 24 m from the toe.
- The borrow pits shall be staggered and on undisturbed ground 6 m wide left at regular intervals to prevent the velocity of flow through the river-side borrow pits. The staggering will also help in inducing silting and filling up of these borrow pits.
- On the country-side the water logged areas (bandhis) shall be cut and interconnected to permit ordinary drainage. These shall be connected to the nearest drainage channel so as to carry away the drainage water.
- The borrow areas selected for taking earth shall be cleared of all trees, shrubs, grass and vegetation mounds.
- No borrow pits shall be made on roads, village tracks, graveyards, canals or embankments.

206. The Indian Road Congress (IRC):10-1961 guidelines for selection of borrow pits and amount that can be borrowed.

- Borrow areas shall not be located on cultivable lands. However, if it becomes necessary to borrow earth from temporarily acquired cultivated lands, their depth shall not exceed 45 cm. The topsoil to a depth of 15cm shall be stripped and set aside for its later use for the purpose of turfing on slopes of the embankments. Thereafter, soil may be dug out to a further depth not exceeding 30 cm and used in forming the embankment.
- Borrow pit shall be selected from wasteland ;
- Priority shall be given to the borrowing from humps above the general ground level within the road land;
- Priority shall be given to the borrowing by excavating/enlarging existing tanks;
- Borrowing shall be from land acquired temporarily and located at least 500m away from the road;
- Borrowing shall be from mounds resulting from the digging of well and lowering of agricultural fields in vicinity of the road;
- In case of settlements, borrow pits shall not be selected within a distance 800 m from towns or villages. If unavoidable, earth excavation shall not exceed 30cm in depth;
- The haulage distance from site shall not be too far.

Operation Phase [32]

207. **Impacts.** Encroachment on embankment for habitation and cultivation purpose may affect embankment stability. Villagers also cut the embankment to create approach to river side for their movement for toileting, cattle grazing, and farming. Borrow areas, if not rehabilitated may have landscape and accidental hazards. Also if the borrow areas are not rehabilitated based on the intended end use of the owner, some social impacts like loss of income may occur

[32] Operation phase in this section means post-construction use period.

208. **Mitigation Measures**. Provision shall be made in the embankment design for providing access[33] to the river bank close to the habitated areas. The construction contractor shall ensure rehabilitation of borrow area before handing over the project.

5.2.1.2 Land use Change due to construction material sourcing (Quarrying)

Design and Construction Phase

209. **Impacts.** A project of this magnitude would require significant amount of construction material. Illegal quarrying may lead to land use change, unstable rock formation, air and noise pollution. The aggregate demand for construction of river embankment with paved road on the top in Palasbari Reach will be met through approved Bamunigaon quarry located at distance of about 30-40 km from the reach. The environmental aspects and control of pollution due to quarrying operation of these approved quarries are controlled and monitored by SPCB. Thus, adverse impacts as a result of quarrying operations are not envisaged in the proposed project.

210. **Mitigation Measures**. Aggregates required for construction of embankment and roads shall be procured from quarries approved by State Pollution Control Board. Air and noise emissions from quarry shall be well within the prescribed limits. Setting up of stone crushers, if required, shall be done only after obtaining consent from State Pollution Control Board and taking adequate measures for air pollution control. While finalizing the site, proper land use assessment shall be done. The land to be earmarked for dumping construction waste if any shall be free from any social or R & R issue.

5.2.2. Soil

5.2.2.1 Soil Erosion

Design and Construction Phase

211. **Impacts.** Soil erosion potential of an area depends on its topography, geological structure, rainfall, soil type and land use/land cover. In the Palasbari Reach, the topography of the terrain covering the alluvial plain is nearly flat with a gentle gradient towards south west, except few occasional hillocks that rise steeply above the plain. Except the upper reaches of tributary rivers originating from the Meghalaya plateau including the Kulsi where slopes are steep, the soils are easily eroded and if rainfall is heavy, the rivers in the valley part of the basin show more of a depositional character due to their greatly reduced slope, transport of higher sediment load from upstream areas and congestion of drainage. Possibility of occurrence of gully and rill erosion is expected in the uncovered side slopes of embankments and other freshly cut or deposited areas.

212. **Mitigation Measures**. Following mitigation measures can prevent the soil erosion:

- Construction shall be scheduled such that large areas of soil particularly at borrow areas near the embankment are not laid bare during the monsoon.
- Exposed surface shall be resurfaced and stabilized as soon as possible. This shall also be covered by straw or mulch to avoid soil loss in the intervening period.
- Ground disturbances shall be phased so that it is limited to workable size.

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[33] During field visit, it has been noticed that people cut the earthen embankment at various places between Gumi village (Ch. 21.0 km) and Nagarbera hill (Ch. 58.0 km) for trespassing buffalo cart to carry resources from river side of the embankment to the countryside.

- Stabilizations of soil around approach roads/slopes shall be done by turfing and tree plantation in ROW.
- Other slope stabilization measures like selection of less eroding materials around water bodies/water streams shall be adopted.
- The embankment and road design shall incorporate adequate engineering measures so that the construction could withstand the earthquake magnitude of more than 6 Mb.
- Soil conservation measures like contour bunding, terracing, aforestation in the hill slopes of the upper watershed and agro-forestry, agro-horticulture along with appropriate structural methods in the plain areas is required to mitigate gully sheet and rill erosion. However, this activity is beyond the scope of proposed project activity and is suggested to be initiated by WRD with concerned other agencies.
- Soil erosion shall be visually checked on potential erosion zones during construction phase. In case soils erosion is found, suitable measures shall be taken to control the same.

Operation Phase

213. **Impacts.** Due to bank erosion, the bank line at various sections through out the reach has shifted up to 7.6 km during the study period of 1911-1988. A total of 16119.83 ha land was eroded between year 1911-2008 in the entire stretch of 74.1 km of Palasbari Reach. The proposed project will have net benefits in terms of soil erosion and preventing progression of land loss which is about 90.1 ha per year (considering reduced scope of the Palasbari sub-project as 25 km length of river running) at present in the Palasbari Reach. Soil erosion may still occur during the operation phase and early detection and remedial measures shall need to be taken for safety of the embankment and roads. Most part of flood plain of Brahamputra in Palasbari sub-project area is covered by lower watershed of Kulsi River and a number of tributaries join it in this region (Figure 5.1). Any attempt to prevent flooding and erosion in this part will necessitate the management of the Kulsi watershed in a holistic manner in order to derive sustainable benefit out of the proposed project. The current land use pattern in the watershed as depicted in the land use/ land cover map (Figure 5.2) based on interpretation of satellite data using a GIS platform shows the highland-lowland interactive nature of the physical as well as cultural landscape of the region with the project area covering the southern most part adjoining the Brahmaputra river. The environmental setting of the watershed *vis-à-vis* the benefiting area of the project therefore warrants an integrated approach of management for the entire watershed.

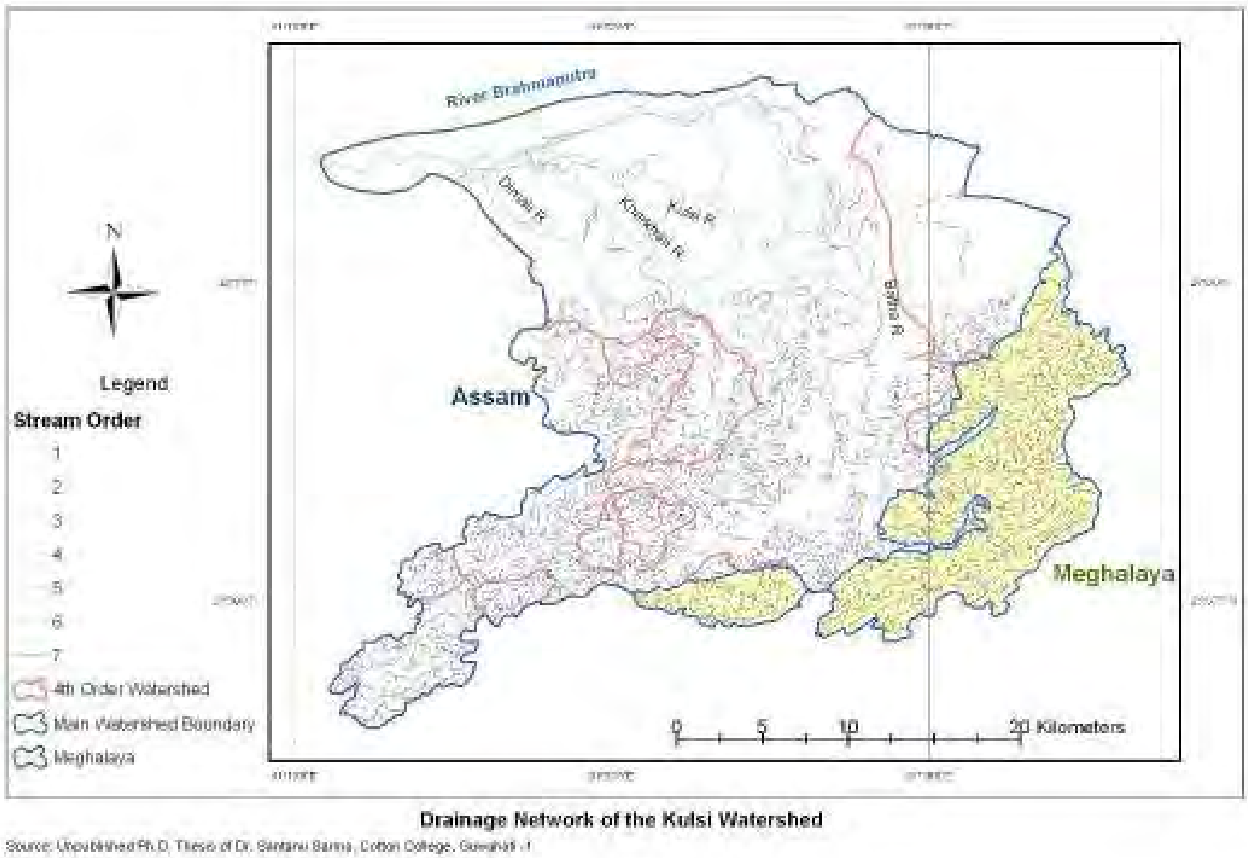

Figure 5.1 Drainage Network of the Kulsi Watershed

214. **Mitigation Measures**. Periodic checking shall be carried out to assess the effectiveness of stabilization measures. A detailed study to assess the location, reasons of soil erosion along the embankment during third year of the operation phase shall be undertaken. Suitable strengthening measures shall be implemented to prevent reoccurrence of soil erosion at existing erosion prone locations and prevent erosion at newer locations. To combat the menace of soil erosion and to ensure its conservation on a sustainable basis, efforts shall be made to develop watershed management plans jointly by Assam Government and Meghalaya Government under the aegis of the North Eastern Council for the Kulsi river system of the reach where both water as well as soil will receive adequate emphasis.

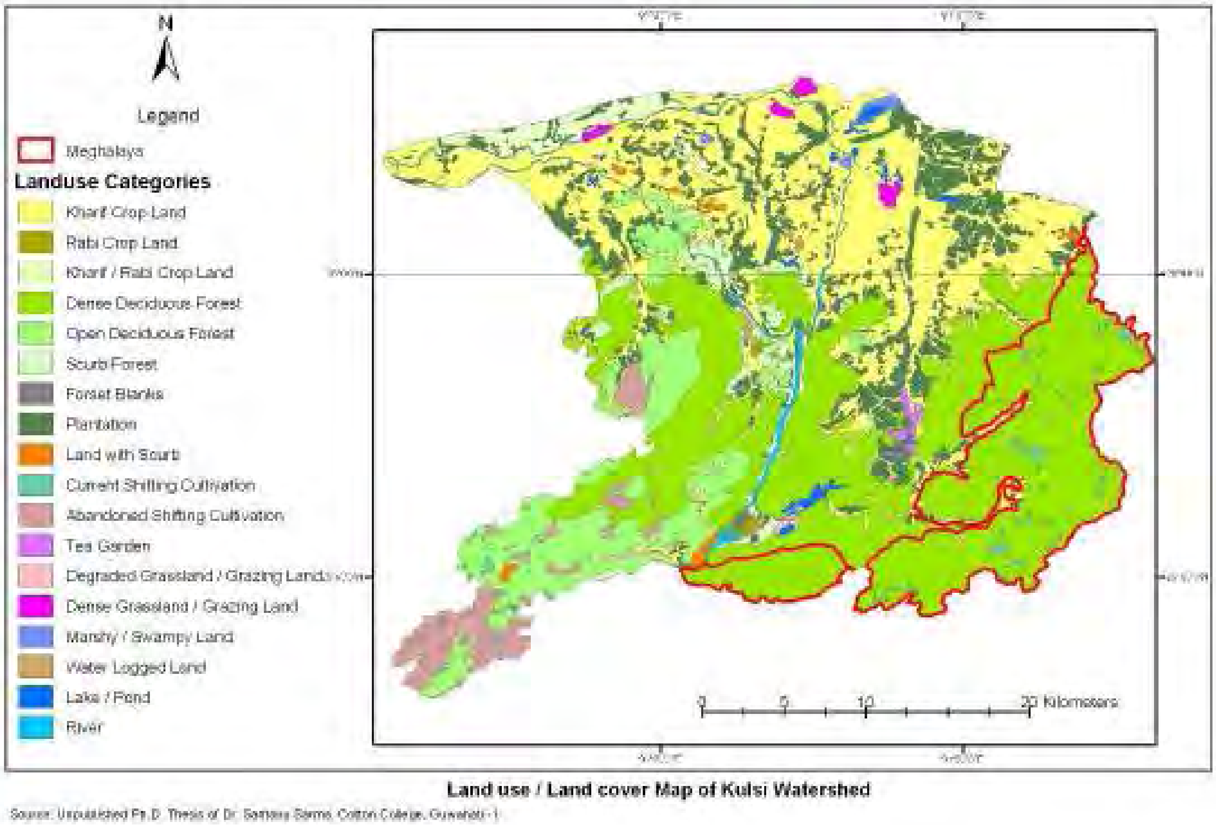

Figure 5.2 Land use/ Land Cover Map of Kulsi Watershed

Soil Compaction and Contamination

Design and Construction Phase

215. Impacts. Soil around construction site, haulage road, construction camp, and workshop, will get compacted due to transportation of man, machine and materials. Considering about 57.7% of land in the closed vicinity of river embankment is used for agricultural purposes in Palasbari Reach, and construction period is for 6 years, the agricultural yield will be reduced substantially due to soil compaction. Soil may also get contaminated around construction site, machine maintenance area, fuelling station, construction camp, hot mix plant site, and haulage road.

216. **Mitigation Measures**. The movement of construction vehicles, machinery and equipment shall be restricted to the embankment site and pre-defined haulage road. Adequate provision for approach roads capable of handling movement and haulage of heavy vehicles and machineries shall be made to avoid damage to existing village roads, crop lands and settlement areas. The non-usable, non-saleable, non-hazardous construction waste shall be dispose of in the properly delineated places. Usable or saleable waste shall not be disposed of to landfill.

217. All efforts shall be made to prevent soil contaminations. Following measures shall be taken to prevent the same:

- The construction vehicle shall be fuelled or repaired/serviced at the designated place with proper arrangement of waste collection and disposal. The arrangement shall include, cemented floor with dyke around for fuel storage and filling as well repairing of construction equipments.

- To avoid the soil contamination at the wash down and re-fuelling areas, “oil interceptors” shall be provided.
- The demolition waste if any shall also be used to the extent feasible for construction.
- Oil and grease spill and oil soaked materials shall be sold off to State Pollution Control Board (SPCB)/ MoEF authorized vendors.

Operation Phase

218. **Impacts**. During the operation phase, contamination of soil is not likely to happen other than due to accidental spillage from vehicle movement.

219. **Mitigation Measures**. Depending on the nature and magnitude of spill, appropriate land remediation measures shall be employed by the concerned authorities.

5.2.3. Hydrology and Morphology

Design and Construction Phase

220. **Proposed Works**. The proposed project works at Palasbari will be implemented in two tranches and consist of retirement of portions of the existing Brahmaputra embankment in the area of Palasbari (around 5 km), construction of two new sluices, together with around 19 km of riverbank protection in different places consisting of revetment and anti-erosion works and renovation of the existing three boulder deflectors near Gumi. The work under Tranche 2, to be implemented from year 4 of the project is at this moment tentative and subject to future confirmation depending on the morphological development.

221. **Impacts.** No impact is envisaged during this phase. The aspects associated with design and construction of various project components associated with hydrology and morphology have been addressed under land use, soil, flora and fauna, air and noise and water quality section. The impacts associated with the operation stage are presented under various sub-sections below.

5.2.3.1 External Effects on Morphology – Upstream and Downstream Impacts

Operation Phase

222. **Impacts**. The impact of the planned flood protection measures along the Brahmaputra is considered negligible, as they focus on strengthening existing embankments. The proposed bank protection measures will confirm and stabilize the present bank line; the pro-siltation measures will have no discernible effect on general bed levels. In summary, the proposed works are expected to have no adverse effects on the dynamic river morphology.

223. The construction of riverbank protection works leads to a river response, commonly a deepening of the channel alongside the protection work. This is a consequence of flow concentration and/or a reduction of sediment entrainment from eroding bank. It is commonly believed that the Brahmaputra instability is largely associated with excessive sediment transport. The proposed interventions, revetments and anti erosion measures, reduce the sediment. Both measures further reduce turbulence and the impact of currents, as opposed to spurs, which actively deflect the currents, and as a consequence minimize negative effects. The reduced sediment entrainment alongside the protected reach has the tendency of

encouraging more pronounced and stable channels without affecting the opposite bank or the upstream area. In order to avoid downstream riverbank erosion the project places the downstream termination with a slight curvature away from the existing bank, which results in passive protection of a certain downstream length. This does not alter the dynamic pattern of constantly changing in-stream channel bars, locally called, chars or chaporis.

224. The project will not build new river training works, namely spurs. In some cases existing spurs will be rehabilitated, not changing their length or orientation, but concentrating on repairing local damages. As the existing spurs are long established, limited rehabilitation under the Project will inflict no change on their impact on the dynamic river and char system.

225. A number of charlands in the Project area are used for seasonal cropping and other uses. It is expected that the current adaptive land use patterns of these charlands will continue into future to ensure their beneficial use. Charland in the immediate vicinity of the project sites does not have permanent settlements.

226. **Mitigation Measures**. The Project envisages a process of systematic annual analysis and prediction of sedimentation and erosion behavior, which includes the analysis of the structural response to riverbank protection work. The analytical tools consist of (i) low-water satellite imagery based large-scale morphological analysis of Brahmaputra reaches, supported with (ii) large-scale bathymetric surveys covering the near bank channel pattern starting from several kilometers upstream of locations of interventions and typically ending around 10 km downstream, and (iii) near-bank surveys, providing a detailed picture of the river response and structural performance. In case unexpected downstream effects are observed, the Project concept allows later rectification within the concept of adaptive approach. To this end, the project has substantial contingencies.

5.2.3.2 External Impacts on Flood and Drainage

<u>Operation Phase</u>

227. Impacts. The proposed structural flood protection works consist of retirement inland of existing lengths of the Brahmaputra dyke. No new embankments are proposed. The proposed works will essentially confirm existing flooding behavior and provide better protection from mainstream flooding to flood-liable areas behind the embankments. The proposed ant-erosion and pro-siltation works will not significantly affect flood behavior, gross cross-section-wide sediment behavior of river morphology. Embankments are to be retired only 50-100 m from their present position, so there is no significant change in floodplain storage or cross-section conveyance. No discernible change in downstream flood levels will occur. The proposed bank protection measures will stabilize the banks and have no discernable effect on flood behavior. .It is also to be noted that the proposed works include construction of two gated drainage sluices to mitigate drainage congestion within the protected areas either side of Dakhala Hill. (The nature and extent of these sluices will be determined during the project implementation).

228. **Mitigation Measures**. Under the Project, it is proposed to develop and use a numerical hydraulic model to investigate flooding and drainage behavior, both within and outside the protected areas, associated with mainstream, tributary and local flooding. . This model will be used to ensure that there is adequate freeboard against embankment overtopping and that adequate provision has been made for sluice gates to facilitate drainage from the protected areas. Natural drainage systems shall be left undisturbed to the greatest extent possible; the flooding behavior of beels and wetlands will be assessed and where possible improved and/or

preserved. Adequate provisions shall be made in designing embankments to withstand extreme meteorological and other geophysical events.

5.2.3.3 Changes in Water Levels

<u>Operation Phase</u>

229. Impacts. The conveyance capacity of the Brahmaputra opposite the Palasbari Reach is enormous – and will remain unchanged by the proposed works on the southern bank. Accordingly, the proposed works will have no discernable effect on river water levels. Changes in channel conveyance brought about by the natural processes of riverbank erosion, accretion and channel avulsion will play a much greater role in any future change in water levels. An improved embankment network will reduce the risk of sudden devastating flooding and as such provide more predictable and stable water levels on the flood plains (especially from temporary local inundation during the flood season).

230. **Mitigation Measures**. Changes in cross-section will be monitored at regular intervals to detect any changes and initiate corrective measures. The Project concept allows later rectification within the concept of adaptive approach. To this end, the project has substantial contingencies. Under the Project, the numerical hydraulic model of the sub-project area will be used to identify low lying areas with a potential risk of deep inundation when major floods occur. The option of providing raised flood refuge platforms in appropriate locations will be explored.

5.2.3.4 Effect on Flow Velocity/ Discharge Intensities

<u>Operation Phase</u>

231. **Impacts.** The proposed interventions are not expected to have any significant effect on the overall velocity profile of the river as the works are limited to the bank or near shore areas of the river and a combination of largely passive river training and flow regulating measures will be taken up to provide an optimum flow velocity in the section. Recognizing instability and unpredictability of the Brahmaputra River, clearly two different scales need to be distinguished for studying effects of flow velocity and discharge changes: (i) the total river cross section, many kilometers in width, and (ii) the cross section of the near bank channel, typically below one kilometer in width. Limited interventions along the bank do not change the cross section average flow velocities in alluvial rivers. Areas of faster flow are compensated through areas of slower flow and lower discharges, which on average even out. The average flow velocity and discharge is affected by different river stages with increasing discharges resulting in increasing flow velocities. The lack of systematic measurements limits the present ability of quantifying this satisfactorily.

232. The magnitude and variation of discharge in the Brahmaputra River undergoes drastic changes on seasonal as well as annual basis due to the unique hydro-meteorological and geophysical characteristics of its basin. The potential increase of these natural perturbations in the river hydrograph in the wake of unfolding climate change scenario appears to be more significant compared to any minor change that may be introduced as a result of the proposed activities on or near the river bank. The river being very wide with appreciable channel roughness due the presence of multitudes of sandbars and bed forms, transmission of any minor disturbance in the flow close to the bank to areas midstream or across the channel to the other bank appears quite unlikely. Only major proactive river training interventions like spurs protruding into the river may have direct impact on the flow pattern and channel configuration affecting it significantly.

233. **Mitigation** Measures. Flow velocity changes along the bankline will be systematically monitored as part of the near-bank surveys. This includes establishing systematic records of discharges and flow velocities during the hydrological cycle. It is expected that this monitoring will contribute to a better understanding and a gradual optimization of the layout of structural flood and erosion countermeasures. Open revetments, such as dumped stone (rip-rap) placed on geotextile filters or multi-layers of sand-filled geotextile bags shall be preferred. Impermeable bituminous or interlocked revetments shall not be preferred as they have impact on the natural environment by interrupting exchange between flowing water and ground water. Any of the eco-friendly local resource based methods may be used in preference to the impermeable surfaces like bituminous or cement slab.

5.2.3.5 Impacts of Development Works in Upstream Catchments

234. **Impacts.** A large number of hydroelectric projects (57 till February 2008 with a total generation capacity of 15,000 MW) are under various stages to implementation in the Brahmaputra basin in Arunachal Pradesh. It is likely that these projects will have impacts on flood behavior in the subproject areas. The upstream dams, albeit mostly run-of-the-river schemes, would reduce flood peaks while acting as sediment traps that will lesson the outflow of sediments (until these reservoirs are filled up over the years).[34] Likewise, improved watershed management pursued in upstream catchment will contribute to reduction of flood peaks and sediment transport over the long term. Any affect of this reduction in sediment inflows on the Brahmaputra main stream channel cross sections and flood behaviors is difficult to predict, but any effects are likely to lead to a reduction in flood levels and aggradation, since reduced sediment loads supports a more stable channel pattern with deeper channels characterized by higher conveyance.

235. **Mitigation Measures.** Systematic monitoring and analysis of hydrological and geo-morphological parameters will help identify any measures that may have to be considered to adapt to any unexpected changes over the longer term. The project will also promote holistic catchment management through state wide planning and coordinated implementation.

5.2.3.6 Impact on Silt Deposition and Bed Level Change

<u>Operation Phase</u>

236. **Impacts.** The Brahmaputra River carries the second highest sediment load of all major rivers in the world. The high amount of sediment is largely mobilized during the high flood season flows and often leads to dramatic changes of the platform (river appearance on maps). While the riverbed is largely formed by the coarser sediments especially sand and more upstream gravel, the floodplains are built from finer silts and clay. The latter constitute the wash load in the river, which means they are transported within the channels to the sea without settlement. Only after inundation and in areas without noticeable flow do the finer sediments settle. Part of this settlement has been cut-off through the construction of embankments in many places since minimum 25 years (the end of the major embankment construction program). It is noted that the inhibited deposition of the fertile finer clay and silt requires the use of alternative fertilizing methods in order to maintain overall soil fertility.

237. Problematic at this moment are breaches in the embankments, which result in high velocities in the breach area allowing the flowing water to transport coarser, infertile sand

[34] Nevertheless, effective information network needs to be set up to inform the local population the sudden changes in discharge volumes in advance, to cope with abrupt water level rise in the tributaries.

through the breached section. This sand gets deposited downstream where the area widens and the flow velocities drop. The resulting sand carpets are disastrous for the overwhelmingly small and marginal farmers as they render the fertile floodplain land unusable and can only be removed at great cost.

238. **Mitigation Measures**. The bank stabilization and retirement of the embankment system in the Palasbari Reach will reduce the risk of embankment breaches with associated deposition of infertile land in the area of the breach. This will help in supporting agriculture and livelihood of the dominant small and marginal farmers. In general, about 35.5% of the land within an eight kilometers buffer behind the embankments is used for agricultural activities. The dynamic pattern of silt deposition in the river and areas adjacent to the bank, especially in the vicinity of anti-erosion and river training works, will be monitored at regular intervals in order to contribute to the knowledge base and understanding of the Brahmaputra morphology, and initiate necessary corrective measures if required.

5.2.3.7 Effect on Subproject Drainage System

<u>Operation Phase</u>

239. **Impacts**. The existing embankment system along the Brahmaputra impedes the present drainage channels of the area, including the Kulsi River, which has been truncated at several places near its earlier outfalls and forced to flow towards its present outfall along a joint channel with Jaljali River near Nagarbera. Moreover, the embankment acts as a barrier for the drainage of accumulating countryside water into the Brahmaputra during the wet season. The proposed works will have no additional adverse impacts on drainage. In fact, the incorporation of two gated sluices will relieve drainage congestion in key areas.

240. **Mitigation Measures**. Under the Project, the numerical hydraulic model will be used to undertake a comprehensive analysis of the existing natural drainage system to identify drainage behavior and problems, key drainage channels/ systems and drainage congestion areas. This model will be used to investigate the optimum location, size and method of operation of the sluice gates. The cost-effectiveness of various remedial measures will be assessed with the object of improving drainage conditions. As part of this investigation, the preservation and/or improvement of the environmental flooding regime of wetlands and beels will be investigated.

5.2.3.8 Effect on Wetlands/ Beels within the Subproject

<u>Operation Phase</u>

241. Impacts. Deepar Beel is the only wetland which has direct connection with the River Brahmaputra along the Palasbari Reach. However, it is situated about 3 km aerial distance from the Khanajan mouth (which is the only outlet of this important wetland). The retired embankments will not impede the functioning of the beel, as they are not impeding the connection between the beel and the Khanajan River. The Garbhanga Reserved Forest is adjoined with the Deepar beel, but it is far away from the embankment and is a different strand of south bank ecosystem. The other wetlands located in the study area are fed by Kulsi River and will not be affected by the proposed project activities.

242. With the flood protection measures in place, farmers may use more fertilizers and grow more crops in the fields. The fertilizers and pesticides could reach the wetland as the land slopes towards the latter. This increases the tendency of eutrofication in the wetlands. The flood water is essential to the wetlands for flushing the pollutants in the wetlands.

243. Mitigation Measures. Since, various terrestrial and aquatic wildlife species depend on these wetlands, due care shall be taken to insure that no direct or indirect impact like siltation or flow of waste/debris is caused to any wetland located in the close vicinity of project construction activities.

5.2.3.9 Water Quality

<u>Design and Construction Phase</u>

244. **Impacts**. The major source of surface water pollution during project construction phase will be sewage and wastewater generated from labor camp/ colonies as well as workshop areas. The project construction is likely to last for a period of 6 years. Most of the laborers would come from nearby areas. About 50-60 labor families (total population 250 to 300) are likely to stay in each construction camp. The domestic water requirements in each construction camp will be about 45 m^3/day. It is assumed that about 80% of the water supplied will be generated as sewage. Thus, total quantum of sewage generated is expected to be of the order of 36 m^3/day. However, it may pollute land and other nearby water bodies if discharged untreated, especially during the low flow season.

245. No arsenic pollution is noticed either in river water or ground water in this area. Hence no impact of arsenic is anticipated in this area which is otherwise prevalent problem in West Bengal and adjoining areas.

246. As significant quantity of groundwater is not likely to be extracted as part of this project, any appreciable quantitative impact on ground water because of the construction activities is also ruled out. In addition to that ground water is easily available in 5 m BGL even during the lean periods. Impact on ground water quality is not likely due to the project activities as the wastewater generated from the project will be trapped for treatment before it will discharge/ percolate from the project sites.

247. **Mitigation Measures**. Septic tanks shall be provided in each camp to treat the domestic sewage. Provision of mobile toilets may also be considered with the provision of channeling the sewage to septic tank in a closed loop system. Discharge of untreated domestic sewage to the Brahmaputra River or to any natural waters will not be permitted. No debris shall be dumped in the water bodies.

<u>Operation Phase</u>

248. **Impacts.** No impact is anticipated due to the project in this phase.

5.2.4. Climate

<u>Design and Construction Phase</u>

249. **Impacts.** Short term impact in terms of minor increase in temperature may happen in the immediate vicinity of the embankment due to cutting of large number of trees located within the project intervention zone. However, these trees are of fast growing species like Bamboo, Simul, and the like.

250. **Mitigation Measures**. The maximum possible efforts have to be made for minimizing cutting of the trees while designing the embankments. Compensatory tree plantation to be

undertaken on the basis of 3 trees plantation against each tree cut as per the state government policy[35].

Operation Phase

251. **Impacts.** No direct impact is anticipated on the climate of the study area due to the proposed project. However, changes in the catchments area of the river and extreme events due to possible climate change (global warming) can have indirect impacts on project and project area. With respect to the proposed project, climate change can play a major role due to its implications on water resources, water availability, and inland/ fresh water wetlands. The climate change impacts on water resources for throughout the country were studied as part of India's Initial National Communication (Natcom 1) Project[36]. The study revealed that climate change impacts on the inland wetlands would be a complex issue dependent on several variables, including temperature increase, rate of evaporation, changes in precipitation on the catchment, changes in nutrient cycling and the responses of a variety of aquatic species. Although tropical lakes are less likely to be impacted by climate change as compared to temperate lakes, an increase in temperature would alter the thermal cycles of lakes, oxygen solubility and other compounds, and affect the ecosystem. Shallow-water marshes and swamps would be even more vulnerable to increased temperatures and lower precipitation. The increased evaporation of water and reduced inflow from rainfall could desiccate the marshes, swamps and shallow lakes.

252. GCM model projections (by HadCM2) for India indicate an increase in precipitation by up to 30% for the north-eastern region in addition to a relatively moderate increase in temperature of about 2°C by the period 2041-2060. This could increase the incidence of flooding in the Brahmaputra basin. Since, there are divergent views on the above findings; these can not be taken into consideration for any design change at this stage till more specific and dependable information related to climate change effect on river hydrology in this region is available.

253. **Mitigation Measures**. The likely impact framework shown above is generalized. However, more information has to be collected based on newer studies and monitoring data. Further action on this account can be considered only in the following phases of the project. The flood pattern needs to be closely analyzed during proposed life span of the embankment and take appropriate timely protective measures in case the flood levels increase earlier than the projected levels for 2041-2060 due to climatic changes.

5.2.5. Air Environment

5.2.5.1 Design and Construction Phase

254. **Impacts**. The ambient air quality of the area is good. The level of SPM, RSPM, NOx, SO_2, Pb, CO, is much lower at both the locations monitored (Majirgaon and Khanajan) than the prescribed National Ambient Air Quality Standards for rural areas (Refer Table 3.11). While

35 The rate of compensatory aforestation mentioned here is as per the consultation with Chief Conservator of Forests, Forest Department, and as per Assam Government's Guidelines for Compensatory Aforestation, 2000.

36 The SWAT water balance model has been used in this study for the river basins to carryout the hydrologic modelling of the country. The SWAT model has been used on each of the river basins separately using daily weather generated by the HadRM2 control climate scenario (1981-2000). The model has been run using climate scenarios for the period 2041 to 2060, without changing the land use pattern. The outputs of these two scenarios have been analyzed with respect to the possible impacts on the run-off, soil moisture and actual evapotranspiration.

various construction activities will increase the ambient air quality but the level is likely to remain within the prescribed standards.

255. During the construction phase, there will be two main sources of air emissions, i.e. mobile sources and stationary sources. Mobile sources are mostly vehicles involved in construction activities, whereas emissions from stationary sources include construction equipments & machinery, diesel generator sets, excavation/ grading activities etc. Hot Mix Asphalt (HMA) plants will be one of the major sources of emission, which will be used for road carpeting. In addition to these, fugitive emissions will also form a major proportion of air pollution in the form of particulate matter from storage and handling of construction material.

256. HMA plants have two major categories of emissions: ducted sources (those vented to the atmosphere through some type of stack, vent, or pipe), and fugitive sources (those not confined to ducts and vents but emitted directly from the source to the ambient air). Dryers are the most significant ducted sources of emissions from both batch mix and drum mix HMA plants. Emissions from these sources consist of water (as steam evaporated from the aggregate); PM; products of combustion (carbon dioxide [CO2], NOx, and sulfur dioxides [SO2]); CO; and small amounts of organic compounds of various species (including VOC, methane [CH4],). The CO and organic compound emissions result from incomplete combustion of the fuel and also are released from the heated asphalt.

257. Fugitive dust sources associated with construction phase include vehicular traffic generating fugitive dust on paved and unpaved roads, aggregate material handling, and other aggregate processing operations. Fugitive dust generated from these activities may range from 0.1 µm to more than 300 µm in aerodynamic diameter.

258. The emission of particulate matter during the construction phase will be generated from the activities like receipt, transfer and screening of aggregate, crushing activity, road dust emissions. The likely emission levels from these sources are indicated at Appendix 3.14. In addition to that emissions from various construction machinery fuelled by diesel and from mobile source will be in the form of PM10, VOC, CO, NOx and SO2. The emissions from stationary and mobile diesel engines with respect to their working/ movement are presented in Table 5.1:

Table 5.1 Exhaust Emissions for Stationary and Mobile Machinery

Source	PM10	VOC	CO	NOx	SO2
Diesel exhaust emissions (idle)	0.043 g/min	0.208 g/min	1.57 g/min	0.917 g/min	18.8 S g/l
Diesel exhaust emissions (moving)	0.4 g/mile	3.18 g/mile	18.82 g/mile	8.5 g/mile	18.8 S g/l

259.

260. **Mitigation Measures**. Hot mix plants should be located away from the populated areas and be fitted with the air pollution control devices, the emission shall meet National/ State Pollution Control Board standards. Further, the hot mix plants must be sited at least 1 km in the downwind direction from the nearest human settlement. It shall be ensured that the dust emissions from the crusher and vibrating screen of the stone quarries do not exceed the standards.

261. Vehicles delivering loose and fine materials like sand and fine aggregates shall be covered to reduce spills on existing road. Water may be sprayed on earthworks, on a regular

basis. During and after compaction of the sub-grade, water will be sprayed at regular intervals to prevent dust generation.

262. The following mitigation measures will also be taken to mitigate the dust entrainment and fugitive emissions from the various sources in Palasbari Reach:

- Covering of loads in trucks, and the paving of access areas to unpaved lots or construction sites, are examples of preventive measures. Examples of mitigation controls include water flushing, and broom sweeping and flushing.
- Redistribution of loose material onto the travel lanes will actually produce a short-term increase in the emissions. In general, preventive controls are usually more cost effective than mitigation controls.
- Sprinkling water will control fugitive dust entrainment.
- Sprinkling of water on the dust prone areas and construction yard.
- Regular maintenance of machinery and equipment will be carried out.
- Ambient air quality monitoring should be carried out during construction phase. If monitored parameters are above the prescribed limits, suitable control measures must be taken.
- Care shall be taken to keep all material storages adequately covered and contained so that they are not exposed to situations, where winds on site could lead to dust/ particulate emissions.
- Fabrics and plastics for covering piles of soils and debris is an effective means to reduce fugitive dust from the material stores/ warehouses.
- Spills of dirt or dusty materials shall be cleaned up promptly so that the spilled materials do not become a source of fugitive emission.
- Spilled concrete slurries or liquid wastes shall be contained/ cleaned up immediately before they can infiltrate into the soil/ ground or runoff in nearby areas.
- All slopes and embankments will be turfed as per best engineering practices to help minimize the dust generation during operation of the road.
- Plantation along the embankment should be maintained.
- Ambient air quality monitoring should be done for the first 3 years of the operation phase. If monitored parameters are above the prescribed limits, suitable control measures must be taken.

263. A wide variety of options exist to control emissions from unpaved roads in the form of:

- Vehicle restrictions that limit the speed, weight or number of vehicles on the road;
- Surface improvement, by measures such as (a) paving or (b) adding gravel or slag to a dirt road; and
- Surface treatment, such as watering or treatment with chemical dust suppressants.

Operation Phase

264. **Impacts.** The prime source for air pollution during operation phase will be the vehicular movement on the paved road on top of the embankment, which will be used for transportation as well as maintenance of the embankment. However, during the operation phase, the embankment will be strengthened and will be covered with turf and construction of paved roads

will reduce the fugitive emissions. Due to all these developments, impact on air quality during operation phase will beneficial.

265. **Mitigation Measures**. Plantation along the embankment and turfing on the embankment slopes should be maintained and their survival rates should be monitored. In addition to that regular maintenance of the road on the top of embankment as well as connecting roads shall be done for reducing fugitive emissions.

5.2.6. Noise

<u>Design and Construction Phase</u>

266. **Impacts.** During construction phase, noise will be generated from various activities such as site clearing, excavation, erection, finishing etc. The general noise levels during construction phase such as due to working of heavy earth moving equipments and machineries installation may sometimes go up to 100 dB(A) or more at the work sites.[37] As per the proposed plan, manual labor is likely to be preferred with limited use of machinery.

267. As a worst case scenario, considered for prediction of noise levels during construction phase, it has been assumed that all these equipments generate noise from a common point. The increase in noise levels due to operation of various construction equipments is expected to increase the noise level from 100.3 dB (A) at a distance of 1m to 52.4 dB (A) at a distance of 250 m from the sources. The predicted levels are presented at Table 5.2.[38]

Table 5.2 Increase in Noise Levels due to Operation of various Construction Equipments

Distance (m)	Ambient Noise Levels dB(A)	Increase in Noise Level dB(A)	Increase in Ambient Noise Levels dB(A)
1	51.0	100.3	49.3
10		80.3	29.3
50		66.3	15.3
100		60.3	9.3
150		56.8	5.8
200		54.3	3.3
250		52.4	1.4

268. In addition to the above, there will be significant increase in vehicular movement for transportation of construction material. At present, vehicular movement near the project site is of the order of 5 to 10 vehicles/ hour. During construction phase, the increase in vehicular movement is expected to increase up to a maximum of 40 to 50 trucks/ hour.

37 The noise level from various construction equipment /machinery is (all levels are in dB(A)): Dozers (95-100), front Loaders (72-84), Backhoes (72-93), Tractors (76-96), Toppers/Trucks (82-94), Concrete mixers (75-83), Concrete pumps (75-83), Concrete pumps (81-83), Cranes (movable) (75-86), Vehicular Traffic (construction material & plant & Machinery) (85-98), Dg Set (90-95), Pumps (69-71), Compressors (74-86), Pneumatic Wrenches (83-88), Jack Hammer and rock drills (81-98), Pile Drivers (peak) (95-105

38 In absence of the data on actual location of various construction equipments and machinery, all the equipments have been assumed to operate at a common point. This assumption leads to over-estimation of the increase in noise levels. However, the noise levels shall attenuate as the sound wave passes through a barrier. The transmission loss values for common construction materials like brick, light concrete, dense concrete, concrete block with a thickness of 4 to 6 inches vary in the range of 30 to 40 dB(A). Thus, the walls of various houses will attenuate at least 30 dB(A) of noise. In addition there will be attenuation due to Air absorption, atmospheric in homogeneities, vegetal cover.

269. As a part of the EIA study, impact on noise level due to increased vehicular movement was studied using Federal Highway Administration Model. The results of modeling are outlined in Table 5.3:

Table 5.3 Increase in Noise Levels due to Increased Vehicular Movement

Distance (m)	Ambient Noise Level dB(A)	Increase in Noise Level dB(A)	Increase in Ambient Noise Level dB(A)
10	51	72	21
20		67	16
50		61	10
100		57	6
200		52	1

270. Hence, during construction phase, increase in noise level is expected to be between 25% to 30%. However, the increase in noise levels will be localized, temporary in nature and mostly will be during daytime only.

271. **Mitigation Measures**. Following noise control measures shall be adopted, and included in the civil work contracts:

- Site Controls: Stationary equipments shall be placed along un-inhabited stretches meeting the National Noise Quality standard, particularly for residential areas (Category C) and silence zones (Category D: hospitals, educational institutions, courts, religious places, etc.), keeping the distance at least 150m (Category C) and 250m (Category D), to minimize objectionable noise impacts. In the envent potential nose sensitive receptors are identified who will fact higher noise due to construction, appropriate temporary noise barriers will be established.
- Scheduling of Project Activities: Operations will be scheduled to when people would be least likely to be affected. Construction activities shall be restricted between 10 P.M. and 6 A.M. near residential areas.
- Protection devices (ear plugs or ear muffs) will be provided to the workers operating in the vicinity of high noise generating machines.
- Construction equipment and machinery shall be fitted with silencers and maintained properly.
- Noise measurements shall be carried out along the reach as well as in nearby villages, to ensure the effectiveness of mitigation measures.
- Use of manual labor

Operation Phase

272. **Impacts**. The prime source of noise pollution during operation phase will be the vehicular movement. However, as the roads will be paved and will provide smooth traffic movement, the impact due to vehicular movement will be less significant.

273. **Mitigation Measures**. Adequate signage shall be provided restricting the use of pressure horn particularly in near noise sensitive locations e.g schools, hospitals and populated areas. Noise measurements shall be carried out along the road to ensure the effectiveness of

mitigation measures. Tree barriers between the road and village, semi urban and urban area shall be developed in a layered manner as suggested under air environment mitigation measures.

5.2.7. Terrestrial Ecology

5.2.7.1 Disturbance to Vegetation

Design and Construction Phase

274. **Impacts**. There would be no major impact on terrestrial flora except cutting of trees during project intervention in the Palasbari reach, as there is no protected forest, reserved forest or sanctuary etc present in this area. The natural terrestrial ecosystem (bio-diversity) has already been damaged by the heavy floods and erosions in the past in this area. The present vegetation is the cultural one which can always be compensated by aforestation program. The proposed project will help to improve the terrestrial biodiversity of the area.

275. The baseline survey along the Palasbari Reach taking into consideration of the entire 74.1 km length and 100m around the embankment on either side revealed a total of 271,124 trees on the riverside of the embankment and 239,092 trees on country side the embankment. In most of the area, the trees are located close to the existing dyke (maximum of 50m from the dyke). Majority of the tree are of bamboo and Simul variety. Most of these trees are matured trees with an average age of about 20-30 years. Retirement of embankment by 50 m will result in loss of agriculture land and vegetation cover.

Table 5.4 Counting of Total Tree Species present in Palasbari Reach (100m either side of the embankment)

Tree species	Total trees and tree density country side of the Embankment		Total trees & Tree density River side of the Embankment	
	No. of trees	Tree density	No. of Trees	Tree Density
Simul-Bombax ceiba	7500	0.13	6300	0.11
Gamari-Gmelina arborea	2100	0.04	1200	0.02
Karas-Pungamia pinnata	1200	0.02	900	0.02
Bijuli banh-Bambusa pallida	3000	0.05	2400	0.04
Khongal Dimoru-Ficus tinctoria	600	0.01	300	0.01
Pakori-F. rumphii	180	0	120	0
BhimKol-Musa balbiciana	7800	0.13	7200	0.12
Jati banh- Bambusa tulda	28200	0.47	12000	0.2
Kathal-Artocarpus heterophylus	1680	0.03	1080	0.02
Palas-Butea monosperma	120	0	0	0
Phulkabi-Brassica oleracea var	0	0	12000	0.2
Morapat-Corchorus capsularis	0	0	30000	0.5
Devil tree-Alstonia scolaris	300	0.01	0	0
Ghehu-Triticum aestivum	0	0	3000	0.05
Krishna sura-Delonix regia	300	0.01	600	0.01
Dimoru-Ficus lipidosa	1800	0.03	1200	0.02

Tree species	Total trees and tree density country side of the Embankment		Total trees & Tree density River side of the Embankment	
	No. of trees	Tree density	No. of Trees	Tree Density
Ahot-Ficus religiosa	600	0.01	600	0.01
Segun-Tectona grandis	4200	0.07	0	0
Atlas-Annona squamosa	1200	0.02	1200	0.02
Kadam-Anthocephalus cadamba	300	0.01	0	0
Kolajamun-Syzygium cumini	120	0	0	0
Siris-Albizzia lebek	300	0.01	300	0.01
Jalphai-Elaeocarpus floribundus	0	0	60	0
Amita-Carica papaya	120	0	0	0
Sajina-Moringa oleifera	300	0.01	0	0
Narikol-Cocos nucifera	240	0	0	0
Total	62160	0.04	80460	0.05

276. **Mitigation Measures**. Efforts shall be made to minimise the tree loss. Provision shall be made for planting three trees for every tree cut. Plantation programme shall be initiated parallel to construction activity. The native and existing vegetation profile shall be maintained during plantation programme, so that local inhabitants can utilize their resources. Indigenous plants namely Jati-bet- Calamus erectus, Bamboo- Bambusa balcooa, Bamboosa tulda, Delbergia sisso, Artocarpus heterophylus, Dimoru-Ficus lipidosa and Ahot-Ficus religiosa shall be preferred. Aforrestation shall be undertaken with community participation. Communities affected shall be invited to participate in the planting and maintenance to ensure high survival rate.

Operation Phase

277. **Impacts.** No direct impact is anticipated during operation stage except accidental damages or absence of tree management.

278. **Mitigation Measures**. Arrangement shall be made for effective tree management to ensure survivability of the tree plantation. The Department of Environment and Forest - Social Forestry Wing may be consulted or involved in this programme. The tree survivability audit shall also be conducted at least once in a year to assess the effectiveness of the programme.

5.2.7.2 Habitat Fragmentation and Destruction

Design and Construction Phase

279. **Impacts.** No habitat fragmentation and destruction is envisaged due to the project activities in the reach. However, provision of construction of drainage sluices will help in improving the re-colonization of aquatic bio diversity.

280. **Mitigation Measures**. Awareness program shall be initiated to inform the people about the usefulness of the sluice gate and remove the fear of increased flood due to such opening.

Operation Phase

281. **Impacts**. Inappropriate opening of the sluice gate may have substantial damage to the eco system.

282. **Mitigation Measures**. Appropriate management will have to be made for the operation of the sluice gate as resident around are not very favorable to this gate due to the fear of increased flood from Brahmaputra. The purpose is that the water connection is available between the lake and river Brahmaputra for the movement of the aquatic life between river and lake.

5.2.7.3 Animal Distribution/Migratory Route

Design and Construction Phase

283. **Impacts.** There is no migratory route of wildlife species in entire Palasbari Reach area; hence there is no possibility of impact on animal distribution. There are two dolphin breeding sites located at Dharapur-Khonajan mouth and Palasbari Boatghat area (Coordinates: 26°07′88″N - 91°35′24″E). The Dolphin breed during monsoon period between (May to August). Dolphin is sensitive to polluted water and any obstruction of the channels at this stage may disturb the breeding activities.

284. **Mitigation Measures**. The construction activity should be restricted during the breeding period of May to August at these two Dolphin breeding sites. About 2km section around the identified Dolphin breeding site will be designated as sensitive area. All care shall be taken to ensure that construction waste does not find its way to water in this area and pollute it. Care shall also be taken to ensure that channel is not obstructed in any way. Civil work contract documents will specify these requirements, including the regular monitoring by an environment expert from the subproject implementation office.

Operation Phase

285. **Impacts.** No impact is anticipated during operation stage with regards to animal distribution and migration.

5.2.7.4 Endangered Species

Design and Construction Phase

286. **Impacts.** No impact is anticipated on any endangered species since these are not found in this area currently. As per the information, 9 Reptilian Fauna, 17 Avian Fauna and 1 Amphibian Fauna, and Gangetic dolphin which are categorized as endangered species have reached this area. The reptile fauna are still found some time in this area. However, no impact on any endangered species due to project intervention is envisaged.

5.2.8. Aquatic Ecology

5.2.8.1 Effect on Fishing Activities/productivity

Design and Construction Phase

287. **Impacts.** Palasbari Boat Ghat (Co-ordinates: 26°07’88” N, 91°35’24” E) and Majgumi (Ch. 26.0 km) (Co-ordinates: 26°05’42” N, 91°19’34” E) are the two major fish landing sites in the Palasbari Reach where the bulk selling and buying of the catch is done mostly on wholesale basis and are important facility for transportation of fish catch. These fish landing sites may be

disturbed during the project implementation period. There are 10 minor fish landing sites in the reach. Temporary flushing of the fish species towards the deeper part of the river may happen during construction of bank line protection measures. The construction of spurs and deflectors will not affect the fish activity in the river as they move with the river current. The construction activity may increase the turbidity on the bank temporarily.

288. **Mitigation Measures**. Adequate provision shall be made in the design to ensure access to the fish landing site/Boatghat. Adequate requisite facilities shall be restored or maintained for undisturbed movement of the fisherman. The provision of sanitary facilities and concreted platform area with grease trap for collection of spill over or waste oil shall be provide at fish landing site/ boatghat to prevent contamination of river water specially at boatghat which is also the fish/ Dolphin breeding site.

<u>Operation Phase</u>

289. **Impacts.** No impact is anticipated during operation stage with regards to fish activities.

5.2.8.2 Migratory Routes

<u>Design and Construction Phase</u>

290. **Impacts.** There is no migratory route of fish in the Palasbari Reach, which can be affected due to the proposed project. The migratory fish species like Hilsa (anadromus[39]) and Anguilla (catadromous[40]) migrate through the main channel of the river i.e. through the deeper zones of the river. Therefore, project will not have any impact on the migratory route of these fishes. Other fish species like *Crossocheilius, Tor* also show only local migration from upper to lower reaches of the river but these also migrate in the deeper zone of the river. The construction of the dyke and revetment measures will not have any effect on the migratory routes.

5.2.8.3 Effect on Spawning and Breeding Grounds

<u>Design and Construction Phase</u>

291. **Impacts**. Along the whole stretch of Palasbari Reach, there are few breeding grounds as well as spawning grounds for fish. It has been observed that all fish species do not breed in same place. Breeding grounds varies from fish to fish as well as location. It has been observed that most of the riverine fish species, e.g. *Baralious, Salmostoma, Danio, Gara* etc., prefer the shallow courses of river for breeding and spawning. For other fish species like *Minnows, Channa, Labeo* and the like prefer beel for breeding. Fish spawning seasons also vary from fish to fish. However, most normal seasons for almost 80% of fish species starts from April and ends in August (i.e. during pre-monsoon and monsoon seasons).

292. At Ch. 0.0 km of Palasbari Reach, fish diversity is rich near the bank of the river and is breeding place for some minor carp fish. Last Spur No. 7 (Ch. 11.7 km) (Co-ordinates: 26° 05’ 48” N, 91° 20’ 52” E), small channels of the River Brahmaputra flows here. Due to the spur the river channel shifted to other direction. During the flood seasons many fishes come here for breeding and playing. Increase in siltation due to construction activity in this area particularly during the breeding season, may disturb the breeding activities.

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[39] Migration of fish from sea to fresh water for breeding.
[40] Fish that lives in fresh water and breeds in sea.

293. **Mitigation Measures**. The construction activity should be restricted during the breeding period of April to August at above breeding sites. All care shall be taken to ensure that construction waste does not find its way to water in this area and pollute it. These will be included in the civil work contracts with the designation of the sensitive areas where construction works will be restricted during the specified period.

Operation Phase

294. **Impacts.** No impact is anticipated during operation stage with regards to fish activities.

5.2.8.4 Effect on Pond Fisheries

Design and Construction Phase

295. **Impacts**. No pond fisheries activities are found along the existing embankment. However pond fisheries are found in the study areas. The current productivity of these places is low. Once flood scenario is stabilized, siltation problems will be minimized, and the fish productivity of these areas will be improved.

296. **Mitigation Measures**. The fish productivity can be improved substantially with use of better fish culture and increasing the capacity of fish ponds as well institutional strengthening support. Fish productivity audit may also be undertaken to assess the effect of institutional support.

5.2.9. Socio Economic

5.2.9.1 Demography

Design and Construction Phase

297. **Impacts.** Owing to the proposed project, there will be establishment of construction camps that will add to the population of the study area. Migrant workers will have the potential impacts of conflicting culture and lifestyle; compete with local laborers over job opportunities, and potential health issues such as HIV/AIDS. This shall also exert pressure on the natural resources in the project area. However, this will only be a temporary phase lasting only during the construction period.

298. **Mitigation Measures**. Early consultations will be made by the contractor with the local communities to determine the appropriate location of work camp sites with the encouragement that local people are given preference in employment when they meet basic job requirements. All migrant workers will undergo workshop/briefings to sensitize them on local culture and lifestyle awareness.

5.2.9.2 Establishments

Design and Construction Phase

299. **Impacts**. Good number of houses and establishments are located close to the existing embankment. Even some of the habitats have their hutments on the embankment itself. The households likely to be affected will be covered under the RAP report. The household likely to be affected by project intervention will receive compensation and assistance as per the RAP, to be prepared based on ADB policy on IR, National Policy on R&R and Assam state laws. Various educational, physical or cultural heritage facilities viz., temples, prayer halls, mosque,

graveyard, cremation ground, id-gah maidan etc., are located close to the embankment which may affected partially or due to construction Noise and Air pollution. The details of such facilities are presented in Table 5.5:

Table 5.5 Establishments Located within 100 m impact zone

Facility	Majirgaon-Dakhala		Dakhala hill- Gumi		Gumi-Nagarbera	
	CS	RS	CS	RS	CS	RS
Education Facility						
L.P.school	2	Nil	2	Nil	9	1
M.E.school	1	Nil	Nil	Nil	4	Nil
High School	1	Nil	2	Nil	4	Nil
Madrassa	Nil	Nil	Nil	Nil	3	Nil
Religious and Cultural Heritage Facilities						
Temple	3	Nil	2	Nil	Nil	Nil
Namghar(prayer Hall)	2	Nil	2	Nil	1	Nil
Mosque	Nil	Nil	2	Nil	9	1
Graveyard	Nil	Nil	Nil	Nil	1	Nil
Cremation ground	1	Nil	Nil	Nil	Nil	Nil
Id-gah maidan	Nil	Nil	Nil		1	Nil

300. **Mitigation Measures**. Efforts shall be made to prevent any relocation or demolition of these establishments. Where required, the social infrastructure shall be rehabilitated taking account of social and cultural values. Temporary Noise Barrier will be installed close to school and place of worship during the construction stage. Thick plantation shall be made close to these establishments

5.2.9.3 Archaeological Sites to be impacted

301. **Impacts.** No archaeological sites will be impacted due to the proposed construction of river embankment along the Palasbari Reach

5.2.9.4 Places of Pilgrimage and Tourism to be impacted

302. **Impacts.** There is no pilgrimage or tourist spot along the Palasbari Reach. Hence, no impact to this valuable component is expected. In fact, with the strengthening of embankment and improvement of roads will have positive impact on the accessibility of the villages along the reach.

5.2.9.5 Water Supply and Sanitation

<u>Design and Construction Phase</u>

303. **Impacts**. Local residents are dependent on ground water for meeting their drinking water supply. The quality of ground water in this reach was found fit for drinking purposes. The proposed sub-project activities are not likely to affect the water supply of the area.

304. Sanitation facilities are poor in the area. People residing near the embankments usually go to river bank for their daily needs. Many places in the embankment have been damaged to create access to the river. Drinking water and sanitation becomes one of the major problems

during floods. Another problem in the embankment construction is that it complicates the disposal of sewage and runoff water from the countryside to the riverside. Open drainage canal that drains individual houses usually runs almost parallel to the embankment for some distance until a creek or river intercepts and drains towards Brahmaputra River. The extended open drainage canals are usually not maintained and poses serious health hazard. Several points along the embankment are also used as disposal site for municipal solid wastes. The need for disposal sites should be considered in the design of the embankment.

305. **Mitigation Measures**. Access should be provided to river near intensive settlement areas. Awareness should be created among the residents about the upkeep of the embankment. Garbage shall be collected at designated locations. The promotion against the disposal of untreated sewage (through septic tanks) shall be conducted under the sub-project.

Operation Phase

306. **Impacts**. Unplanned development, encroachment, and tree plantation may effect the stability of the embankment

307. **Mitigation Measures**. Uncontrolled and unplanned development should be prevented. Awareness shall be created amongst the people for the upkeep of the embankment.

5.2.10. Land Use

Design and Construction Phase

308. **Impacts**. A large number of households are affected by flood and erosion. In the Palasbari Reach alone, about 78.61 % of households surveyed by socio-economic team under this TA are affected due to flood and erosion. The proposed project will bring relief to the entire population in this area. The project will also provide employment to a large number of people for about 6 years. The project will boost the local economy as small businessmen and entrepreneurs will provide the daily needs of the workers and officers of the proposed project.

309. With the stabilization of the area and prevention of land loss due to erosion every year (about 90.1 ha/year) land availability for multiple crops will increase bringing positive impact on the local economy.

310. Nevertheless, some of the subproject infrastructure would require land acquisition and resettlement, including the construction of 15.1km of retired embankment, as well as renovation of existing embankments. The embankment retirement would require the acquisition of land for the shifting of the embankments, which will be assessed after embankment alignments can be fixed following the bank line stabilization through riverbank protection works. In addition, strengthening of the existing embankments, riverbank protection, sluice gates, and associated structures will also require certain amount of land acquisition and resettlement, including the embankment informal dwellers.

311. The subproject area also has existing embankments and associated structures of which land acquisition process has not been completed. It is a demand of concerned local population that the past dues of the land acquisition and resettlement payments should be provided in association with the improvements of the concerned infrastructure.

312. There are twelve fish landing stations in this reach. The average fish collection at these centers is of the order of 100 to 150 Kg per day. These stations may get disturbed during construction stage.

313. **Mitigation Measures**. The resettlement activities will be implemented in accordance with ADB's voluntary resettlement and other social safeguards policies, as well as the applicable laws and regulations of the Government of India and the Assam State. In the context of the project, a resettlement framework (RF) and indigenous people's development framework (IPDP) were prepared to cover the subproject infrastructure, for which specific scopes will be finalized following the detailed design and prior to the tendering of the concerned infrastructure works.

314. Regarding the pending compensation of past structure works, if any subproject sections to be covered by the proposed project have any outstanding grievances from past acquisition for embankments that are being strengthened and/or improved, a due diligence would be undertaken to assess the scope of the problem with detailed recommendations to address the grievances prior to launching the subproject work.

315. It is recommended that the PAPs are given preference as daily wage laborers. Proper income generation program should be included in RAP for the post construction period. The training programs for agriculture and fish production improvement shall be implemented so that the local economy is positively impacted by the proposed project.

316. Farmers can also consider switching over to shallow water rice cultivation means from anaerobic verity to aerobic verity of rice cultivation. Farmers will be able to get three crops which are otherwise mostly limited to two crops.

317. Appropriate provision shall be made to provide alternate fish landing stations so that economic activities of the fishermen are not disturbed due to project activities.

5.2.11. Accidents and Safety

Design and Construction Phase

318. **Impacts.** The risks associated with the proposed project are minimal. However, roads being narrow, efforts shall be made that no hazardous traffic conditions are created due to construction vehicle movement. Local people may encroach to construction area and get hurt.

319. **Mitigation Measures**. Adequate lighting and fluorescent signage shall be provided at the construction sites. Signage shall be made in local language.

320. The workers shall be provided with necessary Personal Protective Equipments and a First Aid unit including adequate supply of dressing materials, transport means, nursing staff and an attending doctor, shall be available at each construction site. Health check up camps shall also be organized every year.

Operation Phase

321. **Impacts.** Due to improved road condition, drivers may have tendency to drive fast on embankment road resulting in accidents.

322. **Mitigation Measures**, Speed limits shall be prescribed for vehicular movement on the embankment road to avert the accidents. Adequate signage and light reflectors shall be placed along the road side.

5.2.12. Navigation

Design and Construction Phase

323. **Impacts.** This river section is navigated by people for moving from one place to another located at river bank and moving to char lands for fishing & farming. They use small motor boats and fish landing sites or boat Ghats for these movements. There are various fish landing sites in this sub project area. Palasbari Boat Ghat and Majgumi are the big sites where fishes are traded in whole sale. These landing sites/boat ghats could be temporarily disturbed due to project activities. However there will not be any impact on the general navigability of the river due to the project since project activities are limited to river bank and beyond.

324. **Mitigation Measures**. During construction, contractors are asked to provide alternate landing sites (ghats) with similar berthing facilities, access, and other common infrastructure, as part of the tender documents. In places the riverbank protection will provide steps to facilitate landing of local boats in support of trade and river crossings. The project design has additional provisions to closely monitor the general river behavior as well as its response to the new works and, within the concept of adaptive approach, to mitigate any negative impacts (through phased implementation).

5.3. Summary of Impacts

325. With implementation of proposed mitigation measures the residual impact in most of cases is expected to be minimized. The summary of impacts/ mitigation measures & residual impacts is given at 0.

6. ENVIRONMENTAL MANAGEMENT PLAN (EMP) AND MONITORING PLAN (EMOP)

326. The aim of the Environmental Management Plan (EMP) is to ensure implementation of the recommended mitigations measures throughout the subsequent subproject development stages. The mitigation measures are designed either to prevent impacts or by mitigating those to reduce the effect to an acceptable level by adopting the most suitable techno-economic option. The EMP also ensures that the positive impacts are conserved and enhanced.

6.1. The EMP

327. The Environmental Management Plan (EMP) is consists of a set of mitigation, monitoring and institutional measures to be taken during the design, construction and operation (post construction) stages of the project. The plan also includes the actions needed for implementation of these measures. The major components of the Environmental Management Plan are:

- Mitigation of potentially adverse impacts
- Monitoring during project implementation and operation
- Institutional Capacity Building and Training
- Implementation Schedule and Environmental Cost Estimates
- Integration of EMP with Project planning, design, construction and operation

328. The Environmental Management Plan is detailed at Appendix 6.1.

6.1.1. EMP Implementation Timetable

329. The mitigation measures shall be implemented depending on the nature and time of impact. The implementation schedule has been prepared considering 72 months of construction phase starting from year 2009 and Operating Phase of 30 years. The proposed implementation schedule is enclosed as Appendix 6.2.

6.1.2. Social Development Program

330. A separate social impact assessment study has been undertaken and social development program is addressed as per SIA. The various impacts having significant impact of social nature like agriculture, fish catch etc. have also been addressed under this study. The mitigation measures including training aspects has been covered under this section and detailed at Chapter 5.

6.1.3. Contingency Response Plan

331. Field study, public consultation, and consultant's experience reveal that this project may have only two environmental emergency i.e. accidents on paved roads and consequent spillage, and breach of embankment/overtopping of embankment.

332. It is suggested that the communication and response system be developed and practiced to minimize the response time. This should be covered under environmental guidelines to be prepared by WRD for effective implementation of mitigation measures. The local people/fishermen should be informed about likely accidental spills, nature of contamination

and response. The project authorities (WRD) should ensure accidental spill management either by developing in-house capabilities or by associating with any competent third party.

333. Improved flood forecasting and warning by the WRD to communities is one of the components of this Project to be developed during Year 1 of implementation. A variety of national (CWC, IMD), State (WRD, Department of Revenue) and local government (DCs) agencies participate in the flood forecasting-warning process in Assam. The crucial element of this process is the provision of timely and accurate warning of villagers about an impending flood. Discussions to date indicate that most villagers receive no formal flood warnings.[41] They generate their own warning by watching the river during the flood season, taking into account local rainfalls. Local villagers seem to be highly flood aware and flood resilient. Improvements to 'upstream' elements of the FFW process will be pointless if they are not translated into more effective responses at the community level. *Again, it would seem that improvements to the FFW system at the national and State levels will not provide a panacea to flood risk management in Assam.* It is noted that during the flood season, WRD station officers at 5 km intervals patrol the embankments, measure flood levels and report back to the flood control centre. These front-line observers have the training to provide effective and accurate local flood warnings with levels meaningful to villages along their respective 5-km sections of embankment.

334. The Project will review the various elements of FFW process, paying special attention to warning needs at the village level and possible improvements (i) at the community level and (ii) at the flood emergency management level. It is anticipated that an important element of an improved FFW system will be the provision of local forecasts by WRD, i.e. the translation of regional forecasts by CWC into clear and easily understandable warnings at the village level. Local communities will be centrally involved in this process. The Project will work with CWC and IMD regarding FFW.

6.1.4. Authorities and Their Responsibilities for Implementation of the EMP

335. The authorities and responsibilities for the implementation of the environmental management plans shall be tiered based on the activity. The suggested hierarchy and information flow is given in Figure 6.1.

336. All the policy decisions, including incorporation of the EMP requirements in compliance to loan covenants shall be the responsibility of the recommended Assam Integrated Flood Control and Riverbank Erosion Risk Management Program (AIFRERM) Agency as the executing authority and will be registered under the Societies Act. The AIFRERM will be composed of representatives from State: Departments of Water Resources, Agriculture, Char Development, Finance, Fisheries, Forest and Environment, Planning and Coordination, Public Works, Disaster Management and Revenue, Rural Development, Soil Conservation, and Welfare of Plain Tribes and Backward Classes.

337. A Program Management Unit (PMU) will be established in AIFRERM Society that will have multi-disciplinary structure. One of the units in the PMU will be the social and environmental unit The PMU will be assisted by a multidisciplinary team of consultants for institutional strengthening and project management (ISPM) for capacity development, quality control, and project management. The PMU-Social and Environmental Unit will ensure that the environmental mitigation measures are being implemented by the subproject implementation offices (SIOs). The PMU will, among others ensure that the EIA Reports comply with national

[41] At Dibrugarh, the Army warned one of the visited villages of the impending 2002 Flood.

and Bank guidelines, monitor the status of implementation, and preparation of monitoring reports. The regional office of ADB, in close consultation with RSDD, is recommended to confirm the compliance with ADB's safeguard policies by the PMU.

338. The SIO will operate at the field level and will have their respective safeguard cells for each subproject, including one environment expert to monitor and support the environmental monitoring and management plans to be implemented at the subproject level, under the support and guidance of the PMU environment expert and the consultant team for institutional strengthening and project management which include a national and an international environment specialist.

6.1.5. Mechanisms for Feedback and Adjustment

339. The SIO-Safeguards Cell in particular its environment expert with the help of contractors will submit a monthly progress report on implementation level of EMP to the SIO and PMU. Any deviation from the contract requirements with respect to proposed EMP should be corrected within a fortnight and records maintained for the same.

340. As part of the feedback mechanism, the SIO shall monitor project compliance with respect to:

- Environmental Management Plan
- Applicable laws, rules and regulations

341. Public involvement shall be encouraged and ensured throughout the lifecycle of the project. The SIO shall gather and maintain information on any damage or public concern that may be raised by the local people, NGOs and local authorities. While immediate solutions are to be worked out with the help of contractor, a detailed report will be submitted to the SIO for information or detailed consideration, as the case may be. The SIO will be responsible to bring it to the notice of the PMU. Resulting decisions shall be communicated back to SIO and contractor for correction and future implementation. An operation-period workshop may be required for effective implementation of the EMP.

6.2. Environmental Monitoring Plan (EMoP)

342. The aim of environmental monitoring during the construction and operation phases is to compare the monitored data against the baseline condition collected during the study period to assess the effectiveness of the mitigation measures and the protection of the ambient environment based on national standards.

343. A monitoring schedule has been drawn up based on the environmental components that may be affected during the construction and operation of the project. Since project is likely to have impact on various components of environment, a comprehensive monitoring plan covering wildlife, fisheries, cropping pattern, soil erosion, drainage congestion, tree plantation, air quality, noise & vibration are provided as Appendix 6.3. Monitoring Plan has been separately suggested for construction phase and operation phase. Monitoring points have been selected based on the sensitivity of the location with respect to sensitive receptors.

6.2.1. Monitoring Schedule

344. The monitoring schedule has been developed based on the possible occurrence of adverse impacts and required mitigation actions. However, this monitoring schedule is subject to change depending on the analysis results obtained. The protocol for changing the monitoring schedule is given below:

6.2.1.1 River Hydrology, Morphology, and Sediment Transport

345. No significant external negative impacts on river hydrology, morphology, and sediment transport is expected due to the nature of the Project to support the strengthening of the existing embankment systems that will maintain or restore the intended functions of those systems and thus formalize the existing flooding behavior that has persisted since these embankments were first constructed. Riverbank protection measures–with their focus on revetments and pro-siltation measures along the naturally developing bank lines in an adaptive manner–will not alter the existing unstable channel formation pattern of the Brahmaputra morphology. However, the project will put into operation systematic monitoring of river hydrology, morphology, and sediment transport and build sound knowledge base as an important component of the overall investment. This will facilitate the identification of any localized impacts in the subproject areas.

6.2.1.2 Terrestrial and Aquatic Fauna including Fisheries

346. The fish productivity monitoring are important and sensitive issues. In case, any significant decline in terms of fish productivity in the beels/wetlands or pond is noticed the monitoring frequency be increased till the effectiveness of mitigation measures are established.

6.2.1.3 Water quality

347. No significant change in water quality is perceived due to the project in the operation phase. However, in the construction phase owing to construction activities the monitored values for pH, BOD, COD, TDS, DO and Oil & Grease might change. Hence, it is suggested that if the monitored value for any water quality parameter exceeds by more than 20% of its last monitored status the monitoring frequency shall be increased.

6.2.1.4 Tree Plantation

348. The 75% survival rate of re-plantation shall be monitored on the first year of the operation phase. If the survival rate is found below 70%, survival rate monitoring shall be again taken up after 3 years. This cycle should continue until the 70% survival rate is achieved.

6.2.1.5 Soil Erosion and Drainage Congestion

349. No significant soil erosion problem is anticipated due to the project either in the construction phase or in the operation phase. However, in the construction phase, some localized soil erosion may be noticed owing to construction activities. However, if soil erosion is noticed during construction and operation phase, the corrective action shall be initiated and frequency of check be increased to assessed the tendency of recurrence. The river hydrology, morphology and sediment transport shall also be monitored.

6.2.1.6 Air and Noise Quality

350. Due to the variability of the construction activities, namely changes in batch composition, type of construction activity and other anthropogenic influences, the air quality in the project

area may change. If the air quality with respect to any parameter exceeds by more than 25% of its last monitored value, the monitoring frequency shall be doubled and cause of the increase investigated. If the construction activities are found to be the reason for this increase, suitable measures should be adopted.

351. Similarly due to the variability in traffic movement, namely changes in traffic volume, traffic compositions and other anthropogenic influences, the noise quality in the project area is likely to change. If the noise quality exceeds by 20% of the applicable ambient noise quality standard or 5% of its last monitored value, the monitoring frequency shall be increased cause of the increase investigated. If the construction activities are found to be the reason for this increase, suitable measures should be adopted.

6.2.2. Authorities and their Responsibilities for Implementation of EMoP

352. The most essential component of the Environment Monitoring Plan is the execution of the Plan in accordance with the monitoring schedule provided therein. The SIO-DMCT will be responsible for timely monitoring of various parameters and compliance with the mitigation measure proposed. A resultant data base is proposed to be maintained. A Management Information System (MIS) is also proposed to be prepared for effective flow of information between various levels and functions within PMU.

6.3. Institutional Capacity

353. The proposed organization structure to implement the AIFRERM and the environmental management plan is shown at Figure 6.1.

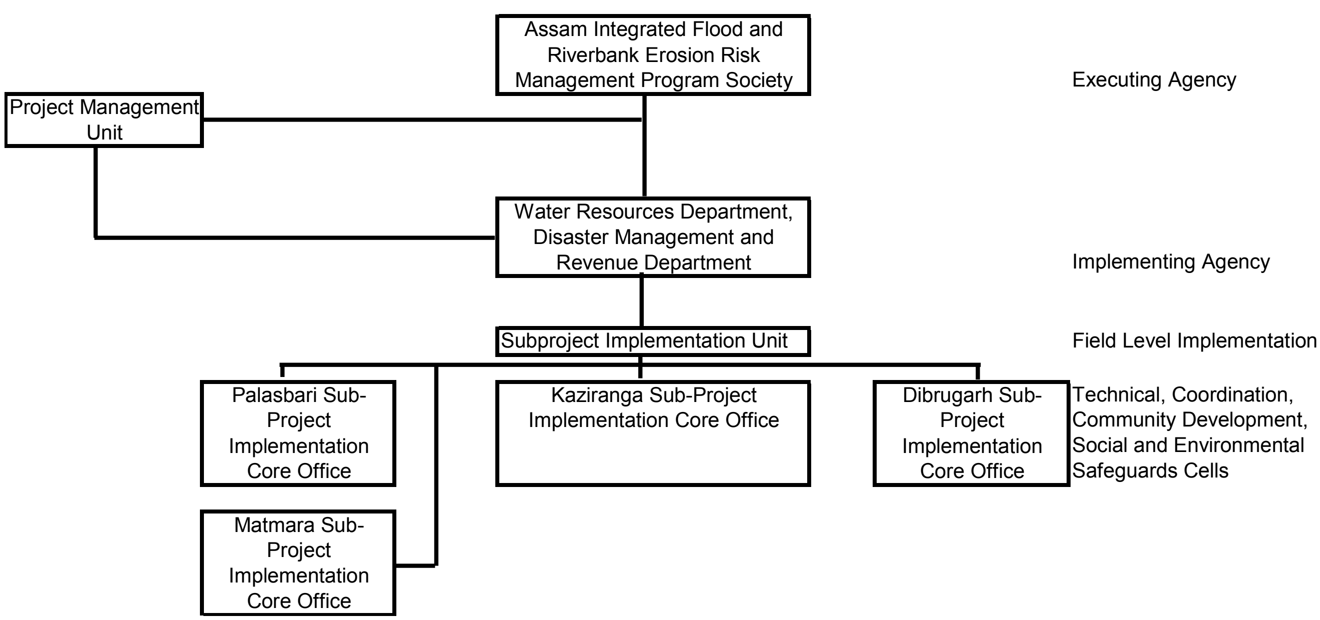

Figure 6.1 Proposed Organization Structure

354. To enhance the capacity of the SIO for effective implementation of proposed mitigation measures and monitoring the resultant effect, some training programs are proposed. The detailed training plan is provided at Appendix 6.4.

355. It would be essential to understand the legislative framework and enhance capacity of WRD officials for analyzing the applicability of various environmental legislations and clearances, approvals and compliance monitoring requirements. An environmental legislation applicability matrix and legislative framework has already given in Chapter 2 above for ready reference.

6.4. Mitigation, Monitoring and Institution Strengthening Cost

356. The environmental budget has been worked out for the entire four projects together since various costs are common in nature. However summary table below highlights sub projects specific costs component. The mitigation cost, inclusive of monitoring cost and training during the project life cycle (construction and operation phase) amounts is estimated to be Rs 77.94 million for all the sub project put together. The mitigation cost including monitoring is estimated as Rs 57.89 million during construction phase and Rs 5.46 Million during operation phase. The costs of establishment and training are estimated as Rs 7.5 million. The detailed break up is given at Appendix 6.5 and summarized in **Error! Reference source not found.** below.

Table 6.1 Summary of Mitigation, Monitoring and Institutional Costs

Component	Total Amount (In Million Rs)	Costs Breakdown where applicable (in Million Rupees)		
		Palasbari Reach	Kaziranga reach	Dibrugarh Reach
Design & Construction Stage				
Technical Support for preparation of Environmental Guidelines	0.5			
Flora- Tree plantation	42.12	23.40	3.12	15.60
Fisheries –Institutional support for improving fish productivity	3.0	1.0	1.0	1.0
Monitoring Fish Productivity	1.2	0.4	0.4	0.4
Water & Soil contamination prevention system /soak pits at construction camps	2.04	0.68	0.68	0.68
Health Check Up	1.8	0.6	0.6	0.6
Environmental Monitoring During Construction Phase	7.23	2.41	2.41	2.41
Operation Phase				
Tree survival and Additional Tree plantation	3.0			
Environmental Monitoring During Operation Phase	2. 46	0.82	0.82	0.82
Establishment & Training				
Establishment	3.5			
Training	3.0			
Management Information Systems	1.0			
Contingencies	7.09			
Total :	Rs. 77.94 Million			

(The components which are covered under engineering costs R & R Budget or Regular maintenance costs during operation phase are not highlighted above)

7. ECONOMIC ASSESSMENT OF THE ENVIRONMENTAL IMPACTS

7.1. The Need for Economic Assessment

357. The proposed project shall cause various short/ long term and primary/ secondary impacts on the study area considered as externalities. Although there are however mitigation measures and environmental management plan proposed, non-conformance to which will lead to much higher costs in terms of social and environmental concerns than the cost of the proposed mitigation measures. Hence, an environmental cost-benefit analysis has been carried out to evaluate the significant environmental impacts identified and their related mitigation costs.

7.2. Approach and Methodology

358. To carry out the environmental economic assessment of the project, economic value of different environmental aspects of the Integrated Flood & Erosion Management project has been quantified and evaluated. Various impacts expected during the construction and operation phases, without any mitigation measures and the cost of implementation of the proposed mitigation measures (Costing of mitigation measures has been computed in Chapter 6) are regarded as the costs to the project while positive benefits from the project after adequate implementation of these measures are taken as the benefits from the project. All the three reaches has been analyzed together for the purposes of cost benefits analysis Different aspects considered for the environmental cost-benefit analysis is given in the following sections.

7.2.1. Erosion

359. **Impact Cost:** The Brahmaputra River is considered to be among the most vulnerable rivers in India. Every year considerable productive land is lost to erosion various sections along the river bank. The net project Erosion and average erosion considered for Palasbari reach under the proposed Integrated Flood and River Bank Erosion Management Project are as follows:

Net Projected Erosion in (ha/year)	90.1
Average Erosion meter /year	17

360. In addition to protection of land from erosion, the farmers will be able to get definite third crop. There will be some land acquisition for embankment shifting but the loss of productive land will be minimal and not included here for analysis purposes. The erosion control is a positive impact and there is no adverse impact cost associated with it. There would be some impact during construction that has been address under air and noise pollution section of this chapter.

361. **Mitigation Cost:** The cost of bank erosion control measures is included under the engineering cost of the project.

362. **Benefit Cost:** Although there is no impact or mitigation cost from erosion, the benefit is considerable. Based on land use record of Govt of Assam, majority of the land in the subproject benefit area is agriculture which is about 62%. The major crops grown are Rice, Rabi, Khariff, Mustard and Tea with rice crop accounting for 66%. Considering the land use and existing cropping pattern, a total benefit of Rs 4.65 mn per annum or US $ 0.12 mn for Palasbari reach

can be achieved (Refer Table 7.1 for calculation basis). These benefits can further improve with improved cropping pattern and use of HYV seeds. With availability of land, even non-polluting industries as agro-based and cottage industries may also be promoted in the area.

Table 7.1 Benefits due to Prevention of Land Loss due to Erosion

Projected erosion	Eroded agriculture land	Crop Composition		Allotted land	Riverbank Length (km)	Average erosion (meter/yr)	Value added per ha.	Total benefits	Total benefits
(ha/yr)	(ha/yr)	Crop	E.f	ha			(Rs'000/mt)	(Rs' mn)	mn. US$
90.10	53.82	Rice	0.98	52.5	53	17	0.02	1.23	0.030795162
		Veg(K)	0.02	1.2			0.07	0.08	0.002093613
		Veg(R)	0.04	2.0			0.08	0.16	0.003959318
		Mustard	0.15	8.0			0.01	0.10	0.002471064
		Others	0.237	12.7			0.02	0.258	0.006444732
		Tea	0.000	0.0			0.00	0.000	0
			0.00	0.1				1.83	0.04576389

363. **Net Benefit:** Since there is no impact cost, or mitigation cost, the net benefit equals the benefit which is Rs 1.83 mn per annum or Rs. 54.9 M in thirty years.

7.2.2. Plantation

364. **Impact Cost:** The project also entails cutting of about 15,000[42] trees in Palasbari Reach due to renovation/construction of new dyke and other project activities. Needless to say, trees play an important role in the environment as oxygen purification, checking soil erosion, habitat of numerous different fauna etc. The Bamboo and Simul trees are found in maximum quantity in all the sub project areas. The maturity period of Bamboo tree is about 3 years and Simul is about 10 years' means most of the trees are fast growing. The economic benefit has been worked out based on direct sale value of a matured tree. The average value of a Simul tree is Rs 1500/tree and that of Bamboo is Rs 4000/ per Bunch[43]. For calculation purposes 60% tree are considered as Bamboo and 40% as Simul. On this basis the cost of tree loss is calculated as Rs 39.6 Million

365. **Mitigation Cost:** With regards to mitigation measures, it is planned to plant three times the tree cut. Means a total of 45,000 trees are to be planted. The cost of plantation and 3 years of maintenance is estimates as Rs 2.34 Million. Additionally the cost of monitoring and additional tree plantation is estimates as Rs 0.075 Million.

[42] Here for calculation purposes a bunch of 100 trees is considered as one tree of bamboo.
[43] One bunch of Bamboo tree has about 100 bamboo tree. Depending of its variety it is sold @ rate of Rs 35-80 per tree. For computation purposes average bunch cost has been considered as Rs 4000

366. **Benefit:** Considering that 80% tree only will survive, a total of 36000 trees will be of economic value. Considering the same ratio of 60% Bamboo and 40% Simul, the economic value of these trees would be Rs 108.0 Million.

367. **Net Benefit:** Against the ecological loss of Rs 39.6 Million and mitigation cost including monitoring of Rs 2.415 Million, an ecological gain of Rs 108.0 million is expected. The net ecological benefit from the proposed mitigation measures is thus Rs 65.99 million.

7.2.3. Agriculture

368. The agricultural gain has been computed in the form of gain from prevention of soil erosion above. In addition to this gain farmers in the project benefit area are likely to gain from definite third crop.

7.2.4. Fishery

369. **Impact Cost:** Due to the proposed project no direct impact is anticipated on fisheries/fish productivity. However with the institutional support, the fish productivity can be enhanced which will have all positive impact.

370. **Mitigation Cost:** There are no direct mitigation costs. However provision has been made for institutional support of Rs 4.0 Mn and Monitoring fish productivity of Rs 1.6 Million.

371. **Benefit**: Currently the fish productivity from pond fisheries and beel is of the order of average 100 to 120 kg/ha/annum (It varies though from 10 kg/ha to 250 kg/ha). This productivity can be doubled with proper institutional support. The area under fisheries in Palasbari reach is of the order of 1191 ha. This means a total gain of fish productivity of about 142920 kg per annum (@ increase of fish productivity of about 120 kg/ha/annum). Considering a very average rate of Rs. 50/kg the total gain works out to be Rs 7.15 Million

372. **Net Benefit:** Hence against the (i) Rs 1.4 Million support cost (ii) a benefit of Rs 7.15 Million (iii) the net gain being Rs 5.75 million.

7.2.5. Water, Air and Noise Pollution

373. **Impact Cost:** The noise and emission generation from construction operations and the induced traffic after road construction on the embankment are likely to increase the ambient noise and air pollutant (mainly SPM) levels in the project area. This may cause disturbances to sensitive locations as schools, medical centers and religious places disturb sleep of the local people resulting in fatigue. This could not be quantified owing to absence of any specific studies conducted to quantify the same. The waste water is likely to be generated from camp and workshop which will be treated before disposal.

374. **Mitigation Cost:** The induced noise and air pollution levels are however expected to be mitigated by the proposed plantation costs and noise barriers at select locations. The cost of plantation is already accounted for in the Plantation section while the cost towards construction of noise barriers is considered part of engineering costs. The costs of waste treatment and oil and Grease trap are estimated to be Rs 0.68 Million. The total environmental monitoring including Air and Noise monitoring has also been proposed for the construction and operation phases to keep the levels in check. A budget of Rs 0.82 Million has been allocated for the same.

375. **Benefit:** It is expected that with the adequate implementation of the proposed mitigation measures, the adverse impacts will be nullified. There are however, no additional benefits anticipated from the implementation of these mitigation measures.

376. **Net Benefit:** Hence, as the benefits are expected to nullify the adverse impacts, the net befit will equal the mitigation costs which is in the negative i.e. Rs. 1.5 Million.

7.3. Conclusion

377. Summary of the economic assessment of the project is given in Table 7.2, it can be concluded, that the net result from the project is positive environmental gains.

Table 7.2 Summary of cost benefit analysis (in Million Rs.)

Issue	Impact Cost (I)	Mitigation Cost (M)	Benefits (B)	Net Benefit N = B – (I + M)
Erosion	--	--	54.9	(+) 54.9
Plantation	39.6	2.42	108.0	(+) 65.99
Fisheries	--	1.4	7.15	(+) 5.75
Air, Water and Noise Pollution	--	1.5	--	(-) 1.5
Total	39.6	5.31	170.05	(+) 125.14

8. PUBLIC CONSULTATION

378. The mode of consultation employed during the course of the study was informal consultation. Government officials from different departments that have relevance to the project were consulted. Public consultations were held during field visits to different sectors of the study reach in December 2007, February and March 2008 covering various stakeholders in the impact corridor. Local people were also consulted from different socio-economic backgrounds in the villages along the Kaziranga reach of the project. In addition to that two workshops on interim progress of the project were also conducted during the months of December 2007 and June 2008 in Guwahati.

379. In addition, two state level workshops were conducted. The first workshop was held in December 2007 on the interim progress of project preparation, and the second workshop in June 2008 on the draft findings of the study. Stakeholder consultations and socio economic and poverty surveys were done in 4 villages in the first phase up to Sept 2007, followed by more detailed surveys in 33 sample villages out of 333 villages in the subproject area, along with one village in char land and another village outside of the subproject area using focus group meetings (FGMs) and participatory rural appraisal techniques. Furthermore, surveys on most vulnerable people were conducted in 18 villages through focus group meetings. Group discussions with women facilitated by Women Enumerators on impact of disaster on their livelihood and their present coping mechanism were held in each village surveyed.

8.1. Public Consultation Milestone

380. Different people contacted and consulted during the course of the project are given below. However, since the consultations were informal, no brochures were supplied to the participants.

PARTICIPANTS

Government Regulators
Department of Environment
<u>Representatives</u> **:** Dr. A. K. Baruwa, Director
Assam Science, Technology & Environment Council &
Assam Energy Development Agency
Mode of Consultation : Informal Consultation
Date : December 2, 2007
Department of Environment and Forests

<u>Representatives</u> **:** Mr. B. B. Hagjer (IAS)
Secretary of Environment and Forests
Government of Assam
Mode of Consultation : Informal Consultation
Date : December 3, 2007
Government of Assam

<u>Representatives</u> **:** Mrs. E. Choudhary (IAS)
Principal Secretary, Soil Conservation
Government of Assam
Mode of Consultation : Informal Consultation
Date : December 3, 2007

Water Resource Department
Representatives : Mr. Biren Thukuria
Executive Engineer
Mode of Consultation : Informal Consultation
Date : December 2, 2007

State Pollution Control Board
Representatives : Dr. Rafiqua Ahmed
Mode of Consultation : Informal Consultation
Date : April 25, 2008

Department of Minority Welfare
Representatives : Mr. Md. Allauddin
Mode of Consultation : Informal Consultation
Date : December 3, 2007

Charland Development Directorate
Mode of Consultation : Informal Consultation
Date : December 3, 2007

NGOs
ASRSG
Representatives : Dr. Bibhab Kumar Talukdar
Co-chair (South Asia)
IUCN SSC Asian Rhino Specialist Group
Mode of Consultation : Informal Consultation
Date : March 3, 2008

Carrier Care Group
Representatives : Mr. Mintu Handique, Co-ordinator
Mr. Gaurav Borgohain, Co-ordinator
Mode of Consultation : Informal Consultation
Date : March 5, 2008

CE-NES
Representatives : Mr. Sanjay Hazarika
Mode of Consultation : Informal Consultation
Date : March 10, 2008

8.2. Information Disclosed

381. The discussions were primarily focused on receiving maximum inputs from the participants regarding their acceptability and environmental concerns arising out of the project. Issues were discussed in depth with the government officials and NGOs while in case of the villagers those issues were touched upon which are relevant to them. To begin with, they were given a brief outline of the project's objectives, type and components of the project in a simplified manner and in their native language. A set of pre-determined common questions were provided to the stakeholders to seek their perception of the proposed subproject.

382. The discussions with the stake-holders were focused mainly on the following points:

- Problem(s) related to environment as a result of flood and erosion of the Brahmaputra river,
- Whether the proposed project will help in providing safety to the people, their property and environment of the area,
- Any significant negative impact of the project on the overall environment of the area,
- Possible impacts of the project on agriculture, wetlands, drinking water facilities, and local economy

383. Impact on the flora and fauna was mainly discussed with the officers of the forest department. The effect of air and noise pollution due to the project (during the design and construction stage) and disturbance in river water was discussed at length.

384. The consultation process was undertaken after studying the project design and identifying the possible impacts due to the project execution and commissioning. The impact assessment study focused mainly on the findings of the assessment and acceptability of the proposed mitigation measures. Issues of tree cutting, impact on physical environment, disturbance on fishing activities and fish productivity, productivity of beels in the study area and proposed mitigation measures were discussed at length.

385. For the purpose of the state-level workshop, the executive summaries of the study findings were shared in advance with the invited participants including the NGOs. The first workshop presented and discussed the interim findings of the project preparatory studies, including the problems and issues related flooding and riverbank erosion in Assam including lessons, key strategic elements for integrated FRERM, and peoples' perspectives on living conditions and aspirations. The second workshop presented the draft final findings, including the rationale and preliminary objective and scope of the IFRERM Assam, social impact assessment and safeguards, and environmental impact assessments. After the workshops, press briefings were organized with the circulation of the executive summaries. The presented materials at the workshops are posted in the following ADB websites on the IFRERM-Assam:

- 1st Workshop held on 1 December 2007 at Administrative Staff College of India, Guwahati (http://www.adb.org/Documents/Reports/Consultant/38412-IND/38412-IND-TACR.pdf)
- 2nd Workshop on 25 June 2008 at the Institute of Engineers Conference Hall, Guwahati (http://www.adb.org/Documents/Reports/Consultant/38412-IND/38412-01-IND-TACR.pdf
- 3rd Workshop held on 4 February 2009 at Brahmaputra Hotel, Guwahati (http://www.adb.org/Documents/Reports/Consultant/38412-IND/38412-02-IND-TACR.pdf).

8.3. Major Comments Received

386. While a wide range of people from different administrative, social and economic backgrounds were consulted, their concerns can be summarized in the following three categories of discussion of issues.

Local people's Comments

387. The project received unanimous support and consent from all local people including those who will be rehabilitated, provided adequate compensation is paid. Environmental awareness and likewise concern were found low and issues such as probable reduction in fish catch also did not raise any significant concern amongst the fishermen. The only concern of the

villagers was pertaining to compensation against loss of land and the mode of payment. People are looking forward for quick compensation and early start of the project.

388. People welcomed the initiative of the Government of Assam for strengthening of embankment and providing revetment to the riverbank, as many of them were inundated during 2004 flood. Condition of the Panchayat Bundh has emerged as the major area of concern for the local people. They were looking forward for enhancement of ghat facilities and environment around it.

389. The local stakeholders were especially supportive of the project as it can reduce the flood inundation scenario as well as protect the land from erosion, which will result in significant safety scenario as well as socio-economic development of the region. The local people did not perceive any adverse impact due to the proposed project.

390. The potential project affected people repeatedly stated their resettlement and compensation worries and on being informed of increased air and noise pollution from induced traffic and construction activities, remarked that it does not concern them much.

NGOs' Comments

391. There are limited NGOs' active in the study area and directly dealing with environmental issues. All the NGOs' consulted had welcomed the flood control project and said that it will help in protection of agricultural land, domestic animals, fishermen communities etc. They also highlighted the importance of maintaining the natural drainage system along the project sites. The NGOs during interaction also highlighted the relief work they are carrying out during the flood situations. They also suggested increasing forest cover through aforestation program. Dr Sanjay Hazarika of CE-NES also indicated the need of enhancing institutional capacity and strengthening review mechanism. He also emphasize on the following:

- Prevent any change to natural drainage,
- Consider provision of alternate platform then only attached to embankment for use by animals and people during flood, and
- Protection of the fish spawning grounds during construction and operation.

Local Officers' Comments

392. Dr. Baruwa from Environmental Council of Assam had raised concern of leaching of arsenic into groundwater which is generally used for drinking water supply from the river bank filtration wells in the floodplains of Brahmaputra River and also asked about the possibility of integration of drinking water and irrigation projects. The analysis of water quality of surface and ground water samples taken in Palasbari reach revealed very low arsenic content in river water as well as ground water and the water quality was found well within the desirable standards as per IS 10500:1991.

393. Mr. Biren Thukuria (EE, WRD) has highlighted the importance of study for impact on fish productivity due to reduced siltation, which can emerge as a benefit to local fishermen. Mr. B. B. Hagjer (Secretary, Department of Environment and Forests) has pointed out requirement of study of impact downstream and upstream of the reach which can be affected after protection of the reach.

394. During the interaction, Mrs. E. Choudhary (Principal Secretary, Soil Conservation) raised the issues of bed level raising, seepage of embankment/ softening of embankment, erosion and

increase in sedimentation as well as the requirement of catchments area treatment plan. She also revealed the requirement of soil conservation, study of earthquakes and its effect on siltation in the river.

395. The interaction with Department of Minority Welfare and Charland Development Directorate revealed that most of the chars in Brahmaputra are semi-permanent and as per their record there are 2,251 char villages. Drinking water is mainly supplied from the hand pumps and tube wells. The department also supports in the form of seed distribution, construction of raised platforms with and without sheds, repairing of schools, vocational training to local villagers,

396. The interaction with Chief Conservator of Forests, Forest Development Department and Head Assistant of the CCF office on May 19, 2008 has provided the useful comments and suggestions on possible intervention of proposed project on Forest and Wildlife. No specific suggestion or comment was made with respect to Palasbari reach as no protected area is located in the project area. However, prior permission is needed from the Chief Conservator of Forests (Wildlife) for cutting of trees within the boundary demarcated as wildlife sanctuaries and national parks. If land is outside the protected areas, then the permission is not necessary from CCF or Forest Department. However, aforestation is needed if there is any loss of tree species during project intervention. At least three plants must be planted in place of one such tree cut during project intervention. For aforestration program, bamboo, simul trees and banana plants must be planted along the side of embankment. These trees have no side roots to destroy the embankments. Again in the borrowing sites water resistant plants such as Salix tetrasperma, Buwal and Pani hizol should be planted.

<u>State Level Workshops</u>

397. Public consultation was also held with the stakeholders during the two state workshops, which were held in the months of December 2007 and June 2008 in Guwahati. Taking into consideration the environmental importance of the project, a number of environmental NGOs were invited during these state workshops. However, only a few had turned up.

398. During the workshops most of the delegates and NGOs present in the workshops have supported the project. While similar comments as recorded for individual meetings were received, key recommendations in the workshops included (i) wider implications beyond the subproject areas should be assessed including downstream hydrology and sediment transport, impacts of global climate change, etc.; (ii) interventions should be carefully defined considering the data unavailability and unreliability, for which progressive knowledge development and adaptive approach learning lessons are critical; (iii) performance and lessons of FRERM (including its hydrological, social, and environmental implications) should be studied and reflected; (iv) livelihood implications of the poor should include those who live outside of the embankments and chars, and appropriate supporting measures should be included in the project design; (v) willingness of WRD to adopt people-centered approach as suggested by the team would remain a concern calling for serious pursuit; (vii) effective quality control and sustainability assurance measures should be put in place for FRERM structural measures with effective stakeholder participation; and (vi) details of the study finding should be made available to the local research organizations and interested groups.

8.4. Integration of comments

399. As observed from their responses, almost everyone interviewed was supportive of the project and believes that it will help provide the much needed protection against the recurrent ravage of erosion and flood and bring prosperity to the region

400. During discussions, notes were taken for any issue raised and suggestions made. These were then tabulated for a comprehensive analysis of the concerns raised. References have been taken from public opinion where no official data were available, while the officially available data have been extensively used for understanding of the study area characteristics. Each of the issue was then analyzed on practical and scientific basis and accorded a likewise importance in terms of their magnitude in Chapter 4: Impacts and Mitigation. For any significant concern, preventive or mitigation measures have been suggested drawing points from all the suggested measures.

9. CONCLUSIONS AND RECOMMENDATIONS

401. The conclusions are based on Environmental Assessment carried out for the Palasbari reach, which is one of the three reaches identified as most vulnerable to flood and erosion of the Brahmaputra River, under Integrated Flood and Riverbank Erosion Management Project. The subproject is needed to safeguard the people, property and environment from frequent and devastating floods of the Brahmaputra River. The project involves retirement of embankment, renovation of existing embankment and riverbank protection.

402. The project was initially considered as environmental category A by ADB. With the structural works focusing on sustaining the functions of the existing embankment systems through renovation categorized as A. Since the project does not have significant adverse environmental impacts that are sensitive, diverse, or unprecedented, and affect an area broader than the sites or facilities subject to physical works, project may not be categorized as A as per ADB's Environmental Guidelines 2003. However due to proximity of Palasbari sub-project to habitated areas, the project may be categorized as B sensitive. The project was initially considered as environmental category A by ADB. With the structural works focusing on sustaining the functions of the existing embankment systems through renovation of deteriorated embankments, provision of inner secondary embankment and sluice gates, and riverbank protection works, the present EIA indicates no significant adverse environmental impacts that are sensitive, diverse, or unprecedented, and affect an area broader than the sites. The Palasbari sub-project may be categorized as B sensitive owing to its proximity with built-up areas.

403. However, one of the sub-projects, the Kaziranga reach is in close proximity to the KNP and almost sharing a common boundary on its north-eastern boundary. Considering this Kaziranga sub-project environmental sensitive silting issue with the KNP and in compliance to the ADB's environmental guideline that project categorization "environmental categorization is based on the most environmentally sensitive component." the Category A classification is maintained.

404. The EIA study was carried out from January to April 2008. The EIA study was based primarily on secondary data. However, primary data were also collected where secondary data were not available or not up to date. The environmental study covered the project area, as well as the area of direct and indirect impacts. The environmental assessment report was prepared in accordance with relevant applicable laws and regulations of the Government of India; and in conformity with the Environmental Policy of the ADB, 2002 and the Environmental Assessment Guidelines of the ADB, 2003.

9.1. Environmental Gains Due to Proposed Work Justifying Implementation

405. The project entails various impacts on the project setting. There are many impacts bearing benefits to the area against the limited number and magnitude of negative impacts. These include the following:

- The Brahmaputra River carries more water per unit area of basin than any other river in the world, The area experiences heavy rainfall during monsoon with annual rainfall of the order of 170 to 220 cm. The proposed project–through strengthening the reliability of the existing embankments–will prevent people from the impacts of devastating floods.
- The reach is prone to extreme hazards of bank erosion, embankment breaches. This results in loss of productive agriculture land, infrastructure and damage to ecology. The

proposed project will result in protecting loss of precious agriculture productivity.

- The project area does not pass through any protected area (reserved forests, wild life sanctuaries, national park) or ecologically sensitive areas. The aforestation will not only help in compensating losses of trees but also increase tree cover in the long run due to the compensatory aforestation at the rate of 1:3 as per the state government policy.
- There are large number of wetlands, beels and other water bodies (fish ponds) in the study area, however these are not likely to be affected due to the project intervention. The proposed project will likely to enhance the fish productivity these water bodies due to the support program proposed under this project.
- The people are largely poor in the area, many of them are depended on fisheries, agricultural activities and forest resources. The area is also vulnerable to the floods of the Kulsi River that joins the Brahmaputra in this reach. The economic gain is expected to be high.

9.2. Potential Impacts, Mitigation, Management and Monitoring

406. The project entails various impacts on the environmental setting of the area. While some are negative, there are many bearing benefits to the area as well. Provided that the recommended mitigation measures are implemented, no impact is anticipated on endangered species like river Dolphin due to project activities. Some of the trees along the embankment are likely to be cut. But, if the proposed compensatory aforestation plans are effectively implemented and survival rate is monitored and sustained, the positive benefits are likely to be accrued. The project is likely to bring positive impact to wetlands, pond fisheries and agricultural productivity due to protection from flood and reduced sedimentation. Project activities are likely to generate some adverse environmental impacts during construction. However these will be temporary. Implementation of the prescribed mitigation measures will minimize the adverse impacts. Moreover, the impacts shall be monitored continually by implementing and updating the Environmental Management Plan and Environmental Monitoring Plan.

407. The project is welcomed by all the stakeholders. The suggestion received from the public/stakeholders has been integrated while developing the mitigation measures and Environmental Management and Monitoring Plan.

408. There is a possibility that the subproject areas may be affected by the impacts of climate change and other external events including major earthquakes and upstream development works such as hydropower development. While the impacts of these events may well extend the economic life of the subproject investments (of 30 years), available study indicates the possible climate change impact of increased precipitation by up to 30% in the north-eastern region by 2040-60, although diverse anticipation still coexists. A large-scale earthquake (and landslides) may exacerbate the sediment loads of the Brahmaputra, whereas the hydropower dams upstream may reduce the sediment inflow. On these accounts, the systematic monitoring of the river dynamics to be strengthened under the project will facilitate the identification and implementation of necessary measures to adapt to any emerging changes in the construction and post-construction phase of the subproject.

409. During the construction stage, some trees along the embankment are likely to be cut, but if the proposed compensatory aforestation plans are effectively implemented and survival rate is monitored and sustained, the positive benefits are likely to be accrued. Project activities are likely to generate other adverse environmental impacts during construction. However these will

be temporary. Implementation of the prescribed mitigation measures will minimize the adverse impacts, with the stipulated environmental management and monitoring plans.

410. The Project involves strip acquisition of land for strengthening the existing embankments and associated structural relocation. There are also pending land acquisition cases for infrastructure constructed in the past. The concerned land acquisition and resettlement cases including the pending cases will be addressed following the Government's and the SGOA's laws and regulations, and ADB's Involuntary Resettlement Policy, which has been stipulated in the resettlement framework, based on which resettlement plans are prepared and implemented to address all the cases. For tranche 1 works, extensive public consultation has been carried out, consistent with state guidelines. For affected persons, support will be provided to improve, or at least restore, the pre-intervention income and livelihoods standards, and productive capacity. In addition, the subproject will provide construction labor opportunities and community development assistance to nearby communities and to landowners whose land is acquired or structures be affected, including non-title holders.

9.3. Irreplaceable Resources

411. Dolphin and other endangered species found in the Brahmaputra River and other nearby areas are not exclusive to the project site. No damage to the habitat of these species is anticipated. There are no other environmental sensitive resources found in the project area which is likely to be affected due to the project.

9.4. Post EIA Surveillance and Monitoring

412. While an EIA is meant to provide a comprehensive understanding of the environment status of the area under the study, post EIA surveillance is the means to ensure that the significant impacts identified are adequately mitigated as per the proposed mitigation plan. A detailed monitoring plan has been provided as part of the Environmental Management Plan. Fisheries, cropping pattern, air, surface water quality, ground water quality, noise, soil erosion, drainage congestion and tree survival rate monitoring and reporting along with the follow up actions in case of deviation from the norms have been detailed. The frequency has been set in consideration of the likely impacts.

9.5. Public Consultations

413. The project received unanimous support and consent from all local people including those who will be rehabilitated, provided adequate compensation is paid. People welcomed the initiative of the SGOA for strengthening of embankment and providing revetment to the riverbank, as many of them were inundated during 2004 flood. The subproject will result in significant safety scenario as well as socio-economic development of the region. The local people did not perceive any adverse impact due to the proposed project. Environmental awareness and likewise concern were found generally low and issues such as probable reduction in fish catch also did not raise any significant concern amongst the fishermen.

414. Nevertheless, local stakeholders as well as NGOs emphasized the need to ensure the effectiveness of institutions and their program delivery mechanisms to implement the subproject structural and non-structural measures. In particular, villagers were concerned on the compensation against loss of land and the mode of payment, stating that the compensation payment of past land acquisition is still to be provided. Capacities and willingness of the project organizations to adopt people-centered approach as suggested by the project also remains a

constraint. The project has included necessary provisions to address these concerns, including the time-bound actions to address these institutional constraints with institutional reforms and capacity development support.

9.6. Recommendations

415. The EIA was carried out while the feasibility study was being prepared. Therefore, the detailed engineering design was not available. In this regard, any major changes during detailed design, or any major additional work other than the proposed project activities will require preparation of another environmental assessment. This additional assessment will have to be submitted to concerned Government authorities, if any clearance is involved. It shall also have to be sent to ADB for concurrence before civil works commence. Moreover, the executing agencies have to submit the detailed engineering designs to ADB, which will review them and examine whether major changes or major additional works have been included. In this context, changes that need to be reported to ADB involve changes with respect to opening or closing of any gap in the embankment with or without the provision of sluice gate, change in the embankment alignment, and significant change in design specification of the embankment.

416. The flooding and riverbank erosion pattern of the river shall have to be closely monitored and analyzed during the proposed life span of the embankment and riverbank protection measures, and appropriate and timely measures need to be taken to adapt to any changes in the natural river environment. Over the medium to long term, effective knowledge base needs to be established including the modeling of flooding and morphological behavior and sediment transport mechanisms of the Brahmaputra River and its tributaries to quantitatively assess the implications of any past and new water sector investments.

417. WRD has limited capacity to address the environmental measures in house. There is a need to enhance institutional capacity of the WRD with regard to environmental training, monitoring infrastructure and environmental guidelines. Adequate training shall be imparted as proposed under environmental management plan to enhance the capability of concerned EA officials. It is recommended to develop environmental guidelines focused on effective implementation of mitigation measures. Performance indicators may also be developed as part of these guidelines to monitor and assess the effectiveness of the mitigation measures.

418. Awareness program for public shall be launched for flood embankment strengthening and river bank protection works, and conservation of natural environment and sanitation during construction and operation phase of the project.

APPENDIX 1. PROGRAM COMPONENTS

The specific components included in the Assam Integrated Flood and Riverbank Erosion Risk Management Investment Program are as follows:

Component 1: Institutional and Knowledge-Base Development

- Policy and strategic planning framework: (a) consultations towards finalizing a state water policy and steps for initiating implementation; and (b) long-term state flood and riverbank erosion risk management (FRERM) plan (building on existing plans, with integration to wider watershed issues).
- Database and knowledge-base (linking with central and state institutions): (a) database on hydrology, morphology, sediment transport, and topography; (b) tools including flood-risk mapping and short-term erosion prediction system; (c) strengthened of flood warning system; and (d) monitoring and evaluation, and research and development system.
- Institutional strengthening for integrated FRERM: (a) institutional development actions for the Water Resources Department and line departments; (b) improved guidelines and manuals including nonstructural measures, (c) FRERM infrastructure asset management information system, and (d) comprehensive capacity development.
- Regional knowledge and networking: (a) international networks for FRERM and disaster risk management, (b) knowledge exchange.

Component 2: Operationalizing Integrated FRERM in Selected Subproject Sites

(i) FRERM structural measures: (a) upgraded embankments with assured maintenance (with extended platforms as appropriate); (b) systematic riverbank protection exploring cost-effective, adaptive, and sustainable alternatives; and (c) associated infrastructure (e.g., drainage sluices, canals).

(ii) FRERM nonstructural measures: (a) flood and erosion risk mapping; (b) improved warning systems; (c) participatory flood emergency response system; and (d) other flood adaptation measures (e.g., adaptive cropping, fish culture).

(iii) Community-based risk management: (a) participatory systems integrated with local disaster management committees; (b) community FRERM plans; and (c) plan implementation such as community awareness, flood shelters, and associated flood coping and development programs, e.g., adaptive cropping, fisheries, and livelihoods

(iv) Sustainable FRERM infrastructure maintenance.

Component 3: Project Management

(i) Project management support with community participation (through disaster management systems) with staffs including those seconded from the existing organizations or hired from the market, implementation consultants, and nongovernment organizations (NGOs).

(ii) Training for program-related operations.

APPENDIX 2.1. USE OF GEOTEXTILE BAGS FOR RIVEBANK EROSION MITIGATION

The use of geotextile bags plays a major role in mitigation of erosion in a way that is both economical and flexible. Geotextile bags have the two most important properties for erosion control, the filter function to prevent the undermining of the riverbank and the ability to withstand the hydraulic load of the current. Geotextiles were first introduced in the market in 1950s and their use has increased rapidly due to the properties, flexible use and stability. Nowadays geotextile sand containers are used in the river and coastal engineering field as construction elements for erosion control, scour fill, artificial reefs, groynes, dams as well as in breakwater and dune revetments.

Geosynthetic containers are multi-purpose elements that can be manufactured according to almost any demand. The additional functions of geotextile bags, which make them so attractive, are as follows:

Filtration: Filtration restricts the migration of fine soil while remaining permeable to water movement at least greater than or at least to the permeability of the protected soil.
Reinforcement: The geotextile bags must also withstand the hydraulic load of the current which can reach up to 3m/s. This function involves the stabilization of a soil mass by providing a closed compartment.

The gradual natural changes to environment may not have much impact as it occurs slowly and fish may get opportunity to adapt. However, any man made and quick changes might have a more important impact. The various field studies and observations show that the overall number of species were better in geotextile bag areas than in areas exposed to erosion or protected by CC-blocks. So geotextile bags do not have any negative impact on fisheries rather the situation is slightly better. Small pockets in between bags, where flow velocity is decreased, may create shelter places for fishes (Munir Ahmed, 2007). After the geotextile gets the characteristics of the environment, fish species adapt to the new environment and hide in the shelter holes. During diving inspection, they feel the fishes and shrimp (Atiqur Afur, 2007).

There are no negative effects known on the flora if geotextile bags are used for river bank protection. The roots are small enough to pass through the geotextile. However, roots have negative effects on geotextile bags and on the whole protection design. In particular when roots dry out after having passed through the geotextile big pores remain where sand can be washed out. In this case the stability of the structure is reduced.

Under normal conditions polypropylene does not present any toxic hazard, either from skin contact or inhalation. The material is inert and shows no toxicity (Dow, 2007). Additionally, it can be said that polypropylene fibers are widely accepted. It is assumed that restrictions in these industries are much tighter. So it can be postulated that PP fibers for geotextile are harmless from a toxicological point of view. (Naue Fasertechnik, 1995). Hence, the use of geotextile bags has no negative effect on the environment, neither to the water quality nor the flora and fauna.

APPENDIX 2.2. RAPID ENVIRONMENTAL ASSESSMENT (REA) CHECKLIST FOR IRRIGATION

Instructions:

- ❑ This checklist is to be prepared to support the environmental classification of a project. It is to be attached to the environmental categorization form that is to be prepared and submitted to the Chief Compliance Officer of the Regional and Sustainable Development Department.
- ❑ This checklist is to be completed with the assistance of an Environment Specialist in a Regional Department.
- ❑ This checklist focuses on environmental issues and concerns. To ensure that social dimensions are adequately considered, refer also to ADB checklists and handbooks on (i) involuntary resettlement, (ii) indigenous peoples planning, (iii) poverty reduction, (iv) participation, and (v) gender and Development.
- ❑ Answer the questions assuming the "without mitigation" case. The purpose is to identify potential Impacts. Use the "remarks" section to discuss any anticipated mitigation measures.

Country/Project Title: Assam Integrated Flood and Riverbank Erosion Risk Management Investment Program
Sector Division: Agriculture, Natural Resources, and Social Services Division

Note: This checklist has been used just for reference purposes being river based project even though project is not directly irrigation related.

Since categorization is generally made on the basis of the components of the entire project, this checklist has been prepared considering all the three selected sub projects.

SCREENING QUESTIONS	Yes	No	REMARKS
A. Project Siting Is the Project area adjacent to or within any of the following environmentally sensitive areas?			
Protected Area	■	□	Kaziranga Reach is located close to Kaziranga National Park. However all project components/activities are outside the park boundary. No protected area is falling in the vicinity of all other three subprojects
Wetland	■	□	There are many wetlands (Deepor Beel a designated Ramsar Site, Mora Kulsi, Bejisuti-Kalidas Beel in Palasbari Reach, Shohola Beel in Kaziranga Reach and . Maijan Beel in Dibrugarh reaches). The productivity of these Beel also depends on flow of flood water of Brahamputra river or its

SCREENING QUESTIONS	Yes	No	REMARKS
			tributaries. None of these Beels are likely to be affected by the proposed project component. None of the channel of flow of water from Brahamputra river to these Beels like in case of Deepor Beel is proposed to be altered or closed under this project.
Mangrove	☐	☐	
Estuarine	☐	☐	
Buffer zone of protected area	☐	☐	
Special area for protecting biodiversity	☐	☐	Proximity to Kairagna National Park in case of Kaziranga Sub project
B. Potential Environmental Impacts Will the Project cause…			
loss of precious ecological values (e.g. result of encroachment into forests/swamplands or historical/cultural buildings/areas, disruption of hydrology of natural waterways, regional flooding, and drainage hazards)?	☐	☐	The project priority is bankline protection. Primarily activities are confined to existing embankment alignment with its retirement at certain locations. The impacts therefore are likely to be confined primarily to Design and construction stage. Some impacts shall occur during post implementation (operational) stage as well. Impacts are likely to be positive as well as negative. Positive Impacts are related to erosion control, land use, recurring loss due to flood, siltation control/ productivity improvement of beels, pond fisheries etc. The other impacts are likely to be related to change if any in Hydrology & Morphology (Upstream & Down Stream effects), Changes in river water levels, flow velocity, discharge intensities, Terrestrial ecology (disturbance to vegetation, habitat, Animal movement), Aquatic ecology-Dolphin (Fish productivity, Spawning site, Breeding site including for Dolphin , pond fisheries), Air Quality, Water quality and Socio economic

SCREENING QUESTIONS	Yes	No	REMARKS
conflicts in water supply rights and related social conflicts?	☐	☒	
impediments to movements of people and animals?	☐	☒	Temporary disturbance may occur during construction phase to people. No movement path of terrestrial animals is either likely to be affected. The movement of Dolphin and other fishes to breeding sites may be affected during their breeding period (generally from May to August) if construction activities are continued around the breeding sites in this period
potential ecological problems due to increased soil erosion and siltation, leading to decreased stream capacity?	☐	☒	This project rather will prevent soil erosion resulting in reduced siltation
Insufficient drainage leading to salinity intrusion?	☐	☒	Salinity may increase in the Beels during flood if flow of flood water to Beels wherever these are directly connected to river Brahamputra is not controlled
over pumping of groundwater, leading to salinization and ground subsidence?	☐	☒	
impairment of downstream water quality and therefore, impairment of downstream beneficial uses of water?	☐	☒	
dislocation or involuntary resettlement of people?	☒	☐	Embankment retirement and other project activities do involve land acquisition.
potential social conflicts arising from land tenure and land use issues?	☐	☒	
soil erosion before compaction and lining of canals?	☐	☒	
noise from construction equipment?	☒	☐	
dust?	☒	☐	Likely during construction phase
labor-related social problems especially if workers from different areas are hired?	☐	☒	Adequate sanitation and other facilities will have to be provided at labor camps.
water logging and soil salinization due to inadequate drainage and farm management?	☐	☒	No disturbance is expected to existing drainage pattern

SCREENING QUESTIONS	Yes	No	REMARKS
leaching of soil nutrients and changes in soil characteristics due to excessive application of irrigation water?	☐	☐	
reduction of downstream water supply during peak seasons?	☐	☐	
soil pollution, polluted farm runoff and groundwater, and public health risks due to excessive application of fertilizers and pesticides?	☐	☐	
soil erosion (furrow, surface)?	☐	☐	It will be rather positive effect
scouring of canals?	☐	☐	
logging of canals by sediments?	☐	☐	
clogging of canals by weeds?	☐	☐	
seawater intrusion into downstream freshwater systems?	☐	☐	
introduction of increase in incidence of waterborne or water related diseases?	☐	☐	

APPENDIX 3.2. WATER QUALITY CRITERIA FOR DESIGNATED BEST USE

Designated-Best-Use	Class of water	Criteria
Drinking Water Source without conventional treatment but after disinfection	**A**	Total Coliforms Organism MPN/100ml shall be 50 or less pH between 6.5 and 8.5 Dissolved Oxygen 6mg/l or more Biochemical Oxygen Demand 5 days 20°C 2mg/l or less
Outdoor bathing (Organized)	**B**	Total Coliforms Organism MPN/100ml shall be 500 or less pH between 6.5 and 8.5 Dissolved Oxygen 5mg/l or more Biochemical Oxygen Demand 5 days 20°C 3mg/l or less
Drinking water source after conventional treatment and disinfection	**C**	Total Coliforms Organism MPN/100ml shall be 5000 or less pH between 6 to 9 Dissolved Oxygen 4mg/l or more Biochemical Oxygen Demand 5 days 20°C 3mg/l or less
Propagation of Wild life and Fisheries	**D**	pH between 6.5 to 8.5 Dissolved Oxygen 4mg/l or more Free Ammonia (as N) 1.2 mg/l or less
Irrigation, Industrial Cooling, Controlled Waste disposal	**E**	pH between 6.0 to 8.5 Electrical Conductivity at 25°C micro mhos/cm Max.2250 Sodium absorption Ratio Max. 26 Boron Max. 2mg/l
	Below-E	Not Meeting A, B, C, D & E Criteria

APPENDIX 3.3. NATIONAL AMBIENT AIR QUALITY STANDARDS

Pollutants	Time-weighted average	Concentration in ambient air			Method of measurement
		Industrial Areas	Residential, Rural & other Areas	Sensitive Areas	
SulphurDioxide (SO_2)	Annual Average*	80 µg/m3	60 µg/m3	15 µg/m3	- Improved West and Geake Method - Ultraviolet Fluorescence
	24 hours**	120 µg/m3	80 µg/m3	30 µg/m3	
Oxides of Nitrogen as (NO_2)	Annual Average*	80 µg/m3	60 µg/m3	15 µg/m3	- Jacob & Hochheiser Modified (Na-Arsenite) Method
	24 hours**	120 µg/m3	80 µg/m3	30 µg/m3	- Gas Phase Chemiluminescence
Suspended Particulate Matter (SPM)	Annual Average*	360 µg/m3	140 µg/m3	70 µg/m3	- High Volume Sampling, (Average flow rate not less than 1.1 m3/minute).
	24 hours**	500 µg/m3	200 µg/m3	100 µg/m3	
RespirableParticulate Matter (RPM) (size less than 10 microns)	Annual Average*	120 µg/m3	60 µg/m3	50 µg/m3	- Respirable particulate matter sampler
	24 hours**	150 µg/m3	100 µg/m3	75 µg/m3	
Lead (Pb)	Annual Average*	1.0 µg/m3	0.75 µg/m3	0.50 µg/m3	- ASS Method after sampling using EPM 2000 or equivalent Filter paper
	24 hours**	1.5 µg/m3	1.00 µg/m3	0.75 µg/m3	.
Ammonia1	Annual Average*	0.1 mg/ m3	0.1 mg/ m3	0.1 mg/m3	.
	24 hours**	0.4 mg/ m3	0.4 mg/m3	0.4 mg/m3	.
CarbonMonoxide (CO)	8 hours**	5.0 mg/m3	2.0 mg/m3	1.0 mg/ m3	- Non Dispersive Infra Red (NDIR)
	1 hour	10.0 mg/m3	4.0 mg/m3	2.0 mg/m3	Spectroscopy
*	Annual Arithmetic mean of minimum 104 measurements in a year taken twice a week 24 hourly at uniform interval.				
**	24 hourly/8 hourly values should be met 98% of the time in a year. However, 2% of the time, it may exceed but not on two consecutive days.				

APPENDIX 3.4. NATIONAL AMBIENT AIR QUALITY STANDARDS IN RESPECT OF NOISE

Area code	Category of Area / Zone	Limits in dB(A) Leq*	
		Day Time	Night Time
(A)	Industrial area	75	70
(B)	Commercial area	65	55
(C)	Residential area	55	45
(D)	Silence Zone	50	40

Note:-
Day time shall mean from 6.00 a.m. to 10.00 p.m.
Night time shall mean from 10.00 p.m. to 6.00 a.m.
Silence zone is an area comprising not less than 100 meters around hospitals, educational institutions, courts, religious places or any other area which is declared as such by the competent authority
Mixed categories of areas may be declared as one of the four above mentioned categories by the competent authority.
* **dB(A) Leq** denotes the time weighted average of the level of sound in decibels on scale A which is relatable to human hearing.
A “decibel” is a unit in which noise is measured.
“A”, in **dB(A) Leq,** denotes the frequency weighting in the measurement of noise and corresponds to frequency response characteristics of the human ear.
Leq: It is an energy mean of the noise level over a specified period.
Note : The Principal Rules were published in the Gazette of India, vide S.O. 123(E), dated 14.2.2000 and subsequently amended by the Noise Pollution (Regulation and Control) (Amendment) Rules, 2000 vide S.O. 1046(E), dated 22.11.2000 and by the Noise Pollution (Regulation and Control) (Amendment) Rules, 2002 vide S.O. 1088(E), dated 11.10.2002, under the Environment (Protection) Act, 1986.

APPENDIX 3.5. SAMPLING DATA OF TREE SPECIES IN PALASBARI REACH (CH. 22.0 KM TO CH. 60.0 KM)

Tre species	1spur7thINside	1spur7th OUTside	2majguri Inside	2majguri OUTside	3GoroimarialikashINside	3GoroimarialikashOUTside	4BorakhatINside	4Borakhatoutside	5BejisutiKalidasInside	5BejisutiKalidasOutside	6Nagarberahillside out	6Nagarberahillside IN(ch60)
Simul-Bombax ceiba	25	30	25	35	10	10	25	30	20	20	7	3
Gamari-Gmelina arborea	15	20	0	0	0	10	5	5	0	0	0	1
Karas-Pungamia pinnata	15	20	0	0	0	0	0	0	0	0	0	0
Bijuli banh-Bambusa pallida	40	50	0	0	0	0	0	0	0	0	4	6
Khongal Dimoru-*Ficus tinctoria*	0	0	5	10	0	0	0	0	0	0	2	5
Pakori-F. rumphii	0	0	2	3	0	0	0	0	0	0	2	0
BhimKol-Musa balbiciana	0	0	20	30	100	100	0	0	0	0	0	0
Jati banh- Bambusa tulda	0	0	0	1	0	2	2	2	0	0	4	3
Kathal-Artocarpus heterophylus	0	0	0	10	0	0	10	10	8	8	3	0
Palas-Butea monosperma	0	0	0	2	0	0	0	0	0	0	0	0
Devil tree-Alstonia scolaris	0	0	0	0	0	5	0	0	0	0	0	0
Krishna sura-*Delonix regia*	0	0	0	0	0	5	10	0	0	0	0	0
Dimoru-Ficus lipidosa	0	0	0	0	0	0	20	30	0	0	0	0
Ahot-Ficus religiosa	0	0	0	0	0	0	10	10	0	0	0	0
Segun-Tectona grandis	0	0	0	0	0	0	0	50	0	20	5	2
Atlas-Annona squamosa	0	0	0	0	0	0	10	10	10	10	0	2
Kadam-Anthocephalus cadamba	0	0	0	0	0	0	0	0	0	5	0	0
Kolajamun-Syzygium cumini	0	0	0	0	0	0	0	0	0	2	0	0
Siris-Albizzia lebek	0	0	0	0	0	0	0	0	5	5	0	0
Jalphai-Elaeocarpus floribundus	0	0	0	0	0	0	0	0	1	0	0	0
Sajina-Moringa oleifera	0	0	0	0	0	0	0	0	0	5	0	0
Narikol-Cocos nucifera	0	0	0	0	0	0	0	0	0	4	0	0

APPENDIX 3.6. TREE SAMPLING DATA IN MAJIRGOAN-NAGARBERA PROJECT SITE (KHANAJAN CH. 0.0 KM TO CH. 10..5 KM)

Tree Species	Khonajan ch.0.0 km OUT	Khonajan ch.0.0 kmIN	DarapurCh. 0.5km OUT	DarapurCh. 0.5km IN	Darapurjangrabari INSIDE	3Darapurjangrabari OUTSIDE	Ch 1.0 kmAlutaliIN	Ch 1.0 kmAlutaliOUT	1outsideDBHcm	1insideDBH CM	2dbhoutside	3DBHINSIDE	3DBHout	4DBHin	4DBHout	palsbariIn	palsbariOUT	GuimaraIN	GuimaraIOut
Alstonia scolaris	5	0	5	0	0	10	4	0	38	0	50	0	20	40	0	0	0	0	2
Artocarpus lacusha	7	0	0	0	0	0	0	0	42	0	0	0	0	0	0	0	0	0	0
Bombax ceiba	18	7	20	15	10	18	30	18	45	50	45	28	40	40	45	0	5	3	4
Cassia fistula	3	0	0	0	0	0	0	2	32	0	0	0	0	0	32	0	0	0	0
Areca catachus	6	0	20	0	0	0	0	0	19	0	18	0	0	0	0	0	5	0	5
- Duabhanga grandifolia	2	0	0	0	0	0	0	0	38	0	0	0	0	0	0	0	0	0	0
Toona cialita	4	0	0	0	0	4	0	4	35	0	0	0	40	0	30	0	0	0	0
Musa balbiciana	2	0	3	0	0	0	10	2	25	0	25	0	0	30	25	0	0	0	0
Bambusa balcooa	30	25	15	8	9	8	0	0	0	0	0	0	0	0	0	0	0	0	0
Cascabela thevetia	2	0	0	0	0	0	0	0	20	0	0	0	0	0	0	0	0	0	0
Annona squamosa	10	3	8	10	4	0	0	10	24	24	20	12	0	0	10	0	1	2	2
Segun-Tectona grandis	0	2	4	2	0	0	0	5	0	80	40	0	0	0	45	0	5	0	0
Bambusa tulda	0	30	18	10	12	12	0	0	0	0	0	0	0	0	0	0	2	0	5

Tree Species	Khonajan ch.0.0 km OUT	Khonajan ch.0.0 kmIN	DarapurCh. 0.5km OUT	DarapurCh. 0.5km IN	Darapurjang rabari INSIDE	3Darapurjan grabari OUTSIDE	Ch 1.0 kmAlut aliIN	Ch 1.0 kmAlut aliOUT	1outsideDB Hcm	1insid eDBH CM	2dbho utside	3DBHI NSIDE	3DBH out	4DBHi n	4DBH out	palsba riIn	palsba riOUT	Guima raIN	Guima raIOut
Bambusa pallida	0	0	40	40	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0
Bauhinia spp.	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Zizyphus mauritiana	0	0	0	0	7	4	0	2	0	0	0	30	20	0	18	0	0	5	7
SDelbergia sisso	0	0	0	0	0	0	37	0	0	0	0	0	0	50	0	3	2	2	0
Musa spp.	0	0	0	0	0	0	25	0	0	0	0	0	0	0	0	0	0	0	0
Ficus religiosa	0	10	0	1	0	0	20	0	0	198	0	0	0	30	0	0	1	3	2
Ficus bengalensis	0	2	0	0	2	0	0	0	0	142	0	40	0	0	0	0	0	1	2
Tamarix dioica	0	40	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	1
Orozylum indicum	0	2	0	0	0	0	0	0	0	48	0	0	0	0	0	0	0	0	0

APPENDIX 3.7. REPTILIAN FAUNA REPORTED IN MAJIRGOAN-NAGARBERA PROJECT SITES (DATA PRESENTED AS ABSENT DATA).

Reptilian Species/family	**Present absent data of Reptilian fauna in different study sites**													
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Typhlopidae: Typhlops diardii Schlegel, 1839	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Pythonidae : Python molurus bivittatus Kuhl, 1820	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Colubridae *Ptyas mucosa* (Linnaeus 1758)	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Oligodon albocinctus (Cantor, 1839)	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Dendreaphis pictus (Gmelin, 1789)	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Lycodon aulicus (Linnaeus, 1758)	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Xenochrophis piscator (Schneider, 1799)	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Rhabdophis subminiatus (Schlegel, 1837)	1	1	1	0	0	1	0	0	0	0	0	1	1	1
Amphiesma stolatum (Linnaeus, 1758)	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Amphiesma platyceps (Blyth, 18540)	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Enhydris enhydris (Schneider, 1799)	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Elapidae : Naja kaouthia Lesson, 1831	1	1	1	1	0	0	1	1	1	1	1	1	1	1
Bungarus caeruleus (Schneider, 1801)	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Agamidae Calotes jerdoni Gunther, 1870	1	1	0	0	1	0	0	0	0	0	1	0	0	1
Calotes versicolor (Daudin 1802)	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Gekkonidae: Hemedactylus frenatus Schlegal 1836	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Reptilian Species/family	Present absent data of Reptilian fauna in different study sites													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Hemedactylus garnoti Dum. And Bibr. 1836	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Gekko gecko (Linnaeus 1758)	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Hemedactylus brooki Gray, 1845	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Scincidae Mabuya carinata (Schneider, 1801)	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Sphenomorphys maculatus (Blyth, 1853)	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Riopa punctata (Linnaeus, 1766)	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Anguidae Varanus bengalensis (Linnaeus, 1758)	1	1	1	1	1	1	1	1	1	1	1	1	1	1
V. flavescens	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Kachuga tecta (Gray)	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Kachuga smithi (Gray)	1	1	1	1	0	0	1	0	0	0	0	1	1	1
K. sylhetensis (Jerdon)	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Geoclemys hamiltoni (Gray)	1	1	1	1	1	1	1	1	1	1	0	1	1	1
hardella thurgii (Gray)	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Lacepede Lissemys punctata	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Trionix hurum (Gray)	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Chitra Indica (Gray)	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Trionix gangeticus	1	1	1	1	1	1	1	1	1	1	1	0	1	1

Abbrebriation: 1:(0point)Darapur; 2: Darapur; 3: jangrabari; 4: Alutalibari; 5: DBHcm; 6:dbh; 7: DBH; 8DBHin; 9: spur7th; 10: Majguri; 11:Goroimarialikash; 12: Borakhat;13: BejisutiKalidas; 14: Nagarberahillside (1: Present;0: Absent).

APPENDIX 3.8. COMPREHENSIVE LIST OF AVIAN FAUNA IN MAJIRGOAN-NAGARBERA PROJECT SITE.

English Name	Family/Scintific Name
Little Grebe	Podicepedae Tachybaptus ruficollis
Great Crested Grebe	Podiceps cristatus
Red-Necked Grebe	P. grisegena
Spot-billed Pelican	Pelicanidae Pelecanus philippensis
Little Cormorent	Phalacrocoracidae Phalacrocorax niger
Indian Cormorent	Phalacrocorax fuscicollis
Great Cormorent	Phalacrocorax carbo
Darter	Anhingidae Anhinga melanogaster
Little Egret	Ardeidae Egretta garzetta
Intermediate Egret	Mesophoyx intermedia
Cattle Egret	Bubulcus ibis
Great Egret	Casmerodius albus
Indian Pond Heron	Ardeola grayii
Grey Heron	Ardea cinerea
Black-Crowned Night Heron	Nycticorax nycticorax
Grey Heron	Ardea cinerea
Purple Heron	Ardea purpurea
Chinese Pond Heron	Ardeola bacchus
Yellow Bitern	Ixobrychus sinensis
Black Bittern	Dupetor flavicollis
Cinnamon Bittern	Ixobrychus cinnamomeus
Little Bittern	Ixobrychus minutus
Asian Openbill	Ciconidae Anastomus oscitans
Lessar Adjutant Stork	Leptoptilos javanicus
Fulvous Whistling-Duck	Dendrocygnidae Dendrocygna bicolor
Lesser Whistling-Duck	Dendrocygna javanica
Bar-Headed Goose	Anatidae Anser indicus
Ruddy Shelduck	Tadorna ferruginea
Gadwall	Anas strepera
Mallard	Anas platyrhynchos
Spot-billed Duck	Anas poecilorhyncha
Common Teal	Anas crecca
Garganey	Anas querquedula

English Name	Family/Scintific Name
Northern Pintail	Anas acuta
Northern Shoveler	Anas clypeata
Red-crusted Pochard	Rhodonessa rufina
Common Pochard	Aythya ferina
Ferrruginous Poachered	Aythya nyroca
Tufted Duck	Aythya fuligula
White-breasted Waterhen	Rallidae Amaurornis phoenicurus
Water Cock	Gallicrex cinerea.
Common Moorhen	Gallinula chloropus
Water Rail	Rallus aquaticus
Common Coot	Fulica atra
Pheasant-tailed Jacana	Jacanidae Hydrophasianus chirurgus
Bronze-winged Jacana	Metopedius indicus
Paintd Snipe	Rostratulidae Rostratula bengalensis
Common Snipe	Scolopacidae Gallinago gallinago
Solitary Snipe	Gallinago solitaria
Eurasian Woodcock	Scolopax rustica
Wood Sandpiper	Tringa glareola
Common Redshank	Tringa Totanus
Spotted Redshank	Tringa erythropus
Common Greenshank	T. nebularia
Nordman Greenshank	T. guttifer
Common Sandpiper	Actitis hypoleucos
Marsh Sandpiper	T. stagnatalis
Little Stint	Calidris minuta
Collared Partincole	GlareolidaeGlareola lecta
Small Indian Partincole	G. pratincola
Common Ringed Plover	Charadridae Charadrius hiaticula
Little Ringed Plover	Charadrius dubius
Pacific Golden Plover	Pluvialis fulva
Red-wattled Lapwing	Vanellus indicus
Grey-headed Lapwing	Vanellus cinereus
Northern Lapwing	Vanellus vanellus
River Tern	Laridae Sterna aurantia
Black-bellied Tern	Sterna acuticauda
Whiskered Tern	Chlidonias hybridus
White-winged Tern	C. leucopterus

English Name	Family/Scintific Name
Brown-Headed Gull	Larus brunnicephalus
Black-headed Gull	Larus ridibundus.
Mew Gull	Larus canus
Black-winged Stilt	Himantopidae Himantopius himantopus
Osprey	Accipitridae Pandion haliatus
Black Kite	Milvus migrans
Brahmni Kite	Haliastur Indus
Pallas's Fish Eagle	Haliaeetus leucoryphus
Grey-headed Fish eagle	Ichthyophaga ichthyaetus
White-Ramped Vulture	Gyps bengalensis
Long-billed Vulture	Gyps indicus
Red-headed Vulture	Sarcogyps calvus
Crested Serpent Eagle	Spilornis cheela
Eurasian Marsh-Harrier	Circus aeruginosus
Pied Harrier	Crcus melanoleucos
Hen Harrier	C. cyaneus
Pallied Harrier	C. macrourus
Montagu's Harrier	C. pygargus
Shikra	Accipiter badius
Besra	Accipiter virgatus
Eurasian Sparrowhawk	A. nisus
Common Buzzard	Buteo buteo
Oriental Honey-Buzzard	Pernis ptilorhyncus
Long-legged Buzzard	Buteo rufinus
Lesser Spotted Eagle	Aquila pomarina
Greater Spotted Eagle	A. clanga
Red-necked Falcon	Falconidae Falco chicquera
Lesser Kestrel	Falco naumanni
Oriental Hobby	Falco severus
Peregrine Falcon	Falco peregrinus
Common Kingfisher	Alcidinidae Alcedo atthis
Blyth's Kingfisher	Alcedo hercules
Blue-eared Kingfisher	Alcedo meninting
White-throated Kingfisher	Halcyon smyrnensis
Stork-billed Kingfisher	Dacelonidae Halcyon capensis
Pied Kingfisher	Cerylidae Ceryle rudis
	Passeridae

English Name	Family/Scintific Name
House Sparrow	Passer domestica
Tree Sparrow	Passer montanus
Blackheaded Munia	Lonchura malacca
White-rumped Munia	Lonchura striata
White Wagtail	Motacilla alba
Yellow Wagtail	Motacilla flava
Grey Wagtail	Motacilla cinerea
Paddyfield Pipit	Anthus rufulus
Richard's Pipit	Anthus richardi
Citrine Wagtail	Motacilla citriola
Rosy Pipit	Anthus roseatus
Olive-backed Pipit	A. hodgsoni
Golden Fronted Leafbird	Irinidae Chloropsis auriforns
Orange Billed Lefbird	Chloropsis hardwiskii
Eurasian Golden Oriole	Corvidae Oriolus oriolus
Blck-hooded Oriole	Oriolus xanthornus
Rufous Treepie	D endrocitta vagabunda
House Crow	Corvus splendens
Large-billed Crow	Corvus macrorhynchos
Black Drango	Dicrurus macrocercus
Crow-billed Drongo	Dicrurus annectans
Bronzed Drongo	Dicrurus aeneus
Spangled Drongo	Dicrurus hottentottus
Ashy Drongo	Dicrurus leucophaeus
Common Iora	Aegithina tiphia
Black-naped Monarch	Hypothymis azurea
Large Cuckoo-shrike	Coracina macci
Ashy Wood Shallow	Artamus fuscus
Blue Throated Barbet	Megalaimidae Megalaima asiatica
Coppersmith Barbet	Megalaima haemocephala
Lineated Barbet	Megalaima lineata
Golden-throated Barbet	Megalaima franklinii
Blue-eared Barbet	Megalaima australis
Great Barbet	Megalaima viren
Asian Pied Starling	Sturnidae:Sturnus contra
Common Maina	Acridotheres tristis
Bank Maina	Acridotheres giginianus
Jungle Myna	Acridotheres fuscus
Whitevented Myna	A. grandis
Greyheaded Myna	Sturnus malabaricus

English Name	Family/Scintific Name
Hill Myna	Gracula religiosa
Creg Martin.	Hirundinidae Hirundo rupestris
Barn Swallow	Hirundo rustica
Northern House Martin	Delichon urbica
Sand Martin	Riparia riparia
Nepal House Martin	Delichon nipalensis
Red-Whiskered Bulbul	Pycnonotidae Pycononotus jocosus
Red-Vented Bulbul	Pycononotus cafer
Blue-tailed Bee-ater	Meropidae Merops philippinus
Green Bee-eater.	Merops orientalis
Chestnut-headed Bee-eater	Merops leschenaulti
Purple Sunbird	Necterinidae:Nectarinia asiatica
Purple-throated Sunbird	Necatrinia seperata
Mrs Gould's Sunbird	Aethopyga gouldiae
Crimson Sunbird	Aethopyga siparaja
Plain Flowerpacker	Dicaeum concolor
Common Tailor Bird	Sylvidae Orthotomus sutorius
Jungle Babbler	Turdoides striatus
Marsh Babbler	Pellorneum palustre
Black Redstart	Muscicapidae Phoenicurus ochruros
Oriental Magpie Robin	Copsichus saularis
Blue Whistling Thrush	Myophonus horsfieldii
Dark-sided Flycatcher	Muscicapa sibirica
Blackheaded Shrike-Babbler	Pteruthius rufiventer
Bluethroat	Luscinia svecica
Pied Buchchat	Saxicola caparata
Common Stonchat	Saxicola torquata
Verditer Flycatcher	Eumyias thalassina
Grey-breasted Prinia	Cisticolidae Prinia hodgsonii
Great Tit	Paridae Parus major
Graybacked Shrike	Lanidae Lanius tephronotus
Indian Roller	Coracidae Coracias benghalensis
Oriental Skylark	Alaudidae Alauda gulgula
Crested Lark	Galirida cristata

English Name	Family/Scintific Name
Rufous-winged Bushlark	Mirafra assamica
Common Swift	Apodidae Apus apus
House Swift	Apus affinis
Alpine Swift	Tachymarptis
Fork-tailed Swift	Apus pacificus
Asian Palmswift	Cypsturus balasiensis
Rose-ringed Parakeet	Psittacidae Pisttacula karmeri
Alexandrine Parakeet	Psittacula eupatria
Blossom-headed Parakeet	Psittacula roseata
Spotted Dove.	Culombidae Streptopelia chinensis
Red Collared Dove	Streptopelia tranquebarica
Eurasian Collared Dove	Streptopelia decaocto
Oriental Turtle Dove	Streptopelia orientalis
Emerald Dove	Chalcophaps indica
Yellow-footed Green Pigeon.	Treron phoenicoptera
Wedge-tailed Green Pigeon	Treron sphenura
Orange-breasted Green Pigeon	Treron bicincta
Black-rumped Flameback.	Picidae Dinopium bengalensis
Yellow-crowned Wood pecker	Dendrocoposmahrattensis
Grey-capped Pygmy Woodpecker	Dendrocopos canicapillus
Greater Coucal	Centropodidae Centropus sinensis
Lesser Caucal	Centropus bengelensis
Asian Koel	Cuculidae Eudynamys scolopacca
Common Hawk Cuckoo	Hierococcyx varius
Hodgson's hawk Cuckoo	Hierococcyx fugax
Large Hawk Cuckoo	Hierococcyx sparverioides
Indian Cuckoo	Cuculus micropterus
Oriental Cuckoo	Cuculus canorus
Lesser Cuckoo	Cuculus poliocephalus
Chestnut-winged Cuckoo	Clamator coromandus
Pied Cuckoo	Clamator jacobinus
Plantative Cuckoo	Cacomantis merulinus
Drongo Cuckoo	Surniculus lugubris
Green-billed Malkoha	Phaenicophaeus tristis
Common Hoopoe	Upopidae Upupa epops
Spotted Owlet	Strigidae Athene brama

English Name	Family/Scintific Name
Collared Scops Owl	Otus bakkamoena
Asian Barred Owlet	Glaucidium cuculoides
Jungle Owlet	Glaucidium radiatum
Great Eared Nightjar	Eurostopodus macrotis
Brown Fish Owl	Ketupa zeylonensis
Tawny Fish Owl	Ketupa flavipes

APPENDIX 3.9. COMPREHENSIVE LIST OF MAMMALIAN FAUNA IN STUDY AREA.

S. No.	English Name	Order/ Family/ Scientific Name
1	Himalayan Hoary-bellied Squirrel	Order: Rodentia Fam: Sciuridae Callosciurus pygerythrus
2	House Shrew	Fam: Soricidae Suncus murinus
3	Pigmy shrew	Suncus etruscus
4	House Mouse	Fam: Muridae Mus musculus
5	Large Bandicota -rat	Bandicota indica
6	Lesser bandicota-rat	Bandicota bengalensis
7	Black Rat	Rattus rattus
8	Chinese Porcupine	Fam: Hystricidae Hystrix brachyura
9	India Hare	Order: Lagomorpha Fam: Leporidae Lepus nigricollis
10	Indian Elephant	Order: Proboscidea Fam: Elephantidae Elephas maximus
11	Domestic Pig	Order: Artiodactyla Fam: Suidae Sus sp.
12	Barking Deer	Fam: Cervidae Muntiacus muntjak
13	Domestic Buffalo	Fam: Bovidae Bubalus sp.
14	Domestic Cattle	Bos sp.
15	Domestic Goat	Capricornis sp.
16	Indian flying fox.	Order: Chiroptera Fam: Pteropodidae Pteropus gigenteus
17	Long-winged tom bat	Fam: Emballonuridae Taphozous longimanus
18	Rhesus Macaque	Order: Primate Fam: Cercopithecidae Macaca mulatta
19	Asiatic Jackel	Order: Carnivora Fam: Canidae Canis aureus
20	Common Otter	Fam: Mustelidae Lutra lutra
21	Large India Civet	Fam: Viverridae Viverra zibetha
22	Small India Civet	Viverricula indica
23	Indian Mongoose	Fam: Herpestidae Herpestes javanicus

APPENDIX 3.10. DIVERSITY INDEX & SPECIES RICHNESS

Species Richness of Amphibian Species using Rarefaction on present absent data (Rarefaction, See Lambshead et al. 1983*).

Sample	Finite est.	Std. Error	Infinite est.	Std. Error
Using 1 samples	6.767	1.48	6.63	1.535
Using 2 samples	9.342	1.102	9.118	1.176
Using 3 samples	10.32	0.7539	10.11	0.8537
Using 4 samples	10.67	0.538	10.51	0.6522
Using 5 samples	10.85	0.3727	10.73	0.4977
Using 6 samples	10.93	0.2544	10.84	0.3884
Using 7 samples	10.97	0.1667	10.9	0.3072
Using 8 samples	10.99	0.1023	10.94	0.2446
Using 9 samples	11	0.05702	10.96	0.1954
Using 10 samples	11	0.02755	10.98	0.1564
Using 11 samples	11	0.01176	10.98	0.1281
Using 12 samples	11	0.003004	10.99	0.1026
Using 13 samples	11	0.0002211	10.99	0.08214
Using 14 samples	11	5.686E-7	11	0.06579

Abbrebriation: 1:(0point)Darapur; 2: Darapur; 3: jangrabari; 4: Alutalibari; 5: DBHcm; 6:dbh; 7: DBH; 8DBHin; 9: spur7th; 10: Majguri; 11:Goroimarialikash; 12: Borakhat;13: BejisutiKalidas; 14: Nagarberahillside (1: Present; 0: Absent).

Species Diversity Index of Amphibian Fauna in Majirgoan- Nagarbera Project Sites

Sample	H	Variance H	Lower95%	Upper 95%
Darapur(“0” P) Ch. 0.0 km	2.398	0.04132	1.499	2.146
Darapur	2.398	0.04132	1.468	2.146
Jangrabari	2.303	0.045	1.359	2.025
Alutalibari Ch. 1.0km	2.197	0.04938	1.215	2.043
DBHcm	2.197	0.04938	1.273	2.043
Dbh	2.197	0.04938	1.244	2.043
DBH	2.197	0.04938	1.273	2.043
DBHin	2.197	0.04938	1.273	2.043
spur7th	2.197	0.04938	1.273	2.043
Majguri	2.197	0.04938	1.215	2.043
Goroimarialikash	2.303	0.045	1.418	2.095
Borakhat	2.398	0.04132	1.499	2.146
BejisutiKalidas	2.398	0.04132	1.468	2.146
Nagarbera hillside (Ch. 60)	2.398	0.04132	1.499	2.146

Diversity Index & Species Richness of Reptilian Species

Species Richness of Reptilian Species using Rarefaction on Present-Absent Data (Rarefaction, See Lambshead et al. 1983*).

Sample	Finite est.	Std. Error	Infinite est.	Std. Error
Using 1 samples	20.54	2.699	20.11	2.743
Using 2 samples	28.59	1.889	27.92	2.016
Using 3 samples	31.4	1.191	30.82	1.38
Using 4 samples	32.4	0.7424	32	0.952
Using 5 samples	32.76	0.4756	32.5	0.6787
Using 6 samples	32.9	0.3097	32.73	0.4982
Using 7 samples	32.96	0.2056	32.85	0.3821
Using 8 samples	32.98	0.133	32.91	0.3007
Using 9 samples	32.99	0.07984	32.94	0.2391
Using 10 samples	33	0.04424	32.96	0.1938
Using 11 samples	33	0.02095	32.97	0.1582
Using 12 samples	33	0.007389	32.98	0.1298
Using 13 samples	33	0.00114	32.99	0.1063
Using 14 samples	33	2.519E-7	32.99	0.08775

Abbrebriation: 1: (0point) Darapur; 2: Darapur; 3: jangrabari; 4: Alutalibari; 5: DBHcm; 6: dbh; 7: DBH; 8DBHin; 9: spur7th; 10: Majguri; 11: Goroimarialikash; 12: Borakhat;13: Bejisuti Kalidas; 14: Nagarbera hillside (1: Present; 0: Absent).

Species Diversity Index of Reptilian Fauna in Polasbari-Gumi Sites

Sample	H	Variance H	Lower 95%	Upper 95%
Darapur	3.497	0.01469	2.745	3.118
Jangrabari	3.497	0.01469	2.733	3.103
Alutalibari	3.466	0.01514	2.697	3.086
DBHcm	3.434	0.01561	2.668	3.059
Dbh	3.401	0.01611	2.619	3.032
DBH	3.401	0.01611	2.636	3.032
DBHin	2.636	3.032	2.657	3.068
spur7th	3.401	0.01611	2.638	3.032
Majguri	3.401	0.01611	2.627	3.032
Goroimarialikash	3.401	0.01611	2.624	3.032
Borakhat	3.401	0.01611	2.626	3.032
BejisutiKalidas	3.434	0.01561	2.667	3.059
Nagarbera hillside	3.466	0.01514	2.687	3.086

Shannon Diversity Indices of Avian Fauna in Inside and Outside the Embankent of Majirgoan-Nagarbera Project Site.

Sample site	Shannon Wiener Diversity Indices H	Variance H	Lower 95%	Upper 95%
Inside the embankment	4.958	0.0008989	4.77	4.887
Outside the embankment	4.43	0.001312	4.201	4.337

Species Diversity and Richness of Mammalian Fauna in Mazirgoan-Nagarbera Embankment Site

Sample	Finite est.	Std. Error	Infinite est.	Std. Error
Using 1 samples	18.66	0.8778	18.18	0.9651
Using 2 samples	19.99	0.08848	19.11	0.7772

Species Diversity and Richness of Mammalian Fauna in Mazirgoan-Nagarbera Embankment Site

Sample	Finite est.	Std. Error	Infinite est.	Std. Error
Using 1 samples	18.66	0.8778	18.18	0.9651
Using 2 samples	19.99	0.08848	19.11	0.7772

APPENDIX 3.11. COMPREHENSIVE LIST OF AVIAN FAUNA IN PALASBARI SUB PROJECT AREA

English Name	Family/Scientific Name	Status	Status of IWPA/GS/habitat
Little Grebe	Podicepedae *Tachybaptus ruficollis*	R	aq
Great Crested Grebe	Podiceps cristatus	R	aq
Red-Necked Grebe	P. grisegena	R	aq
Spot-billed Pelican	Pelicanidae Pelecanus philippensis	R	aq, **NT**
Little Cormorant	Phalacrocoracidae Phalacrocorax niger	R	LC
Indian Cormorant	Phalacrocorax fuscicollis	R	LC
Great Cormorant	Phalacrocorax carbo	R	LC
Darter	Anhingidae Anhinga melanogaster	R	LC
Little Egret	Ardeidae Egretta garzetta	R	aq
Intermediate Egret	Mesophoyx intermedia	R	aq
Cattle Egret	Bubulcus ibis	R	aq
Great Egret	Casmerodius albus	R	aq
Indian Pond Heron	Ardeola grayii	R	aq
Grey Heron	Ardea cinerea	R	aq
Black-Crowned Night Heron	Nycticorax nycticorax	R	aq
Grey Heron	Ardea cinerea	R	aq
Purple Heron	Ardea purpurea	R	aq
Chinese Pond Heron	Ardeola bacchus	R	aq
Yellow Bitern	Ixobrychus sinensis	R	aq
Black Bittern	Dupetor flavicollis	R	aq
Cinnamon Bittern	Ixobrychus cinnamomeus	R	aq
Little Bittern	Ixobrychus minutus	R	aq
Asian Openbill	Ciconidae Anastomus oscitans	R	aq
Lessar Adjutant Stork	Leptoptilos javanicus	R	GT, aq
Fulvous Whistling-Duck	Dendrocygnidae Dendrocygna bicolor	R	--------
Lesser Whistling-Duck	Dendrocygna javanica	R	aq

Bar-Headed Goose	Anatidae Anser indicus	M	Schedule-I/GT,aq
Ruddy Shelduck	Tadorna ferruginea		
Gadwall	Anas strepera	M	aq
Mallard	Anas platyrhynchos	M	aq
Spot-billed Duck	Anas poecilorhyncha	M	aq
Common Teal	Anas crecca	M	aq
Garganey	Anas querquedula	M	aq
Northern Pintail	Anas acuta	M	aq
Northern Shoveler	Anas clypeata	M	aq
Red-crusted Pochard	Rhodonessa rufina		
Common Pochard	Aythya ferina		
Ferrruginous Poachered	Aythya nyroca		
Tufted Duck	Aythya fuligula		
White-breasted Waterhen	Rallidae Amaurornis phoenicurus	R	aq
Water Cock	Gallicrex cinerea.	R	aq
Common Moorhen	Gallinula chloropus	R	aq
Water Rail	Rallus aquaticus	R	aq
Common Coot	Fulica atra	M	aq
Pheasant-tailed Jacana	Jacanidae Hydrophasianus chirurgus	R	aq
Bronze-winged Jacana	Metopedius indicus	R	aq
Paintd Snipe	Rostratulidae Rostratula bengalensis	R	aq
Common Snipe	Scolopacidae Gallinago gallinago	R	aq
Solitary Snipe	Gallinago solitaria	R	aq
Eurasian Woodcock	Scolopax rustica		
Wood Sandpiper	Tringa glareola		
Common Redshank	Tringa Totanus		
Spotted Redshank	Tringa erythropus		
Common Greenshank	T. nebularia		
Nordman Greenshank	T. guttifer		
Common Sandpiper	Actitis hypoleucos	M	aq
Marsh Sandpiper	T. stagnatalis	M	aq
Little Stint	Calidris minuta	M	aq
Collared Partincole	GlareolidaeGlareola lecta	M	aq
Small Indian Partincole	G. pratincola	M	aq
Common Ringed Plover	Charadridae Charadrius hiaticula		

Little Ringed Plover	Charadrius dubius		
Pacific Golden Plover	Pluvialis fulva		
Red-wattled Lapwing	Vanellus indicus	R	aq
Grey-headed Lapwing	Vanellus cinereus	M	aq
Northern Lapwing	Vanellus vanellus	M	aq
River Tern	Laridae Sterna aurantia	M	aq
Black-bellied Tern	Sterna acuticauda	R	aq
Whiskered Tern	Chlidonias hybridus	R	aq
White-winged Tern	C. leucopterus	R	aq
Brown-Headed Gull	Larus brunnicephalus	R	aq
Black-headed Gull	Larus ridibundus.	R	aq
Mew Gull	Larus canus	M	aq
Black-winged Stilt	Himantopidae Himantopius himantopus	R	aq
Osprey	Accipitridae Pandion haliatus	R	Schedule-I/GT,T
Black Kite	Milvus migrans	R	T
Brahmni Kite	Haliastur Indus	R	T
Pallas's Fish Eagle	Haliaeetus leucoryphus	R	T
Grey-headed Fish eagle	Ichthyophaga ichthyaetus	R	T
White-Ramped Vulture	Gyps bengalensis	R	T
Long-billed Vulture	Gyps indicus	M	T
Red-headed Vulture	Sarcogyps calvus	R	GT,T
Crested Serpent Eagle	Spilornis cheela	R	T
Eurasian Marsh-Harrier	Circus aeruginosus	M	T
Pied Harrier	Crcus melanoleucos	M	T
Hen Harrier	C. cyaneus	M	T
Pallied Harrier	C. macrourus	M	T
Montagu's Harrier	C. pygargus	M	T
Shikra	Accipiter badius	M	Schedule-I/GT,T
Besra	Accipiter virgatus	M	
Eurasian Sparrowhawk	A. nisus	M	T
Common Buzzard	Buteo buteo	M	T
Oriental Honey-Buzzard	Pernis ptilorhyncus	M	T
Long-legged Buzzard	Buteo rufinus	M	T
Lesser Spotted Eagle	Aquila pomarina	M	T
Greater Spotted Eagle	A. clanga	M	T
Red-necked Falcon	Falconidae Falco chicquera	M	T
Lesser Kestrel	Falco naumanni	M	T

Oriental Hobby	Falco severus	M	T
Peregrine Falcon	Falco peregrinus	M	T
Common Kingfisher	Alcidinidae Alcedo atthis	R	aq
Blyth's Kingfisher	Alcedo hercules	R	aq
Blue-eared Kingfisher	Alcedo meninting	R	aq
White-throated Kingfisher	Halcyon smyrnensis	R	aq
Stork-billed Kingfisher	Dacelonidae Halcyon capensis	R	aq
Pied Kingfisher	Cerylidae Ceryle rudis	R	aq
	Passeridae	R	T
House Sparrow	Passer domestica	R	T
Tree Sparrow	Passer montanus	R	T
Blackheaded Munia	Lonchura malacca	R	T
White-rumped Munia	Lonchura striata	R	T
White Wagtail	Motacilla alba	M	aq
Yellow Wagtail	Motacilla flava	M	aq
Grey Wagtail	Motacilla cinerea	M	aq
Paddyfield Pipit	Anthus rufulus	M	aq
Richard's Pipit	Anthus richardi	M	aq
Citrine Wagtail	Motacilla citriola	M	aq
Rosy Pipit	Anthus roseatus	M	aq
Olive-backed Pipit	A. hodgsoni	M	aq
Golden Fronted Leafbird	Irinidae Chloropsis auriforns	R	T
Orange Billed Lefbird	Chloropsis hardwiskii	R	T
Eurasian Golden Oriole	Corvidae Oriolus oriolus	R	T
Blck-hooded Oriole	Oriolus xanthornus	R	T
Rufous Treepie	D endrocitta vagabunda	R	T
House Crow	Corvus splendens	R	T
Large-billed Crow	Corvus macrorhynchos	R	T
Black Drango	Dicrurus macrocercus	R	T
Crow-billed Drongo	Dicrurus annectans	R	T
Bronzed Drongo	Dicrurus aeneus	R	T
Spangled Drongo	Dicrurus hottentottus	R	T
Ashy Drongo	Dicrurus leucophaeus	R	T
Common Iora	Aegithina tiphia	R	T
Black-naped Monarch	Hypothymis azurea	R	T
Large Cuckoo-shrike	Coracina macci	R	T

Ashy Wood Shallow	Artamus fuscus	M	T
Blue Throated Barbet	Megalaimidae Megalaima asiatica	R	T
Coppersmith Barbet	Megalaima haemocephala	R	T
Lineated Barbet	Megalaima lineata	R	T
Golden-throated Barbet	Megalaima franklinii	R	T
Blue-eared Barbet	Megalaima australis	R	T
Great Barbet	Megalaima viren	R	T
Asian Pied Starling	Sturnidae:Sturnus contra	R	T
Common Maina	Acridotheres tristis	R	T
Bank Maina	Acridotheres giginianus	R	T
Jungle Myna	Acridotheres fuscus	R	T
Whitevented Myna	A. grandis	R	T
Greyheaded Myna	Sturnus malabaricus	R	T
Hill Myna	Gracula religiosa	R	T
Creg Martin.	Hirundinidae Hirundo rupestris	M	T
Barn Swallow	Hirundo rustica	R	T
Northern House Martin	Delichon urbica	R	T
Sand Martin	Riparia riparia	M	T
Nepal House Martin	Delichon nipalensis	M	T
Red-Whiskered Bulbul	Pycnonotidae Pycononotus jocosus	R	T
Red-Vented Bulbul	Pycononotus cafer	R	T
Blue-tailed Bee-ater	Meropidae Merops philippinus	R	T
Green Bee-eater.	Merops orientalis	R	T
Chestnut-headed Bee-eater	Merops leschenaulti	R	T
Purple Sunbird	Necterinidae:Nectarinia asiatica	R	T
Purple-throated Sunbird	Necatrinia seperata	R	T
Mrs Gould's Sunbird	Aethopyga gouldiae	R	T
Crimson Sunbird	Aethopyga siparaja	R	T
Plain Flowerpacker	Dicaeum concolor	R	T
Common Tailor Bird	Sylvidae Orthotomus sutorius	R	T
Jungle Babbler	Turdoides striatus	R	T
Marsh Babbler	Pellorneum palustre	R	T
Black Redstart	Muscicapidae Phoenicurus ochruros	R	T
Oriental Magpie Robin	Copsichus saularis	R	T

Blue Whistling Thrush	Myophonus horsfieldii	R	T
Dark-sided Flycatcher	Muscicapa sibirica	R	T
Blackheaded Shrike-Babbler	Pteruthius rufiventer	R	T
Bluethroat	Luscinia svecica	R	T
Pied Buchchat	Saxicola caparata	M	T
Common Stonchat	Saxicola torquata	M	T
Verditer Flycatcher	Eumyias thalassina	R	T
Grey-breasted Prinia	Cisticolidae Prinia hodgsonii	R	T
Great Tit	Paridae Parus major	R	T
Graybacked Shrike	Lanidae Lanius tephronotus	M	T
Indian Roller	Coracidae Coracias benghalensis	R	T
Oriental Skylark	Alaudidae Alauda gulgula	M	T
Crested Lark	Galirida cristata	M	T
Rufous-winged Bushlark	Mirafra assamica	M	T
Common Swift	Apodidae Apus apus	R	T
House Swift	Apus affinis	R	T
Alpine Swift	Tachymarptis	R	T
Fork-tailed Swift	Apus pacificus	R	T
Asian Palmswift	Cypsturus balasiensis	R	T
Rose-ringed Parakeet	Psittacidae Pisttacula karmeri	R	T
Alexandrine Parakeet	Psittacula eupatria	R	GT,T
Blossom-headed Parakeet	Psittacula roseata	R	T
Spotted Dove.	Culombidae Streptopelia chinensis	R	T
Red Collared Dove	Streptopelia tranquebarica	R	T
Eurasian Collared Dove	Streptopelia decaocto	R	T
Oriental Turtle Dove	Streptopelia orientalis	R	T
Emerald Dove	Chalcophaps indica	R	T
Yellow-footed Green Pigeon.	Treron phoenicoptera	R	T
Wedge-tailed Green Pigeon	Treron sphenura	R	T

Orange-breasted Green Pigeon	Treron bicincta	R	T
Black-rumped Flameback.	Picidae Dinopium bengalensis	R	T
Yellow-crowned Wood pecker	Dendrocoposmahratt ensis	R	T
Grey-capped Pygmy Woodpecker	Dendrocopos canicapillus	R	T
Greater Coucal	Centropodidae Centropus sinensis	R	T
Lesser Caucal	Centropus bengelensis	R	T
Asian Koel	Cuculidae Eudynamys scolopacca	R	T
Common Hawk Cuckoo	Hierococcyx varius	R	T
Hodgson's hawk Cuckoo	Hierococcyx fugax	R	T
Large Hawk Cuckoo	Hierococcyx sparverioides	R	T
Indian Cuckoo	Cuculus micropterus	R	T
Oriental Cuckoo	Cuculus canorus	R	T
Lesser Cuckoo	Cuculus poliocephalus	R	T
Chestnut-winged Cuckoo	Clamator coromandus	R	T
Pied Cuckoo	Clamator jacobinus	M	T
Plantative Cuckoo	Cacomantis merulinus	M	T
Drongo Cuckoo	Surniculus lugubris	M	T
Green-billed Malkoha	Phaenicophaeus tristis	R	T
Common Hoopoe	Upopidae Upupa epops	R	T
Spotted Owlet	Strigidae Athene brama	R	T
Collared Scops Owl	Otus bakkamoena	R	T
Asian Barred Owlet	Glaucidium cuculoides	R	T
Jungle Owlet	Glaucidium radiatum	R	T
Great Eared Nightjar	Eurostopodus macrotis	R	T
Brown Fish Owl	Ketupa zeylonensis	R	T
Tawny Fish Owl	Ketupa flavipes	R	T

(Note: aq = Aquatic; T= Terrestrial habitat; IWPA: Wildlife Protection Act 1972; GT: Globally threatened, NT: Near threatened)

APPENDIX 3.12. COMPREHENSIVE LIST OF MAMMALIAN FAUNA IN PALASBARI SUB PROJECT AREA.

S. No.	English Name	Order/ Family/ Scientific Name	Status of IWPA, 1972
1	Himalayan Hoary-bellied Squirrel	Order: Rodentia Fam: Sciuridae Callosciurus pygerythrus	--
2	House Shrew	Fam: Soricidae Suncus murinus	--
3	Pigmy shrew	Suncus etruscus	--
4	House Mouse	Fam: Muridae Mus musculus	--
5	Large Bandicota -rat	Bandicota indica	--
6	Lesser bandicota-rat	Bandicota bengalensis	--
7	Black Rat	Rattus rattus	--
8	Chinese Porcupine	Fam: Hystricidae Hystrix brachyura	--
9	India Hare	Order: Lagomorpha Fam: Leporidae Lepus nigricollis	--
10	Indian Elephant	Order: Proboscidea Fam: Elephantidae Elephas maximus	EN, Schedule -I
11	Domestic Pig	Order: Artiodactyla Fam: Suidae Sus sp.	--
12	Barking Deer	Fam: Cervidae Muntiacus muntjak	--
13	Domestic Buffalo	Fam: Bovidae Bubalus sp.	--
14	Domestic Cattle	Bos sp.	--
15	Domestic Goat	Capricornis sp.	--
16	Indian flying fox.	Order: Chiroptera Fam: Pteropodidae Pteropus gigenteus	--
17	Long-winged tom bat	Fam: Emballonuridae Taphozous longimanus	--
18	Rhesus Macaque	Order: Primate Fam: Cercopithecidae Macaca mulatta	--
19	Asiatic Jackel	Order: Carnivora Fam: Canidae Canis aureus	--
20	Common Otter	Fam: Mustelidae Lutra lutra	--

21	Large India Civet	Fam: Viverridae Viverra zibetha	--
22	Small India Civet	Viverricula indica	--
23	Indian Mongoose	Fam: Herpestidae Herpestes javanicus	--

Note:- EN: Endangered

APPENDIX 3.13. DETAILS OF FISH SPECIES, MACRO-INVERTEBRATES, CRABS, TURTLES & TORTOISES, LIZARDS, SNAKES, MAMMALS, PLANKTON, CHLOROPHYCEAE, MYXOPHYCEAE, ZOOPLANKTON AND BENTHOS IN PALASBARI REACH

Fishes are listed based on all available published information as shown in table. Current status of nomenclature and systematics are done based on Catalog of Fishes (Eschmeyer, 2006, online version, updated April 16, 2006). Tentative IUCN criteria (EW=extinct in wild, CR=critically endangered, EN=endangered; VU=vulnerable, LR=lower risk (-nt -near threatened, lc=least concern and cd=least concern), DD=data deficient) of fishes are based on CAMP (1998). For fishes which are not assessed, it is marked NA.(Not available)

Sl. No		Stations												Cons. Stat.
		1	2	3	4	5	6	7	8	9	10	11	12	
	Fish Sp.													
1.	Anguilla bengalensis	++	+	-	-	-	-	+	-	-	-	-	-	EN
2.	Gudusia chapra	-	-	-	-	-	+	-	-	-	-	-	+	LRlc
3.	Hilsa ilisha	-	-	-	-	-	-	-	-	-	-	+	+	Vu
4.	Chagunius chagunio	-	+	+	-	-	-	+	+	-	-	-	-	NE
5.	Cirrhinus reba	-	+	-	-	+	-	-	-	-	-	-	-	Vu
6.	Labeo calbasu	-	+	-	-	-	+	-	-	-	-	+	+	LRnt
7.	Labeo gonius	-	-	+	+	+	+	-	-	+	+	+	+	LRnt
8.	Osteobrama cotio	+	-	-	-	-	+	-	-	-	-	-	-	LRnt
9.	Puntius chola	-	-	-	-	-	-	-	-	-	+	+	-	Vu
10.	Puntius sarana	-	+	+	-	-	-	-	-	-	-	-	-	Vu
11.	Puntius ticto	-	-	-	+	+	+	-	-	-	-	+	-	LRnt
12.	Puntius sophore	-	-	+	+	+	-	-	-	-	-	-	-	LRnt
14.	Tor tor	+	+	-	-	-	-	+	-	-	-	-	-	EN
15.	Salmophasia bacaila	-	-	-	-	-	-	-	-	-	-	+	+	LRlc
16.	Barilius barna	-	+	+	+	-	-	+	+	+	-	-	-	LRnt
17.	Barilius	+	+	+	-	-	-	+	+	+	-	-	-	LRnt
18.	Barilius tileo	-	+	+	-	-	-	-	-	-	-	-	-	LRnt
19.	Danio Devario	+	+	+	+	+	+	+	+	+	+	+	+	LRnt
20.	Danio aequipinnatus	-	-	+	+	+	+	-	-	-	+	+	+	LRnt
21.	Devario devario	-	+	+	-	+	+	-	-	-	-	+	+	LRnt
22.	Raiamas bola	-	+	+	-	-	-	-	-	-	-	-	-	Vu
23.	Crossocheilus latius	-	+	-	-	-	-	+	+	-	-	-	-	DD
24.	Garra gotyla	+	+	-	-	-	-	+	-	-	-	-	-	Vu
25.	Garra gotyla stenorhynchus	-	+	-	-	-	-	-	-	-	-	-	-	EN
26.	Garra nasuta	+	+	-	-	-	-	-	-	-	-	-	-	NE
27.	Psilorhynchus balitora	-	+	+	+	-	-	+	+	-	-	-	-	NE
28.	Acanthocobitis botia	-	+	+	+	+	-	-	+	+	+	-	-	LRnt
29.	Schistura scaturigina	-	-	-	-	-	-	+	+	-	-	-	-	Vu
30.	Lepidocephalichthys	-	+	+	+	+	-	-	+	+	+	+	+	NE

Sl. No		Stations												Cons. Stat.
		1	2	3	4	5	6	7	8	9	10	11	12	
	Fish Sp.													
	guntea (Hamilton-Buchanan)													
31.	Cantophrys gongota	+	-	-	-	-	-	-	+	-	-	-	-	LRnt
32.	Botia dario	-	-	-	-	+	+	-	-	-	-	+	+	NE
33.	Sperata aor	-	-	-	-	-	-	-	-	-	+	-	+	NE
34.	Batasio batasio	-	+	+	-	-	-	-	-	-	-	-	-	NE
35.	Ailia coila	-	-	-	-	-	-	-	-	-	-	-	+	Vu
36.	Clupisoma garua	-	-	-	-	-	-	-	-	-	-	+	+	Vu
37.	Eutropichthys vacha	-	-	-	-	-	-	-	-	-	-	+	+	NE
38.	Pseudeutropius atherinoides	-	-	-	-	-	-	-	-	-	-	+	+	NE
39.	Bagarius bagarius	-	-	-	-	-	-	-	-	-	+	-	+	Vu
40.	Erethistes pussilus	+	+	-	-	-	-	+	+	-	-	+	+	NE
41.	Erethistoides montana	-	-	+	+	-	-	-	-	-	-	-	-	CR
42.	Gagata cenia	-	-	-	-	-	+	-	-	-	+	+	+	NE
43.	Gagata gagata	-	-	-	-	-	-	-	-	-	-	+	+	NE
44.	Glyptothorax telchitta	-	-	-	-	-	+	-	-	-	-	-	+	LRnt
45.	Glyptothorax trilineatus	-	+	-	-	-	+	-	-	+	-	+	-	NE
46.	Hara hara	-	+	-	-	+	+	+	-	-	+	-	+	NE
47.	Pseudochenesis sulcatus	-	-	-	-	-	+	-	-	-	-	+	+	Vu
48.	Laguvia shawi	-	-	-	-	+	-	-	-	-	-	-	+	EN
49.	Clarias batrachus	-	-	-	-	-	-	-	-	+	+	-	-	Vu
50.	Heteropneustes fossilis	-	-	-	-	-	-	-	-	-	+	-	+	Vu
51.	Olyra longicaudata	-	+	+	-	-	-	+	-	-	-	-	-	NE
52.	Xenentodon cancila	-	-	-	-	+	-	-	-	-	+	-	+	LRnt
53.	Macrognathus pancalus	-	-	-	-	-	-	-	-	-	+	-	+	NE
54.	Mastacembelus armatus	-	-	+	-	+	-	-	-	-	+	-	+	NE
55.	Chaudhuria indica	-	+	+	-	-	-	-	-	-	-	-	-	Vu
56.	Chanda nama	-	+	+	+	+	+	-	+	+	+	+	+	NE
57.	Parambassis ranga	-	+	+	+	+	+	-	+	+	+	+	+	NE
58.	Johnius coitor	-	-	-	-	-	-	-	-	-	-	+	+	NE
59.	Badis badis	-	+	+	-	+	+	-	-	-	+	+	+	NE
60.	Glossogobius giuris	-	-	-	-	-	-	-	-	-	+	+	+	LRnt
61.	Channa gachua	-	+	-	-	+	-	-	-	+	+	+	-	Vu
62.	Channa punctatus	-	-	-	-	-	-	-	-	-	+	+	-	LRnt
63.	Channa striatus	-	-	+	+	+	-	-	-	-	-	-	-	LRnt

Sl. No		Stations												Cons. Stat.
		1	2	3	4	5	6	7	8	9	10	11	12	
	Fish Sp.													
Macro-Invertebrates														
1.	Gastropods													
2.	Pila globosa	+	+	+	+	+	+	+	+	+	+	+	+	
3.	Pila scutata	+	-	+	+	+	-	-	+	+	+	+	-	
4.	Brotia costula	+	+		+	+		+	+	+	+	+		
5.	Paludomus pustulosa	+	+	+			+	+	+			+	+	
6.	Bivalves													
7.	Lamellidens corrianus	+	+		+	+		+		+		+	+	
8.	Prawn													
9.	Macrobrachium malcomsoni	+	+	+	+	+		+	+	+		+	+	
10.	M. lanchesteri	+	+	+		+	+	+		+	+	+	+	
	Crabs													
1.	Sterteriane spinigera	+	+	+		+	+		+	+	+	+	+	
2.	Peratelphusa eduntula	+		+	+	+	+	+	+			+	+	
3.	P. spingera	+	+		+	+		+	+			+		
4.	Potaman woodmansoni	+	+	+			+	+	+	+	+			
5.	Amphibians													
6.	Chirixalus simus	+	+	+	+	+			+	+	+	+		
7.	Bufo melanostictus	+	+		+		+	+						
8.	Hoplobatrachus tigerinus	+	+	+			+	+	+	+	+		+	
9.	Limnonectes laticeps			+	+	+	+			+	+	+	+	
	Turtles and Tortoises													
1.	*Kachuga sylhetensis*	+	+		+		+	+	+		+	+	+	
2.	*Aspideretes gangeticus*	+		+		+	+	+		+	+	+	+	
3.	*Kachuga tecta*	+	+				+	+	+				+	
	Lizards													
1.	*Gecko gecko*	+		+	+	+	-	+		+	+	+	+	
2.	*Varanus bengalensis*	+	+		+		+	+	+				+	
3.	*Varanus salvator*	+		+	+	+	+	+		+	+	+	+	
4.	*Calotes emma*	+	+				+	+	+				+	
5.	*Calotes maria*	+		+		+	+	+		+	+	+	+	
	Snakes													
1.	*Ophiophagus hannah*	+		+		+	+	+		+	+	+	+	

Sl. No		Stations												Cons. Stat.
		1	2	3	4	5	6	7	8	9	10	11	12	
	Fish Sp.													
2.	Naja naja	+	+				+	+	+				+	
	Mammals													
1.	River Dolphin	+	+		+	+	+		+		+	+	+	
2.	Otter	-	-	-	+	-	-	-	+	+	+	+	+	
	(Conservation status of the above species will be mentioned later on as per IUCN report) Plankton													
1.	Bacillariophyceae													
2.	Diatoma	+		+	+	+	-	+		+	+	+	+	
3.	Fragilaria	+	+		+		+	+	+				+	
4.	Synedra	+		+	+	+	+	+		+	+	+	+	
5.	Cocconeis		+				+	+	+				+	
6.	Achnanthes	+		+		+	+	+		+	+	+	+	
7.	Eucocconeis			+	+	+	-	+		+	+	+	+	
8.	Navicula	+	+		+		+	+	+				+	
9.	Pinnularia			+	+	+	+	+		+	+	+	+	
10.	Gyrosigma	+	+				+	+	+				+	
11.	Frustulia	+		+		+	+	+		+	+	+	+	
12.	Gomphonema			+	+	+				+				
13.	Cymbella		+	+	+		+	+	+		+	+	+	
14.	Nitzschia	+	+	-	+		+	+	+			+		
15.	Surirella	+		+	+	+				+	+		+	
16.	Melosira	+	+	+	+		+	+	+			+	+	
	Chlorophyceae													
1.	UlothrIx		+	+	+		+	+	+	+	+	+	+	
2.	Microspora	+		+		+	+	+	+		+		+	
3.	Cladophora		+	+	+		+		+	+	+	+		
4.	Closterium	+	+	+	+			+			+		+	
5.	Cosmarium	+				+	+	+	+	+			+	
6.	Spirogyra		+	+	+				+		+	+	+	
	Myxophyceae													
1.	Oscillatoria	+	+		+	+		+		+	+	+	+	
2.	Rivularia	+		+			+	+	+		+	+		
3.	Anabaena		+	+	+					+	+	+	+	
	Zooplankton													
1.	Vorticella	+	+	+			+	+	+		+	+	+	
2.	Cyclops	+			+	+			+	+	+	+	+	
3.	Daphnia	+			+	+	+	+	+		+	+	+	
4.	Zoea larva		+	+	+			+	+	+	+	+		
5.	Keratella	+	+	+	+	+	+							
6.	Moina	+	+	+			+	+	+		+	+	+	

Sl. No		**Stations**												**Cons. Stat.**
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	
	Fish Sp.													
7.	Chironomous	+			+	+			+	+	+	+	+	
8.	Gomphus	+			+	+	+	+	+		+	+	+	
9.	Bosmina		+	+	+			+	+	+	+	+		
10.	Ceriodaphnia	+	+	+	+	+	+							
11.	Chydorus	+	+	+			+	+	+		+	+	+	
12.	Nauplis	+			+	+			+	+	+	+	+	
13.	Diaptomus	+			+	+	+	+	+		+	+	+	
14.	Canthocamptus		+	+	+			+	+	+	+	+		
15.	Asplanchna	+	+	+	+	+	+							
16.	Kellicotia		+				+	+	+				+	
17.	Arcella	+		+		+	+	+		+	+	+	+	
18.	Paramecium			+	+	+	-	+		+	+	+	+	
19.	Brachionus	+	+		+		+	+	+				+	
20.	Asplanchna			+	+	+	+	+		+	+	+	+	
21.	Filinia	+	+				+	+	+				+	
22.	Semiocephalus	+		+		+	+	+		+	+	+	+	
23.	Moinodaphnia			+	+	+				+				
24.	Sida		+	+	+		+	+	+		+	+	+	
25.	Macrothrix	+	+	-	+		+	+	+			+		
26.	Epistilis	+		+	+	+				+	+		+	
27.	Rotifer eggs	+	+	+	+		+	+	+			+	+	
28.	Gomphus		+				+	+	+				+	
	Benthos													
1.	Nais			+	+	+	-	+		+	+	+	+	
2.	Tubifex	+	+		+		+	+	+				+	
3.	Chironomus			+	+	+	+	+		+	+	+	+	
4.	Viviparus	+	+				+	+	+				+	
5.	Gyraulus	+		+		+	+	+		+	+	+	+	
6.	Pisidium			+	+	+				+				

N.B. Fishes were identified after the methods of Talwar and Jhingran (1991), Nath and Dey (2000) and Vishwanath (2002).
The plankton were identified after Edmonson (1959), Needham and Needham (1966) and APHA (1998).

APPENDIX 3.14. EMISSION FACTORS OF VARIOUS DUST GENERATION PROCESSES

Source	Unit	Emission Factor
Receipt of new aggregate at Hot Mix Plant	g/ton	1.86
Transfer of aggregate from storage to conveyor belt or between conveyor belts in Hot Mix Plant	g/ton	0.021
Screening of aggregate in Hot Mix Plant	g/ton	0.38
RAP crushing	g/ton	0.27
Paved road dust emissions	g/VMT	7.26
Unpaved road dust emissions	g/VMT	925.3

(Note: VMT: Vehicle Mile Traveled)

APPENDIX 5.1. SUMMARY OF IMPACT ASSESSMENT AND RESIDUAL MPACT

Activity	Environmental Issue/ Component	Nature of Impact	Remedial Measures	Residual Impacts Level after Mitigation Measures
DESIGN AND CONSTRUCTION PHASE				
Landuse				
Change in Landuse	Loss of agriculture land Loss of homestead plantation in 100 m core zone around the embankment	Adverse	Use of uncultivated areas near embankments only for storage and/or handling of construction materials Construction camps on uncultivated areas only with requisite facilities of drinking water supply, sanitation, waste collection and fuel supply No dumping of construction waste on agricultural land Adequate compensation for loss of land and/ or loss of crops Land used for construction camps shall made reusable/ cultivable after closer of construction camp All efforts during the design stage shall be made to minimize the tree felling requirement. Compensatory plantation shall be started during construction phase parallel to the construction activities. Monitoring of tree felling.	Acceptable even though landuse will be changed permanently around the core zone Restoration of sites used for construction material handling and storage as well as construction camps will be required
Borrow area location and rehabilitation	Loss of agricultural land and homestead plantation due to borrowing earth from country side of embankment Permanent disfiguration of land Seepage to the foundations of embankment	Adverse	Borrow pits shall be preferred on river side to embankment as these can get silted in the course of time Use of waste land or excavation or enlargement of existing lank or any hump above ground level for borrowing of earth Use of dredge material from River Kulsi/ Jajali Strictly following WRD guidelines with respect to borrow area location and rehabilitation	Acceptable in case of borrow areas will be located on river side Borrow pits on the country side shall be cut and interconnected to permit ordinary drainage IRC guidelines may also be followed for borrow pits.

Activity	Environmental Issue/ Component	Nature of Impact	Remedial Measures	Residual Impacts Level after Mitigation Measures
Construction material sourcing (Quarrying)	Illegal quarrying may lead to landuse change, unstable rock formation, air and noise pollution	Adverse	Aggregates required for construction of embankment and roads shall be procured from quarries approved by SPCB. Air and noise emissions from quarries shall be well within the prescribed limits. Stone crushers, if required, shall be set up only after consent from SPCB and taking adequate measures for air pollution control. Land earmarked for dumping of construction waste shall be free from any social and R&R issue and away from settlements	Stabilization of quarries and dumping sites after use.
Soil				
Soil erosion	Soil erosion from construction sites during monsoon season Loss of topsoil	Medium	Opening of borrow areas near the embankments shall not be done during monsoon season Identification of potential erosion zones during construction phase Stabilization of soil around the approach roads/ slopes by turfing and tree plantation in ROW Slope stabilization measures on the embankment like selection of less eroding materials	Acceptable but requires continuous monitoring of the stabilized areas and identification of potential erosion zones for advance mitigation for lowering any adverse impacts
Soil compaction	Soil compaction around construction sites, haulage roads, construction camps, and workshops due to transportation of man, machine, and materials Construction waste handling	Medium	Movement of construction vehicles, machinery and equipments in embankment site and pre-defined haulage road Adequate provision for approach roads capable of handling movement and haulage of heavy vehicles and machines	Restoration of compacted sites after construction will be required
Soil contamination	Soil contamination around construction sites, machine maintenance areas, fuelling stations,	Medium	Fuelling and maintenance of construction machinery and vehicles shall be carried out at designated place with proper arrangement of waste collection and disposal. Fuel storage and refuelling sites to be kept away	No further mitigation will be required.

Activity	Environmental Issue/ Component	Nature of Impact	Remedial Measures	Residual Impacts Level after Mitigation Measures
	construction camps, hotmix plant and haulage roads		from drainage channels. Unusable debris to be dumped in designated places. Provision of oil interceptors Waste oil shall be sold off to recyclers authorized by SPCB/ MoEF.	
Site clearing etc	Contamination of soil from construction wastes and quarry materials	Medium	All spoils to be disposed off as desired and the site to be restored back to its original conditions before handing over. Non-bituminous wastes from construction activities to be dumped in borrow pits and covered with a layer of the conserved topsoil. Bituminous wastes to be disposed off in identified dumping sites.	No further mitigation required
Hydrology and Morphology				
Flood	Inundation during heavy flood	Medium	Adequate provisions of sluice gates shall be made. Natural drainage systems shall not be disturbed. Adequate provisions shall be made in engineering design to withstand extreme meteorological and geo-physical events	Continuous maintenance and protection of embankments will be required
Changes in water levels	No significant change due to project intervention	Low to Nil	None	No residual impact
Effect on flow velocity/ discharge intensities	No significant change due to project intervention	Low to Nil	Monitoring of flow shall be carried out at regular intervals using field data as well as satellite remote sensing data.	No residual impact
Silt deposition and bed level change	Prevention in silt deposition on agricultural land due to breach of embankments	Beneficial	Monitoring of anti-erosion and river training works at regular intervals	No residual impact

Activity	Environmental Issue/ Component	Nature of Impact	Remedial Measures	Residual Impacts Level after Mitigation Measures
Water quality	Impact on surface and ground water quality Contamination of water due to construction waste Contamination of water from fuel and lubricants	Low to Nil	Adequate supply of drinking water to workers. Septic tanks shall be provided to treat the domestic sewage from construction camps. Provision of mobile toilets for use at flood platforms Construction work close to the channels or other water bodies to be avoided. All necessary precautions to be taken to construct temporary devices to prevent water pollution due to increased siltation and turbidity. Oil and grease traps to be provided at fuelling locations, to prevent contamination of water. Slopes of embankment leading to water bodies to be modified and screened so that contaminants do not enter the water channel/ water body. Water quality to be monitored as envisaged in the environmental monitoring plan.	No residual impact
Climate	No direct impact but increase in temperature due to construction activities and trees to be cut	Medium	Minimization of tree cutting while designing the embankment Compensatory tree plantation preferably on the basis of 3 trees plantation against each tree cut	Acceptable as increase in temperature due to project intervention will be minimized
Air Environment	Change in air quality due to construction activities	Medium	Approach roads should be paved and widened All slopes and embankments to be turfed as per best engineering practices to minimize the dust generation All the machinery and plants to be placed at the downwind direction with respect to human settlements. All vehicles, equipments and machinery used for construction to be regularly maintained. The hot mix plants, crushers and batching plants to be sited at least 500 m in the downwind direction from the nearest human settlement. Hot mix plants shall comply with applicable	No residual impact

Activity	Environmental Issue/ Component	Nature of Impact	Remedial Measures	Residual Impacts Level after Mitigation Measures
			National/State Pollution Control Board Standards for emissions from hot mix plants. Fugitive emissions from handling of construction material, storage as well as from transportation shall be taken care. Speed restriction, surface improvement and surface treatment shall be taken as options for control of emissions from unpaved roads.	
Noise	Increase in sound pressure levels due to construction machineries, vehicles etc.	Low to Nil	Options of noise control by site controls, scheduling of project activities, Protection devices (ear plugs or ear muffs) to be provided to the workers operating in the vicinity of high noise generating machines. Construction equipments and machinery shall be fitted with silencers and maintained accordingly. Construction of temporary noise barriers near the sensitive areas, e.g. schools Noise and vibration level monitoring as per monitoring plan.	No residual impact
Terrestrial ecology				
Disturbance to vegetation	Cutting of trees in core zone during project intervention	Medium to High	Minimization of tree cutting while designing the embankment Compensatory tree plantation on the basis of 3 trees plantation against each tree cut	Monitoring of survival rates of trees planted during aforestation programme
Animal distribution/ migratory route	Impact on Dolphin breeding sites No Migratory route	Low to Nil	Construction activities shall be restricted during Dolphin breeding period (May to August) at breeding sites. Due to sensitivity of Dolphins with polluted water, construction waste should not dumped near the river bank	No residual impact
Endangered species	Impact on Dolphin		As above	No residual impact
Aquatic ecology				
Fishing activities/	Impact on boat ghats	Medium	Adequate provision shall be made in the design to	No residual impact

Activity	Environmental Issue/ Component	Nature of Impact	Remedial Measures	Residual Impacts Level after Mitigation Measures
productivity	Temporary flushing of fish species towards deeper parts of the river		ensure access to the fish landing sites/ boat ghats Undisturbed movement of the fishermen shall be provided	
Migratory routes	No migratory route near the embankment	Low to Nil	None	No residual impact
Spawning and Breeding Grounds	Disturbance on breeding and spawning grounds	Medium	Restriction of construction activities near the identified breeding and spawning grounds during the breeding period of april to august	No residual impact
Pond fisheries	No adverse impact	Beneficial	Fish productivity can be improved substantial with use of better fish culture and increasing the capacity of fish ponds	No residual impact
Socio economic				
Demography	Pressure on natural resources due to establishment of construction camps	Low to Nil	Construction camps shall be supported with all basic amenities such as drinking water, fuel, sanitation facilities etc.	No residual impact
Establishments	Impact on houses and establishments near core zone	Medium	Efforts shall be made to prevent any relocation or demolition Social infrastructure shall be rehabilitated with social and cultural values Temporary noise barriers shall be installed close to schools and places of worship Thick plantation shall be made close to these establishments	No residual impact
Socio-economic impact	Beneficial impact due to control in flood and erosion Impact on fish landing sites	Beneficial	Daily wage workmanship during the construction phase to local people Training programmes for agriculture and fish production improvement Appropriate provisions shall be made to provide alternate fish landing stations so that economic activities of the fishermen can not disturb during project intervention	No residual impact
Safety	Risk of accidents and	Medium	Adequate lighting and fluorescent signage shall	Adherence to occupational

Activity	Environmental Issue/ Component	Nature of Impact	Remedial Measures	Residual Impacts Level after Mitigation Measures
	safety due to narrow roads and encroachment of people near construction areas		be provided at construction sites. Signage in local language Setting up of speed limits Personal protective equipments for workers Health check up camps for workers	health and safety norms shall be monitored
OPERATION PHASE				
Landuse				
Change in Landuse and borrow area rehabilitation	Encroachment on embankment for habitation and cultivation Cutting of embankment to create approach to river side Non-rehabilitation of borrow areas	Medium	Provision shall be made in the embankment design for providing access to river bank close to the habitats. Construction contractors shall ensure rehabilitation of borrow areas before handling over the project.	No residual impact
Soil				
Soil erosion	Net benefits due to construction of embankment and anti-erosion measures in river banks Erosion due to lower watershed of Kulsi river	Beneficial	Periodic checking of the stabilization measures	
Hydrology and Morphology				
Upstream and downstream effects on river morphology	Reduction of flood absorption due to the flood plains of the reach Impact on charlands near to bankline	Beneficial	Erosion monitoring shall be carried out downstream as well. In case of impact on fringe areas of char, passive type of measures like porcupine screens shall be used.	
Flood	Inundation during	Medium	Adequate provisions of sluice gates shall be	Continuous maintenance

Activity	Environmental Issue/ Component	Nature of Impact	Remedial Measures	Residual Impacts Level after Mitigation Measures
	heavy flood		made. Natural drainage systems shall not be disturbed. Adequate provisions shall be made in engineering design to withstand extreme meteorological and geo-physical events	and protection of embankments will be required
Changes in water levels	No significant change	Low to Nil		No residual impact
Silt deposition and bed level change	Prevention in silt deposition on agricultural land during floods	Beneficial	Monitoring of anti-erosion and river training works at regular intervals	No residual impact
Drainage system	Embankment acts like a barrier for the drainage of accumulating country side water into the Brahmaputra during monsoon season.	Medium	Provision shall be made to the extent possible not to obstruct the natural drainage.	No residual impacts
Wetlands/ beels	No Impact	Low to Nil	Institutional support to enhance the fish productivity	Positive impact
Water quality	Discharge of domestic effluents from nearby villages to the river	Medium	Sanitation facilities shall be provided	No residual impact
Climate	No direct impact but changes in catchments area of the river and global warming can have indirect impact	Low	Attention shall be given for maintaining inland outflow of water to wetland areas. Provision of sluice gates to be made in the embankment.	Flood pattern shall be closely monitored during the project life span of the embankment.
Air Environment	Change in air quality due to traffic	Low to Nil	Plantation along the embankment Turfing of the embankment slopes Regular maintenance of the road on the top of embankment as well as approach roads	No residual impact
Noise	Increase in sound pressure levels due to	Low to Nil	Adequate signage to restrict use of pressure horns particularly in noise sensitive locations	No residual impact

Activity	Environmental Issue/ Component	Nature of Impact	Remedial Measures	Residual Impacts Level after Mitigation Measures
	traffic		Tree barriers between the road and village/ semi urban/ and urban areas	
Terrestrial ecology				
Habitat fragmentation	Inappropriate opening of the sluice gate	Medium	Appropriate management to be made for the operation of the sluice gates Awareness programme shall be initiated to intimate the people about usefulness of the sluice gates	No residual impact
Aquatic ecology				
Fishing activities/ productivity	Likely to increase due to institutional strengthening	Beneficial		No residual impact
Spawning and Breeding Grounds	No impact	Low to Nil		

APPENDIX 6.1. ENVIRONMENTAL MANAGEMENT PLAN (EMP)

Activity	Environmental Issue/ Component	Remedial Measures	Legislative Requirement/ Framework	Approximate Location	Time Frame	Mitigation Cost (Rs.)	Institutional Responsibility	
							Implementation	Supervision
Climate Change	No direct impact but increase in temperature due to construction activities and trees to be cut	Minimization of tree cutting while designing the embankment Compensatory tree plantation preferably on the basis of 3 trees plantation against each tree cut	Kyoto Protocol	Through out the stretch of reach	Throughout the construction period	--	Contractor with guidance of Social Forestry Department	WRD and AIFRERM Agency
Change in Landuse	Loss of agriculture land	Use of uncultivated areas near embankments only for storage and/or handling of construction materials	-	Construction sites and service areas throughout the reach	During design and construction phase	Included in construction cost	Contractor	WRD and AIFRERM Agency
		Construction camps on uncultivated areas only with requisite facilities of drinking water supply, sanitation, waste collection and fuel supply		Identified locations of construction camps (4 to 5)		Included under soil contamination prevention costs	Contractor	WRD and AIFRERM Agency
		No dumping of construction waste on agricultural land					Contractor	WRD and AIFRERM Agency
		Adequate compensation for loss of land and/ or loss of crops	As per Social Assessment and R&R	Identified as per the social assessment		Included in R&R Cost	WRD-SIO	WRD and AIFRERM Agency
		Land used for construction camps shall made reusable/ cultivable after closer of		Sites used as construction camp	After completion of construction	Included in construction cost	Contractor	WRD and AIFRERM Agency

Activity	Environmental Issue/ Component	Remedial Measures	Legislative Requirement/ Framework	Approximate Location	Time Frame	Mitigation Cost (Rs.)	Institutional Responsibility	
							Implementation	Supervision
		construction camp						
		All efforts during the design stage shall be made to minimize the tree felling requirement.		Entire project area	During complete construction phase	Included in design engineering cost	Engineering Team/WRD Field Officer	WRD and AIFRERM Agency
	Loss of homestead plantation	Compensatory plantation shall be started during construction phase parallel to the construction activities (1:3)		Entire project area	During construction	2340000	WRD-SIO	WRD and AIFRERM Agency
		Monitoring of tree felling (census of trees, their numbering etc. based on engineering design)		Entire project area	During complete construction phase	Included in the Monitoring Costs (refer Monitoring Plan)	Independent agency	WRD and AIFRERM Agency
Borrow area location and rehabilitation	Loss of agricultural land and homestead plantation due to borrowing earth from country side of embankment	Borrow pits shall be preferred on river side to embankment as these can get silted in the course of time or earth from retired Embankment	WRD guidelines	Identified locations for borrowing of earth	During complete construction phase	Included in construction cost	Contractor/WRD Field Officers	WRD and AIFRERM Agency
	Permanent disfiguration of land	Use of waste land or excavation or enlargement of existing lank or any hump above ground level for borrowing of earth		Identified locations for borrowing of earth	During complete construction phase	Included in construction cost	Contractor	WRD and AIFRERM Agency

Activity	Environmental Issue/ Component	Remedial Measures	Legislative Requirement/ Framework	Approximate Location	Time Frame	Mitigation Cost (Rs.)	Institutional Responsibility	
							Implementation	Supervision
	Seepage to the foundations of embankment	Use of dredge material from River Kulsi/ Jaljali		Banks of River Kulsi/ Jaljali	During construction	Included in construction cost	Contractor	WRD and AIFRERM Agency
		Strictly following WRD guidelines with respect to borrow area location and rehabilitation		Entire project area	During construction phase as well as after construction	Included in construction cost	Contractor	WRD and AIFRERM Agency
Change in Land use and Borrow Area Rehabilitation	Encroachment on embankment for habitation and cultivation Cutting of embankment to create approach to river side Non-rehabilitation of borrow areas	Provision shall be made in the embankment design for providing access to river bank close to the habitats. Constructions contractors shall ensure rehabilitation of borrow areas before handling over the project.		Entire project area and Borrow Areas	Operation Phase	Included in construction cost	Contractor, WRD (Field Staff)	WRD and AIFRERM Agency
Construction material sourcing (Quarrying)	Illegal quarrying may lead to landuse change, unstable rock formation, air and noise pollution	Aggregates required for construction of embankment and roads shall be procured from quarries approved by SPCB.	Environmental Protection Act and Rules, 1986; Water Act, Air Act	River and Hill Quarries approved by Assam Govt.	During complete construction phase	Included in construction cost	Contractor	WRD and AIFRERM Agency
		Air and noise emissions from quarries shall be well within the prescribed limits for the protection of workers health		Quarrying sites	During complete construction phase	--	WRD	WRD, AIFRERM Agency and SPCB

Activity	Environmental Issue/ Component	Remedial Measures	Legislative Requirement/ Framework	Approximate Location	Time Frame	Mitigation Cost (Rs.)	Institutional Responsibility	
							Implementation	Supervision
		Stone crushers, if required, shall be set up only after consent from SPCB and taking adequate measures for air pollution control.		Location of stone crushers	During complete construction phase	Included in construction cost	Contractor	WRD, AIFRERM Agency and SPCB
		Land earmarked for dumping of construction waste shall be free from any social and R&R issue and away from settlements			During complete construction phase	Included in R&R Cost	Contractor	WRD and AIFRERM Agency
Soil erosion	Soil erosion from construction sites during monsoon season	Opening of borrow areas near the embankments shall not be done during monsoon season		Identified areas for borrowing earth	Except monsoon season during construction phase	Included in construction cost	Contractor	WRD and AIFRERM Agency
	Loss of topsoil	Identification of potential erosion zones during construction phase			Especially during monsoon season	Included in construction cost	WRD Field Officers	WRD and AIFRERM Agency
		Stabilization of soil around the approach roads/ slopes by turfing and tree plantation in ROW		Along the embankment and approach roads	Especially before monsoon starts	Included in construction cost	Contractor	WRD and AIFRERM Agency
		Slope stabilization measures on the embankment like selection of less eroding materials		As suggested by the engineering team	During the construction period	Included in construction cost	Contractor	WRD and AIFRERM Agency

Activity	Environmental Issue/ Component	Remedial Measures	Legislative Requirement/ Framework	Approximate Location	Time Frame	Mitigation Cost (Rs.)	Institutional Responsibility	
							Implementation	Supervision
	Net benefits due to construction of embankment and anti-erosion measures in river banks	Periodic checking of the stabilization measures		Project Benefit Area.	Post Operation Phase	Included in Monitoring Costs. Water Shed Management to be initiated by WRD Separately	WRD	WRD and AIFRERM Agency
Soil compaction	Soil compaction around construction sites, haulage roads, construction camps, and workshops due to transportation of man, machine, and materials	Movement of construction vehicles, machinery and equipments in embankment site and pre-defined haulage road		Construction material dumping sites and construction sites	During the entire construction period	Included in construction cost	Contractor	WRD and AIFRERM Agency
	Construction waste handling	Adequate provision for approach roads capable of handling movement and haulage of heavy vehicles and machines		Approach roads used for material handling	During the entire construction period	Included in construction cost	Contractor	WRD and AIFRERM Agency
Soil contamination	Soil contamination around construction sites, machine maintenance areas, fuelling	Fuelling and maintenance of construction machinery and vehicles shall be carried out at designated place with proper arrangement of		Fuel storage and workshop areas	During the entire construction period	3,20,000	Contractor	WRD and AIFRERM Agency

Activity	Environmental Issue/ Component	Remedial Measures	Legislative Requirement/ Framework	Approximate Location	Time Frame	Mitigation Cost (Rs.)	Institutional Responsibility	
							Implementation	Supervision
	stations, construction camps, hotmix plant and haulage roads	waste collection and disposal.						
		Fuel storage and refuelling sites to be kept away from drainage channels.		Fuel storage and workshop areas	During the entire construction period	Included in construction cost	Contractor	WRD and AIFRERM Agency
		Unusable debris to be dumped in designated places.		Identified inert material dumping sites	During construction phase	Included in construction cost	Contractor	WRD and AIFRERM Agency
		Provision of oil interceptors		At fuel handling and workshop areas	During construction phase	Included above	Contractor	WRD and AIFRERM Agency
		Waste oil shall be sold off to recyclers authorized by SPCB/ MoEF.		At fuel handling and workshop areas	During construction phase	Earning from selling	Contractor	WRD and AIFRERM Agency
Site clearing etc	Contamination of soil from construction wastes and quarry materials	All spoils to be disposed off as desired and the site to be restored back to its original conditions before handing over.		Construction material handling areas and construction sites	After completion of construction phase	Part of Construction Costs	Contractor	WRD and AIFRERM Agency
		Non-bituminous wastes from construction activities to be dumped in borrow pits and covered with a layer of		Inert material dumping sites	After completion of construction phase	Included in construction cost	Contractor	WRD and AIFRERM Agency

Activity	Environmental Issue/ Component	Remedial Measures	Legislative Requirement/ Framework	Approximate Location	Time Frame	Mitigation Cost (Rs.)	Institutional Responsibility	
							Implementation	Supervision
		the conserved topsoil.						
		Bituminous wastes to be disposed off in identified dumping sites.		Identified dumping sites	After completion of construction phase	Included in construction cost	Contractor	WRD and AIFRERM Agency
Flood	Inundation during heavy flood	Adequate provisions of sluice gates shall be made.		In proposed embankment	During the construction phase	Included in construction cost	Engineering team and contractor/WRD Field Officer	WRD and AIFRERM Agency
		Natural drainage systems shall not be disturbed.		Country side of embankment in the buffer zone	During the construction phase as well as operation phase	Included in construction cost	Engineering team and contractor/WRD Field Officer	WRD and AIFRERM Agency
		Institutional support in wetlands and other water bodies shall be enlarged and deepened		Southern part of the reach	During the construction phase as well as operation phase	1,000,000	WRD	WRD and AIFRERM Agency
		Adequate provisions shall be made in engineering design to withstand extreme meteorological and geo-physical events		Proposed embankment	During the detailed engineering design stage	Included in engineering design cost	Design Team and WRD	WRD and AIFRERM Agency
Drainage system	Embankment acts like a barrier for the drainage of accumulating country side	Provision shall be made to the extent possible not to obstruct the natural drainage.		Entire project area	During the detailed engineering design stage	Included in engineering design cost	Engineering Team	WRD and AIFRERM Agency

Activity	Environmental Issue/ Component	Remedial Measures	Legislative Requirement/ Framework	Approximate Location	Time Frame	Mitigation Cost (Rs.)	Institutional Responsibility	
							Implementation	Supervision
	water into the Brahmaputra during monsoon season.							
Upstream and downstream effects on river morphology	Reduction of flood absorption due to the flood plains of the reach Impact on charlands near to bankline	Erosion monitoring shall be carried out downstream as well. In case of impact on fringe areas of char, passive type of measures like porcupine screens shall be used.		Entire project area	Operation Phase	Monitoring Costs included under Monitoring Costs Included in engineering design cost.	WRD Field Officer	WRD and AIFRERM Agency
Effect on flow velocity/ discharge intensities	No significant change due to project intervention	Monitoring of flow shall be carried out at regular intervals using field data as well as satellite remote sensing data.		At upstream and in between the reach	During the lifespan of the project	Part of Engineering Cost	Engineering Team	WRD and AIFRERM Agency
Silt deposition and bed level change	Prevention in silt deposition on agricultural land due to breach of embankments	Monitoring of anti-erosion and river training works at regular intervals		At upstream and in between the reach	During the lifespan of the project	WRD shall take initiative	WRD	WRD and AIFRERM Agency
Impacts from external factors such as climate change, upstream dam construction, and watershed development	Design parameters may need to be changed over the years Impacts may include reduced discharge,	Systematic monitoring of hydrology, morphology, and sediment transport with acquisition of data Establishment of information network of		Subproject reach in particular, but also include basin wide information and tributaries	During the lifetime of the project	Included in data and knowledge development component of IFRERM ASSAM	WRD	WRD and AIFRERM Agency

Activity	Environmental Issue/ Component	Remedial Measures	Legislative Requirement/ Framework	Approximate Location	Time Frame	Mitigation Cost (Rs.)	Institutional Responsibility	
							Implementation	Supervision
	artificial change in discharge volumes, reduced sediments	discharges from upstream reservoirs Developing capacities in WRD to cope with changes in environment						
Impacts of morphological changes to subproject areas	Upstream and downstream erosion process may affect the sustainability of subproject structures	Systematic monitoring of morphology and sediment transport, with establishment of short term prediction models Preparation and implementation of protection measures to prevent outflanking of structures		Subproject reach in particular, but also include basin wide information and tributaries	During the lifetime of the project	Included in data and knowledge development component of IFRERM ASSAM	WRD	WRD and AIFRERM Agency
Water quality	Impact on surface and ground water quality	Adequate supply of drinking water to workers.	The Water (Prevention & Control of Pollution) Act, 1974 and amendments thereof	At construction camps and construction sites	During construction phase	3,60,000	Contractor	WRD and AIFRERM Agency
	Contamination of water due to construction waste	Septic tanks shall be provided to treat the domestic sewage from construction camps.		At construction camps	During construction phase			
		Provision of mobile toilets for use at flood platforms		At high altitude areas	During Operation Phase	Included in construction cost	WRD Field Officer	WRD and AIFRERM Agency
	Contamination of water from fuel and lubricants	Construction work close to the channels or other water bodies to be avoided.			During construction phase	--	WRD Field Officer	WRD and AIFRERM Agency

Activity	Environmental Issue/ Component	Remedial Measures	Legislative Requirement/ Framework	Approximate Location	Time Frame	Mitigation Cost (Rs.)	Institutional Responsibility	
							Implementation	Supervision
		All necessary precautions to be taken to construct temporary devices to prevent water pollution due to increased siltation and turbidity.			During construction phase	Included in construction cost	Contractor	WRD and AIFRERM Agency
		Oil and grease traps to be provided at fuelling locations, to prevent contamination of water.		Fuel handling and workshop areas	During construction phase	Included in construction cost	WRD Field Officer	WRD and AIFRERM Agency
		Slopes of embankment leading to water bodies to be modified and screened so that contaminants do not enter the water channel/ water body.		Along the reach	During construction phase	Included in construction cost	WRD Field Officer	WRD and AIFRERM Agency
		Water quality to be monitored as envisaged in the environmental monitoring plan.		As per monitoring plan	During construction phase	Included in the monitoring costs	WRD	WRD and AIFRERM Agency
	Discharge of domestic effluents from nearby villages to the river	Sanitation facilities shall be provided		Entire Project Benefit Area	Operation Phase	WRD to Initiate with concerned civic authorities	WRD	WRD and AIFRERM Agency
Air Environment	Change in air quality due to construction activities	Approach roads shall be paved and widened	Environmental Protection Act, 1986; The Air (Prevention and	Approach roads to construction sites	At the start of construction activity	Included in construction cost	Contractor/ WRD	WRD and AIFRERM Agency

Activity	Environmental Issue/ Component	Remedial Measures	Legislative Requirement/ Framework	Approximate Location	Time Frame	Mitigation Cost (Rs.)	Institutional Responsibility	
							Implementation	Supervision
		All slopes and embankments to be turfed as per best engineering practices to minimize the dust generation	Control of Pollution) Act, 1981 and amendments thereof	Construction area	During construction phase	Included in construction cost	Contractor	WRD and AIFRERM Agency
		All the machinery and plants to be placed at the downwind direction with respect to human settlements.			Construction period	Included in construction cost	Contractor	WRD and AIFRERM Agency
		All vehicles, equipments and machinery used for construction to be regularly maintained.		Workshop areas	Construction period	Included in construction cost	Contractor	WRD and AIFRERM Agency
		The hot mix plants, crushers and batching plants to be sited at least 500 m in the downwind direction from the nearest human settlement.			At the start of construction activity	Included in construction cost	Contractor	WRD and AIFRERM Agency
		Hot mix plants shall comply with applicable National/State Pollution Control Board Standards for emissions from hot mix plants.			Construction period	Included in construction cost	Contractor	WRD and AIFRERM Agency
		Fugitive emissions from handling of construction material, storage as well as from		Construction and storage sites	During the construction period	Included in construction cost	Contractor	WRD and AIFRERM Agency

Activity	Environmental Issue/ Component	Remedial Measures	Legislative Requirement/ Framework	Approximate Location	Time Frame	Mitigation Cost (Rs.)	Institutional Responsibility	
							Implementation	Supervision
		transportation shall be taken care.						
		Dust Suppression by water sprinkling		Construction and storage sites	During the construction period	Included in construction cost	Contractor	WRD and AIFRERM Agency
		Monitoring of Ambient Air Quality		near sensitive locations/ human settlements near to construction sites, crushers and hotmix plants	During the construction period as per environmental monitoring plan	Included in the monitoring costs	WRD (Environmental Officer)	WRD and AIFRERM Agency
		Speed restriction, surface improvement and surface treatment shall be taken as options for control of emissions from unpaved roads.		Approach roads	During the construction period	Included in project cost	WRD	WRD and AIFRERM Agency
	Change in air quality due to traffic	Plantation along the embankment Turfing of the embankment slopes Regular maintenance of the road on the top of embankment as well as approach roads		Entire Project Area	Operation Phase	Included as part of regular Maintenance costs	WRD	WRD and AIFRERM Agency

Activity	Environmental Issue/ Component	Remedial Measures	Legislative Requirement/ Framework	Approximate Location	Time Frame	Mitigation Cost (Rs.)	Institutional Responsibility	
							Implementation	Supervision
Noise	Increase in sound pressure levels due to construction machineries, vehicles etc.	Options of noise control by site controls, scheduling of project activities	Noise Pollution (Regulation and Control) Rules, 2000 and amendments thereof	At all construction sites	During the construction period	Included in engineering cost	Contractor	WRD and AIFRERM Agency
		Protection devices (ear plugs or ear muffs) to be provided to the workers operating in the vicinity of high noise generating machines.		At all construction sites of high noise intensities	During the construction period	Part of Contractor Obligation	Contractor	WRD and AIFRERM Agency
		Construction equipments and machinery shall be fitted with silencers and maintained accordingly.		Construction sites	At the start of construction activity and also during the construction phase	Included in construction cost	Contractor	WRD and AIFRERM Agency
		Construction of temporary noise barriers near the sensitive areas, e.g. schools		At identified sensitive locations near the construction sites	Before start of construction activities near sensitive locations	Included in construction cost	Contractor	WRD and AIFRERM Agency
		Noise and vibration level monitoring as per monitoring plan.		As per monitoring plan	Once in every year	Included under Monitoring Costs	WRD	WRD and AIFRERM Agency
	Increase in sound pressure levels due to traffic	Adequate signage to restrict use of pressure horns particularly in noise sensitive locations Tree barriers between						WRD and AIFRERM Agency

Activity	Environmental Issue/ Component	Remedial Measures	Legislative Requirement/ Framework	Approximate Location	Time Frame	Mitigation Cost (Rs.)	Institutional Responsibility	
							Implementation	Supervision
		the road and village/ semi urban/ and urban areas						
Disturbance to vegetation	Cutting of trees in core zone during project intervention	Minimization of tree cutting while designing the embankment		Entire project site	During complete construction phase	--	Engineering Team	WRD and AIFRERM Agency
		Compensatory tree plantation preferably on the basis of 3 trees plantation against each tree cut		Entire project site and nearby areas	Starting from construction phase	Already indicated above	WRD	WRD and AIFRERM Agency
Animal distribution/ migratory route Endangered Species	Impact on Dolphin breeding sites No Adverse Impact of Endangered Species	Construction activities shall be restricted during Dolphin breeding period (May to August) at breeding sites. Due to sensitivity of Dolphins with polluted water, construction waste should not dumped near the river bank		Identified breeding sites	During construction phase		WRD	WRD and AIFRERM Agency
Fishing activities/ productivity, Migratory Route	Impact on boat ghats. No Migratory Route near the embankment	Adequate provision shall be made in the design to ensure access to the fish landing sites/ boat ghats		12 boatghats identified along the reach	During construction phase itself	Included in engineering design cost	Contractor	WRD and AIFRERM Agency

Activity	Environmental Issue/ Component	Remedial Measures	Legislative Requirement/ Framework	Approximate Location	Time Frame	Mitigation Cost (Rs.)	Institutional Responsibility	
							Implementation	Supervision
	Temporary flushing of fish species towards deeper parts of the river	Undisturbed movement of the fishermen shall be provided		Along the riverbank	During construction phase itself	Included in engineering cost	WRD (Environmental Division)	WRD and AIFRERM Agency
Spawning and Breeding Grounds/Pond Fisheries	Disturbance on breeding and spawning grounds. No Adverse Impact on Pond Fisheries	Restriction of construction activities near the identified breeding and spawning grounds during the breeding period of April to august Fish productivity can be improved substantial with use of better fish culture and increasing the capacity of fish ponds		At identified spawning and breeding grounds	During April to august in construction phase	--	Contractor	WRD and AIFRERM Agency
Wetlands/ beels	Positive impact	Due to various institutional measures proposed		Project Benefit Area	Operation Phase	--	WRD	WRD and AIFRERM Agency
Habitat fragmentation	Inappropriate opening of the sluice gate	Appropriate management to be made for the operation of the sluice gates		Project Benefit Area	Operation Phase	--	WRD	WRD and AIFRERM Agency
Demography	Pressure on natural resources due to establishment of construction camps	Construction camps shall be supported with all basic amenities such as drinking water, fuel, sanitation facilities etc.		Construction camps	During construction phase	Included in construction cost	Contractor	WRD and AIFRERM Agency

Activity	Environmental Issue/ Component	Remedial Measures	Legislative Requirement/ Framework	Approximate Location	Time Frame	Mitigation Cost (Rs.)	Institutional Responsibility	
							Implementation	Supervision
Establishments	Impact on houses and establishments near core zone	Efforts shall be made to prevent any relocation or demolition		Near embankment sites	During construction phase	Included in R&R Cost	Contractor	WRD and AIFRERM Agency
		Social infrastructure shall be rehabilitated with social and cultural values		Near embankment sites	During construction phase	Included in construction Costs	WRD	WRD and AIFRERM Agency
		Temporary noise barriers shall be installed close to schools and places of worship		Near identified sensitive sites	During construction phase	Included in construction Costs	WRD	WRD and AIFRERM Agency
		Thick plantation shall be made close to these establishments		Near identified sensitive sites and human settlements	During construction phase	Already included above	WRD	WRD and AIFRERM Agency
Socio-economic impact	Impact on fish landing sites	Training programmes for agriculture and fish production improvement		Project buffer zone	During construction phase	Already included above	WRD	WRD and AIFRERM Agency
		Appropriate provisions shall be made to provide alternate fish landing stations so that economic activities of the fishermen can not disturb during project intervention		Identified fish landing sites	During construction phase	Included in construction cost	Contractor/ WRD	WRD and AIFRERM Agency
Safety	Risk of accidents and safety due to narrow roads and encroachment of	Adequate lighting and fluorescent signage shall be provided at construction sites.		Construction sites and approach roads	During construction phase	Included in construction cost	Contractor	WRD and AIFRERM Agency

Activity	Environmental Issue/ Component	Remedial Measures	Legislative Requirement/ Framework	Approximate Location	Time Frame	Mitigation Cost (Rs.)	Institutional Responsibility	
							Implementation	Supervision
	people near construction areas	Signage in local language		Construction sites and approach roads	During construction phase	100,000	Contractor	WRD and AIFRERM Agency
		Setting up of speed limits and speed breakers		Construction sites and approach roads	During construction phase	50,000	Contractor	WRD and AIFRERM Agency
		Personal protective equipments for workers		At construction sites	During construction phase	Included in construction cost	Contractor	WRD and AIFRERM Agency
		Health check up camps for workers		At construction camps	During construction phase	6,00,000	WRD (Environmental Division)	WRD and AIFRERM Agency

APPENDIX 6.2. MITIGATION MEASURES IMPLEMENTATION SCHEDULE

Environmental Issue	EMP	Time line															
		Construction Phase					Operation Phase										
		1	2	3	4	5-6	1	2	3	4	5	6	7	8	9	10	11 -
Technical Support	Preparation of environmental guidelines																
Flora	Compensatory aforestation (minimum 1:3) (plantation and maintenance for one year)																
Agriculture	Technical support to farmers																
	Monitoring of cropping pattern																
Fisheries	Institutional support for productivity improvement for Wetland, beel, and pond fisheries																
	Monitoring of fisheries, breeding and spawning grounds																
	Maintenance and operation of sluice gates																
Drainage Congestion	Provision of adequate opening																
	Monitoring analysis of drainage congestion if any																
Hydrology and Morphology	River bank protection measures																
	Soil conservation																
	Monitoring of river erosion, water levels, and sediments																
Land	Compensation against land acquisition																
	Provision of access to riverbank near habitat areas, Construction of flood platforms																
	Rehabilitation of borrow areas																
Water & Drinking Water Supply	Installation of grease traps at construction sites																
	Construction of soak pits at construction sites																
	Monitoring of surface and ground water quality																
	Ensuring availability of arsenic free drinking water for construction camps																
Air Quality & Dust Management	Water spraying and watering																
	Monitoring of ambient air quality																
Work Safety	Provision of personal protective equipment																
Health Issues	Health checkup camps																
Tree & noise Barriers	Monitoring of tree felling and plantation																
	Maintenance of tree (additional two years)																
	Provision of additional tree plantation																
	Provision of noise barriers																
	Monitoring of noise and vibration																
Establishments	Construction stage																
Training	Environmental training and awareness																
MIS	Establishment and operation																

Legends

Critical

High priority

Environmental Issue	EMP	Time line															
		Construction Phase					Operation Phase										
		1	2	3	4	5-6	1	2	3	4	5	6	7	8	9	10	11 -

Medium priority

Low priority

APPENDIX 6.3. ENVIRONMENTAL MONITORING PLAN (EMOP)

Environmental Component	Project stage	Parameter	Standards	Location	Duration / Frequency	Cost (Rs.)	Implementation	Supervision
Terrestrial and aquatic fauna	Construction Stage	Surveillance Audit for status of fish species, their movement and breeding grounds	None specific	Near the identified spawning and breeding grounds along the reach	Prior to breeding season and during the breeding season (During construction stage)	200,000	Independent Fisheries Expert	WRD and AIFRERM Agency
	Operation Stage	Terrestrial and aquatic fauna status Benefit assessment of the support during the project as a whole	None Specific	Fish landing sites, breeding grounds and near the core zone of the embankment	First two years of construction	200,000	Independent Terrestrial and Aquatic Experts	WRD and AIFRERM Agency
Fisheries	Construction Stage	Fish productivity,	None Specific	Flood plains, beels, rivers and ponds	Once in a year throughout the construction phase	300,000	Survey by Fisheries Experts	WRD and AIFRERM Agency
	Operation Stage	Fish productivity	None Specific	Flood plains, beels, rivers and ponds	Once in a year	100,000	Survey by Fisheries Experts	WRD and AIFRERM Agency
Cropping Pattern	Construction and Operation Stage	Survey of existing cropping pattern and effect of change in cropping pattern in the impacted areas	None Specific	Construction areas, service areas, rehabilitation sites	Once during construction and once after six months of completion of project	Project Management Costs	Institutional support	WRD and AIFRERM Agency

Environmental Component	Project stage	Parameter	Standards	Location	Duration / Frequency	Cost (Rs.)	Implementation	Supervision
Air Quality	Construction Phase	SPM, RSPM, SO2, NOx, CO, Pb	National Ambient Air Quality Standards	With in 100 m of Hot mix plant, construction camp, crusher and near sensitive locations/ settlement	Continuous 24-hourly, twice a week, for two weeks once every year (summer)	750,000 (@RS 1,25,000/year for six year)	Independent Environmental Laboratories approved by SPCB/ MoEF	WRD and AIFRERM Agency
	Operation Phase	SPM, RSPM, SO2, NOx, CO, Pb	National Ambient Air Quality Standards	3 to 4 locations near the embankment sites	Continuous 24-hourly, twice a week, for one week, once in winter and Summer	50,000	Independent Environmental Laboratories approved by SPCB/ MoEF	WRD and AIFRERM Agency
Hydrology	All phases	Water level, discharge, river cross sections	Central W. Commiss-ion	As per CWC guidelines	As per CWC guidelines	Data and knowledge components	WRD	WRD and AIFRERM Agency
Morphology	All phases	Bank line profiles, sediment transport, velocity, float tracking	Same as above	Same as above	Same as above	Same as above	WRD	WRD and AIFRERM Agency
Surface Water Quality	Construction Stage	pH, BOD, COD, TDS , TSS, DO, Oil & Grease	As per CPCB Water Quality Criteria	Brahmaputra river and wetlands/ ponds	Once during the dry season.	300,000 (@ Rs 50,000/year for six year)	Independent Environmental Laboratories approved by SPCB/ MoEF	WRD and AIFRERM Agency
	Operation Phase	pH, BOD, COD, TDS , TSS, DO, Oil & Grease	As per IS 10500:1991	Brahmaputra river and wetlands/ ponds	Once during the dry season.	30,000	Independent Environmental Laboratories approved by SPCB/ MoEF	WRD and AIFRERM Agency

Environmental Component	Project stage	Parameter	Standards	Location	Duration / Frequency	Cost (Rs.)	Implementation	Supervision
Ground water and Drinking Water Quality	Construction Stage	pH, BOD,DO, total coliform, As, Cd, Mn and Ground Water levels	As per IS 10500:1991	Construction site, Rehabilitation site, service areas,	Once at the start of construction	30,000	Independent Environmental Laboratories approved by SPCB/ MoEF	WRD and AIFRERM Agency
	Operation Phase	pH, BOD,DO, total coliform, As, Cd, Mn and water levels	As per IS 10500:1991	Construction site, Rehabilitation site, service areas,	Once at the start of construction	30,000	Independent Environmental Laboratories approved by SPCB/ MoEF	WRD and AIFRERM Agency
Noise and Vibration	Construction Phase	Noise Level in dB (A)	As per National Standards for Noise	Near the construction sites and sensitive locations close to embankment	One day hourly measurement, once in six months	30,000	Independent Monitoring Agency	WRD and AIFRERM Agency
	Operation Phase	Noise Level in dB (A)	As per National Standards for Noise	Near the habitats close to embankment	One day hourly measurement at 3-4 locations once	10,000	Independent monitoring agency	WRD and AIFRERM Agency
Soil Erosion (inland erosion) and siltation	Construction Phase	Visual check for Soil erosion and siltation	--	River bank and River training Structure	After first precipitation	Part of routine action of engineering team	Engineering Team	WRD and AIFRERM Agency
	Operation Phase	Study of Soil erosion and siltation	--	River Training Structure, Up stream and Down Stream of the reach	Once during operation of 1st year	Part of routine action of Engineering Team	Engineering Team	WRD and AIFRERM Agency
Drainage Congestion	Construction Phase	Visual check	--	Project benefit area	After one year of construction.	Part of routine action of Engineering Team	Engineering Team	WRD and AIFRERM Agency

Environmental Component	Project stage	Parameter	Standards	Location	Duration / Frequency	Cost (Rs.)	Implementation	Supervision
	Operation Phase	Visual check	--	Project benefit area	Once during operation of 1st year	Part of routine action of Engineering Team	Engineering Team	WRD and AIFRERM Agency
River Hydrology, Morphology and Sediment Transport	Construction Phase	Scientific techniques applicable to the monitoring of these components	-	Entire sub-project area	Regular	Part of routine action of Engineering Team	Engineering Team	WRD and AIFRERM Agency
	Operation Phase	Scientific techniques applicable to the monitoring of these components	-	Entire sub-project area	Regular	Part of routine action of Engineering Team	Engineering Team	WRD and AIFRERM Agency
Tree Plantation	Operation Phase	Scientific techniques applicable to the monitoring of these components	-	Entire Sub-project area	Regular	Part of routine action of Engineering Team	Engineering Team	WRD and AIFRERM Agency

Environmental Component	Project stage	Parameter	Standards	Location	Duration / Frequency	Cost (Rs.)	Implementation	Supervision
	Operation Phase	Survival rate of trees success of re-plantation	The survival rate should be at least 70% below which re-plantation shall be done.	Entire stretch of the project reach	Every year for 3 years	300,000	WRD Field Officers with the help of Social Forestry Programme	WRD and AIFRERM Agency
Total Costs of monitoring construction stage						Rs22,10,000		
Total Costs of monitoring operation Stage						Rs7,20,000		
Transportation for sample collection, contingencies and other logistic support (Rs. 2,00,000 construction stage, and Rs 1,00,000 Operation stage)						Rs. 300,000		
Total cost of monitoring						Rs. 3,230,000		

APPENDIX 6.4. TRAINING[44]

No.	Target group	Subject(s)	Method	Time Frame
Planning, and Construction Phase[45]				
1	All WRD program staff	Environmental Overview: Environmental regulations and national standards, process of impact assessment and identification of mitigation measures, importance of EMP and monitoring, and monitoring methodology	Lectures (by consultants and local training institutes)	Before implementation of the program
2	Environmental engineers, field officers, contractors, supervision consultants	Implementation of EMPs: Basic features of an EMP, planning, designing and executing of environmental mitigation and enhancement measures, monitoring and evaluation of environmental conditions during construction and operation	Workshops and seminars (by consultants and trained PMU staff)	Before the construction begins
3	Environmental engineers, field officers, contractors, supervision consultants	Environmentally Sound Construction Practices:Soil conservation; vegetation protection; waste management and minimization in construction; pollution control at construction camps, construction sites, hot mix plants, and material transportation; devices and methods for construction sites and equipment; environmental clauses in contract documents and their implications; environmental monitoring during construction	Seminars, lectures and site visits (by consultants and trained PMU staff)	Before the construction begins
4	Environmental engineers, field officers, contractors, supervision consultants	Monitoring Environmental Performance during Construction: Monitoring air, water, soil erosion, noise, and their effect on vegetation and fisheries; evaluation and review of results; performance indicators and their applicability; possible corrective actions; reporting requirements and mechanisms	Lectures, workshop, and site visits (by consultants and trained PMU and SIO staff)	During initial phases of construction
5	Construction laborers	Waste Handling and Sanitation at Construction Sites and Construction Camps:	Workshops and signage (by consultants and trained SIO staff)	During initial phases of construction

[44] The training programs are to be conducted through in house trainers and hired consultants/professionals. The train the trainer mode delivery may also be considered for in house training capacity development.

[45] During construction phase training/awareness programs will be organised twice a year. During operational phase one workshop/awareness program should be organised every year for the first 3 years. This workshop should highlight the details of environmental condition monitored and tips for environmental protection.

No.	Target group	Subject(s)	Method	Time Frame
During Operation Phase				
6	Environmental engineers, field officers, contractors	Long-Term Environmental Issues in Program Management: Designing and implementing environmental surveys for ambient air, noise, biological, and water quality; data storage, retrieval, and analysis; contract documents and environmental clauses; risk assessment and management; contingency planning and management; and value addition	Workshops and seminars (by consultants and local trainint institutes	During implementation of the program
7	Farmers of the area program benefit area, fishers associated with beel and pond fisheries	Cropping Pattern and high yielding crop production techniques	Workshops and seminars (by consultants, and resource persons from research institutes and line departments)	Construction and operations phase
8	Public	Environmental protection awareness program	Workshops and seminars (by consultants and trained PMU and SIO staffs)	Construction and operations phase

EMP = environmental management plan, PMU = program management unit, SIO = subproject implementation office, WRD = Water Resources Department.
Source: Water Resources Department, State Government of Assam

APPENDIX 6.5. ENVIRONMENTAL BUDGET

Component	Item	Unit	Quantity	Rate	Amount (million Rs)
CONSTRUCTION STAGE					
Technical Support	Preparation of Environmental guidelines and performance indicators	Lumpsum	-	Rs 0.5 million	0.50
Flora	Clearing of plantation	km		Covered in engineering costs	
	Compensatory aforestation (Minimum 1:3) (Plantation and maintenance for one year)	No of tree	45000for Palasbari	Rs. 20 per sampling and RS 500 for maintenance	23.40
			6000 for Kaziranga	Rs. 20 per sampling and RS 500 for maintenance	3.12
			30,000 for Dibrugarh	Rs. 20 per sampling and RS 1500 for maintenance	15.60
	• Technical Institutional Support to farmers for change in cropping pattern and monitoring agriculture productivity	Lump sum		Included in the overall project management costs	
Fisheries	• Intuitional support for Improving fish productivity at wetlands/beel and pond fisheries.)	Rupees per /reach	3 reaches	Rs 1.0 million per reach	3.00
	• Monitoring of Fish Productivity	Rupees per /reach	3 reaches	Rs 0.4 million per reach	1.20
Drainage Congestion	• Provision of adequate opening	Covered in engineering cost			
Navigation	• Adequate lighting & Signals	Covered in engineering cost			
Erosion & Sedimentation	• River Bank Protection Measures	Covered in engineering cost			
Land	• Compensation against land acquisition and Development of Rehabilitation sites	Covered in R&R Budget			
Soil	• Maintenance cost in Soil Conservation	Covered in engineering cost			
Noise	• Provision for Noise Barriers	Covered in engineering cost			
Water	Installation of oil and grease traps at construction sites and Waste Water Collection & Disposal system	No	4 per reach for three reaches	0.080 million/system	0.96

Component	Item	Unit	Quantity	Rate	Amount (million Rs)
	Construction of soak pits at construction sites	No	4 per reach	Rs 0.090 million/soak pit	1.08
Dust Management during construction	Water Sprayer / Watering	Covered in Engineering cost			
Construction Safety	Accident risks in construction activity	Covered in Engineering cost/insurance			
	General Safety (provision of PPE like ear muffs, gloves etc.)	No of labour	Av. 1000 labourer/reach	Average 100/labour/year for construction period or six years	To be part of contractors costs
Health	Health check up camps for construction workers	camps	1camp/year/reach	Rs 0.1 million/camp for six years	1.80
Environmental Monitoring in the construction phase	Terrestrial and Aquatic Fauna including Fisheries	Cost as mentioned in monitoring plan. Monitoring Costs considered on an average same for each reach. (@ Rs 2.41 Million per reach for entire construction period)			7.23
	Cropping Pattern				
	Ambient air quality				
	Surface Water Quality				
	Ground Water /Drinking Water Quality				
	Noise & Vibration				
	Soil Erosion & Siltation				
	Drainage Congestion				
	Monitoring Tree Felling & Plantation				
		SUB TOTAL (CONSTRUCTION STAGE)			57.89
OPERATION STAGE					
Erosion Control and land scaping	Reserve Fund for Erosion Control and Embankment Protection.	Lump Sum p	- To be part of Regular maintenance and operation costs		-
Tree survival	Survivance monitoring and Provision of additional tree plantation	Lump sum	Costs towards survival monitoring are included in the Monitoring budget.		3.00
Monitoring of performance indicators	Terrestrial & Aquatic Fauna including Fisheries	Cost as mentioned in the Monitoring plan Monitoring Costs considered on an average same for each reach. (@ Rs 0.82 Million per reach for entire construction period)			2.46
	Ambient air quality				
	Surface Water Quality				
	Ground Water Quality & Levels				
	Noise & Vibration				

Component	Item	Unit	Quantity	Rate	Amount (million Rs)
	Soil Erosion & Siltation				
	Drainage Congestion				
	Monitoring Tree Plantation and Cropping Pattern				
		SUB TOTAL (OPERATION PHASE)			5.46
ESTABLISHMENT & TRAINING					
Establishment	Construction Stage	Per son month s	12	Rs 75,000 per person month + plus expert advise support lumpsum Rs 1.0 Million	1.90
	Operation Stage	Per son Month s	15	Rs 75,000 per person month (@ 2 person month for five years and one person months for additional five year) plus additional experts support lumpsum Rs 0.5 million	1.60
Training	Environmental training & awareness	Lump sum	As per training details	-	3.00
Management Information System		Lump sum	-	-	1.00
Subtotal (Establishment & Training)					7.50
Subtotal (Construction, And Operation And Mobilization)					70.85
Contingencies @ 10 % on total environmental costs					7.09
Grand Total (in Rs)					77.94
Grand Total (in US$) (@ 1 US $ = Rs. 40.10)					US $1.94 Million

APPENDIX 2.1. SUMMARY OF PUBLIC CONSULTATION

Date	Name and Address of Persons Consulted	Topics of Discussion	Important Outcome
2/12/2007	Dr. A. K. Baruwa, Director Assam Science, Technology & Environment Council And Assam Energy Development Agency	1.Regarding any specific problem(s) related to environment as a result of flood & erosion of the Brahmaputra 2. If the proposed project will help in providing safety to the people , their property and environment of the area 3. Any significant negative impact of the project on the overall environment of the area 4. Possible impacts of the project on Agriculture,Wetlands, Drinking Water & Local Economy 5. Suggestion or comment on isssues other than those discussed so far	He has raised concern of leaching of arsenic into groundwater which is generally used for drinking water supply from the river bank filtration wells in the floodplains of Brahmaputra river and also asked about the possibility of integration of drinking water and irrigation projects.
3/12/2007	Mr. B. B. Hagier (IAS) Secretary of Environment and Forests, Government of Assam		He has pointed out requirement of study of impact downstream and upstream of the reach which can be affected after protection of the reach.
3/12/2007	Mrs. E. Choudhary (IAS) Principal Secretary Soil Conservation Government of Assam		She has raised the issues of bed level raising, seepage of embankment/ softening of embankment, erosion and increase in sedimentation as well as the requirement of catchments area treatment plan. She also revealed the requirement of soil conservation, study of earthquakes and its effect on siltation in the river.
2/12/2007	Mr. Biren Thukuria EE, WRD		He has highlighted the importance of study for impact on fish productivity due to reduced siltation, which can emerge as a benefit to local fishermen.
25/04/2008	Dr. Rafiqua Ahmed State Pollution Control Board, Assam		She has highlighted the problem of water contamination in some parts of the Brahmaputra river valley. She was also asked for the pollution problems in the sub-project reaches.
3/12/2007	Mr. Md. Allauddin Department of Minority Welfare		Most of the chars in Brahmaputra are semi-permanent and as per their record there are 2,251 char villages. Drinking water is mainly supplied from the hand pumps and tubewells. The department also supports in the form of seed distribution, construction of raised platforms with and without sheds, repairing of schools, vocational training to local villagers
19/5/2008	Chief Conservatory of Forests	Related to tree cutting, aforestation programme etc.	Prior permission is needed from the Chief Conservator of Forests (Wildlife) for cutting of trees within the boundary demarcated as wildlife sanctuaries and national parks. If land is outside the

Date	Name and Address of Persons Consulted	Topics of Discussion	Important Outcome
			protected areas, then the permission is not necessary from CCF or Forest Department. However, aforestation is needed if there is any loss of tree species during project intervention. At least three plants must be planted in place of one such tree cut during project intervention. For afforestration programme, bamboo, simul trees and banana plants must be planted along the side of embankment. These trees have no side roots to destroy the embankments. Again in the borrowing sites water resistant plants such as Salix tetrasperma, Buwal and Pani hizol should be planted.
3/3/2008	Dr. B. K. Talukdar Co-chair (South Asia) IUCN-SSC Asian Rhino Specialist Group	1.Regarding any specific problem(s) related to environment as a result of flood & erosion of the Brahmaputra 2. If the proposed project will help in providing safety to the people , their property and environment of the area 3. Any significant negative impact of the project on the overall environment of the area 4. Possible impacts of the project on Agriculture,Wetlands, Drinking Water & Local Economy 5. Suggestion or comment on isssues other than those discussed so far	All the NGOs' consulted had welcomed the flood control project and said that it will help in protection of agricultural land, domestic animals, fishermen communities etc. They also highlighted the importance of maintaining the natural drainage along the project sites. The NGOs during interaction also highlighted the relief work they are carrying out during the flood situations. They also suggested increasing forest cover through afferoestation programme. Dr Sanjay Hazarika also indicated the need of enhancing institutional capacity and strengthening review mechanism. Prevent any change to natural drainage. Consider provision of alternate platform then only attached to embankment for use by Animals and people during flood and protection of the fish spawning grounds during construction and operation.
5/3/2008	Mr. Mintu Handique & Mr. Gaurav Borgohain, Carrier Care Group		
10/3/2008	Mr. Sanjay Hazarika CE-NES		
18/02/2008	Santi Das Late Saruram Das Pub-Dharapur Jongrabari	1.Problem(s) related to environment as a result of flood and erosion of the Brahmaputra 2. Whether the proposed project will help in providing safety to the people , their property and environment of the area	The project sounds very good. But it depends on how soon and how good the work is done. It should not affect the local people while under construction. The sand mining from the river bed upstream near Majirgaon is affecting the Palasbari area downstream. This must be stopped. The project should be helpful in getting benefits from the river and to save the people from its fury.
	Ananta Das Pub-Dharapur Jongrabari		
	Prabhat Das Pub-Dharapur		

Date	Name and Address of Persons Consulted	Topics of Discussion	Important Outcome
	Jhongrabari	3. Any significant negative impact of the project on the overall environment of the area 4. Possible impacts of the project on Agriculture, Wetlands, Drinking Water and Local Economy 5. Suggestion or comment on isssues other than those discussed so far	Dolphins come to river mouth of zero point during summer and move upto the sluice gate. Also various types of turtles, snakes also come near to these points during the monsoon season. The overall project will be helpful in protection of land from bank erosion. No negative impact is anticipated.
24/02/08	Monaj Das, Khanajan, Dharapur Baladev Baishya, Dharapur Biren Kashyap, Palasbari ghat. Bhagaban Sharma, Gumi Piyar Mohammad, Zahirpar, Boko. Abdul Kader, Kalidas beel, Bejisuta, Chaygaon. Abul Ali, Bejisuta, Chaygaon Kameswar Das, Sontali Rahim Dewan, Nagarbera	1.Problem(s) related to environment as a result of flood and erosion of the Brahmaputra 2. Whether the proposed project will help in providing safety to the people , their property and environment of the area 3. Any significant negative impact of the project on the overall environment of the area 4. Possible impacts of the project on Agriculture, Wetlands, Drinking Water and Local Economy 5. Suggestion or comment on isssues other than those discussed so far	Once the protection is provided permanently against flood and erosion, the region will prosper. No negative impact is anticipated. Only worry is flood and erosion and hence needs permanent solution. However, this will depend on how well and soon it is done. No adverse impact cited. Protection against erosion and flood is essential. The ghat facility and environment around it should be improved. The sluice gate at Palasbari should be improved. The project will help in saving the area from hazards of erosion and flood. No adverse impact foresees. However quick compensation and early start is required. Cautions about quality of work and proper maintenance shall be taken. If protected, the area will prosper immensely. No negative effect perceived. No negative effect perceived. The Deepar beel needs to be developed. Area should be protected. Safeguard from flood and erosion is the most important issue. Lots of scope for improvement of fishery productivity and crops is there. Protection from the Brahmaputra hazards means more progress for the area. The work should start without any delay. The project affected people should be compensated quickly. Embankment needs to be strengthened and river bank shall be protected.
31/3/2008	Sarat Das Majir Gaon Sabitri Das	1.Problem(s) related to environment as a result of flood and erosion of the Brahmaputra	Permanent protection required. The project should be taken up. Any compensation due should be paid before the work starts.

Date	Name and Address of Persons Consulted	Topics of Discussion	Important Outcome
	Majir Gaon	2. Whether the proposed project will help in providing safety to the people , their property and environment of the area 3. Any significant negative impact of the project on the overall environment of the area 4. Possible impacts of the project on Agriculture, Wetlands, Drinking Water and Local Economy 5. Suggestion or comment on isssues other than those discussed so far	Local people should be benefited from the work. The construction activities should not create any problem for them. People need the river and its various resources. Only people should be protected from its erosion hazards. The project sounds good but we want that it will not affect us adversely in any way Safety from flood and erosion is vital for the survival of people. The work should be carried out with due care and based on urgent requirement.
	Gunoma Das Majir Gaon		
	Tiloma Das Majir Gaon		
	Manoj Bharali 2 No. Palasbari		
	Rajen Bharali 2 No. Palasbari		
	Nayan Das 2 No. Palasbari		
	Vivek Kakati Dhuptala Bazaar,		
	Mr. Chandra Das Dharapur ,Johrupuri		
	Sahadeb Baishya Dharapur		
	Santi Das Dharapur		

The three state-level workshop materials are available in the following website.

1st Workshop (1 December 2007 at Administrative Staff College of India, Guwahati)
http://www.adb.org/Documents/Reports/Consultant/38412-IND/38412-IND-TACR.pdf

2nd Workshop (25 June 2008 at the Institute of Engineers Conference Hall, Guwahati)
http://www.adb.org/Documents/Reports/Consultant/38412-IND/38412-01-IND-TACR.pdf

3rd Workshop (4 February 2009 at Brahmaputra Hotel, Guwahati)
http://www.adb.org/Documents/Reports/Consultant/38412-IND/38412-02-IND-TACR.pdf

PHOTO DOCUMENTATION (PLATES)

Plate 1: Erosion at Gumi

Plate 2: Interaction With local people


Plate 3: Interaction With local people


Plate 4: Bamboo Vegetation along the Embankment

Plate 5: Bamboo Vegetation along the Embankament

Plate 6: Kalidas Beel close to River