Resilient River Basin

The Landscape Planning of Jamuna River Basin

ARCH 226: Landscape Planning Studio
Department of Urban and Regional Planning
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ARCH 226
LANDSCAPE PLANNING STUDIO

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Abstract

Bangladesh has unique hydrological setting and deltaic floodplain which is jointy formed by the world's major rivers namely the Ganga(Padma), Brahmaputra(Jamuna), Meghna river.This study analyzes the basin of the Jamuna, the largest braided rivers in terms of topography,hydrology, geology, biodiversity, infrastructure to understand the interactions and complexity between human and nature.

To preserve the ecological resources, conserving the biodiversity of the study area, landscape planning is incorporated. One approaches have emerged to define landscape when the definitions of landscape are evaluated. The approach considers landscape as an ecological unit. The changes and decesion making in planning strategies are taken in such a way that the monetary loss and gain of planning will be calculated as an ecological unit.

This study resolves the problems of the river basin under specific aspects such as nature conservation, land use, Transportation, ecology and energy. It has been found that the issues are interlinked to each other and impacting the nature and ecology of that area. The existing embankment, infrastructure on floodplain, industrial pollution, settlement pattern,energy consumptions are the key issues which directly and indirectly affecting the environment. Considering those parameters, strategies are taken step by step yearly.

The study has been found to face some challenges implementing the planning strategies. On the other hand, these strategies induced great positive impact on social, economic and environmental priorities. Overall, the findings from the study can shed light on the river basin planning and ecological adption. The study will enhance further research in this related field.

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Background

Bangladesh is located at the lower parts of the basins of the Ganges, the Brahmaputra, and the Meghna with only 7% of the total area lying within the country. There are 57 rivers, which originate outside the boundary of Bangladesh. About 1.18 trillion cubic meters of water flows annually to the sea, of which 1.07 trillion cubic meters or 91 percent enters Bangladesh from upstream basins (principally from the three major basins), and the rest are contributed by total internal rainfall (Rashid 1991). As a result, Bangladesh has been shaped by and is dependent upon these three mighty rivers and their innumerable tributaries and distributaries. The rivers provide fertile soils and a diverse flora and aquaculture to millions of people in their floodplains, but also bring significant flood hazard and risk to infrastructure for a large & growing population.

Brahmaputra-Jamuna river basin is the principal arm of the Ganges-Brahmaputra-Meghna (GBM) river system of Bangladesh. The Brahmaputra River originates in the Tibetan plateau and runs on the northern side of the Himalaya before flowing into Bangladesh (Fig. 1). After crossing the Assam valley, the Brahmaputra finally enters Bangladesh through Lalmanirhat District of northern Bangladesh. The river is joined by one of the largest tributaries, the Teesta River (or Tista) at Bahadurabad (Dewanganj upazilla of Jamalpur district). From the confluence point of the Teesta and Brahmaputra, the river once again changes its name. It is then known as Jamuna. Many small tributaries join the Jamuna inside Bangladesh like the Korotoya and Atrai. The Brahmaputra River flows across the plains of Bangladesh for 337 kilometres before joining the Ganges, at Goalanda (Sarma,2005). Brahmaputra-Jamuna, and Old Brahmaputra, with their main tributary Teesta, and a good number of small tributaries and distributaries constitute the largest floodplain of Bangladesh. Excepting for a small portion in the north, the entire floodplain lies within the Pleistocene terrace regions. In the plains of Bangladesh, Brahmaputra flows in a highly braided channel with some well-defined nodal points where the river is narrow and restricted by nodal point (Alam et al,2007).

Brahmaputra-Jamuna river basin is an extremely complex system made up of an intricate web of rivers that flow through different hydro-ecological regimes, housing many ethnic groups and endemic species, flora and fauna as the river basin provide a multitude of services such as water supply, waste assimilation, fisheries, energy production, flood attenuation, spiritual, cultural and recreational benefits, and the habitat that supports a wide range of ecosystems. It is precisely because river basin provide so many functions that planning for their use is so complex. The demands on rivers increasingly exceed their natural capabilities, resulting in over- abstraction, pollution, floodplain alteration and habitat destruction. These failures are usually the consequence of poor decision-making, inadequate management and inappropriate planning. Effective landscape planning can be the starting point for sustainable management of river basins which will not just meet straightforward, externally set objectives, but to choose from a series of possible river basin management objectives that will best contribute to a range of competing economic, social and ecological goals.

Image Source: https://www.researchgate.net/publication/306523432

About 200 km

Figure: Brahmaputro Jamuna River Basin

Rationale

The Brahmaputra River basin presents a picture of an economically prized, and environmentally dynamic fluvial system. Spanning over vast expanses of diverse topographical and climatic regimes, the basin is often perceived as an important engine of regional economic development, a crucial base of livelihood resources, and a site of biodiversity conservation, cultural and recreational benefits. With a large population dependent on agriculture and natural resources for their livelihood, there is a great need to conserve its resources in a sustainable manner. Guided by traditional engineering, quite a large number of structural inventions are being made or planned in the basin with little recognition of the ecological, social, economic and cultural benefits of allowing water to flow freely. River basin development is therefore often seen as an important strategy for lifting up economy -notably ecological preservation and restoration-have been absent from development schemes. The expansion of infrastructure and economic development has resulted in an increase in the intensity of flood damage, the change of free flow of the river, pollution, the destruction of ecosystems and the extinction of wildlife in the river basin.

The study has been conducted to manage the natural resources of Brahmaputra-Jamuna river basin and their users in order to identify and satisfy social, economic and environmental priorities. Moreover, it has focused on the following criteria which will make the landscape planning more sustainable for future:

1. Trade-offs between alternative economic, social and environmental objectives, and between existing and potential future demands.
2. A sophisticated approach to recognizing environmental water needs and the importance of aquatic ecosystem functioning in providing goods and services
3. Understanding basin interactions, including the range of hydrological, ecological, social and economic systems and activities at work within a basin.
4. Prioritization, to identify which of many demand are the key needs for economic development, social justice and environmental protection.

Objective of the Project

Landscape planning takes into account the interconnection of human habitats, living environments, and natural areas. It is concerned with the planning of different land uses, public places, as well as environmental, social, and political issues. Protecting natural resources and the environment, as well as managing lands in a sustainable manner, is critical for both established and developing an area. Landscape planning places considerable emphasis on ecological footprint as well as a multi-disciplinary approach to analysis and planning. Landscape planning has been incorporated in the selected site of Jamuna river basin in order to:

1. To analyze the existing planning scheme of the site and its impact on ecology.
2. To identify key issues of the site and propose strategies.
3. To guide future planning strategies through landscape planning for conserving the environment and biodiversity.

Limitations

There are a number of limitations in the study that should be considered as caveats. Firstly, the study is fully reliant on secondary sources for collecting data and information. There was no scope for conducting physical survey due to time and cost constraint. Google earth pro software has been used for viewing the site and creating necessary maps for the research purpose. As google earth pro can't provide high resolution images, some of the features of the selected site could not be identified which was necessary for mapping the site. Moreover, the exact uses of some of the lands could not be identified. Secondly, another limitation is that not to get access to some of the thesis papers, journal articles, reports which could come out very helpful for the study. Thirdly, as a small portion of Brahmaputra-Jamuna river basin has been selected as the study area, collecting exact information of that particular site was difficult, because in google, only the information about Brahmaputra- Jamuna river basin is available, instead of that particular portion of the river basin.

Methodology-Phases

01 Site Selection

02 Mapping

03 SWOT Analysis

04 Literature Review

05 Case Study

06 Regeneration of Strategies

07 Proposal of Planning Strategies

Site Selection

Our study area is Brahmaputro-Jamuna river basin for the project. Initially, we have selected a twenty five sq. kilometres area by the jamuna river basin. From google earth pro, we have selected an area of 5km by 5km for our project. The selected site is located at Pogaldigha ward, Sarishabari upa-zilla under Jamalpur district.

BANGLADESH

Image Source: GOOGLE EARTH PRO

JAMUNA RIVER BASIN

Image Source: GOOGLE EARTH PRO

SELECTED SITE OF THE JAMUNA RIVER BASIN

Image Source: GOOGLE EARTH PRO

Site Description

Geographical location and characteristics of the study area

A 5*5 rectangular area has been selected from Brahmaputra-Jamuna river basin of Bangladesh as study area. The area is located at Pogoldigha union, which is under the Sarishabari upazilla of Jamalpur district. A small portion of Jamuna river has been flowing from north-east to south-west through the western part of the area. The area enjoys a humid, warm, tropical climate. This area's annual average temperature ranges from a maximum of 33.3 degree Celsius to a minimum of 12 degree Celsius (BBS,2011). There is significantly less rainfall in winter than there is summer. This area receives an average of 1963nmillimetres of rainfall every year. The area has approximately a population of 20275 people with a population density 811 people per square kilometer. The lives of many citizens of this site are reliant on the rivers. The site's rural economy relies upon annual " normal floods* to bring moisture and fresh sediments to the floodplain soils. For instance, two of the three seasonal rice varieties, (Aus and Aman) cannot survive without water and the fish caught both on the floodplain during flood season and ponds provide the main source of protein for many rural populations of the site. The study area has comparative advantage in terms of abundant agriculture and livestock resources along with extensive presence of low cost manpower. The government has strategically proposed an economic zone in the area in order to utilize this resource potential of the area and other neighboring district to boost the economic development in this region. However, the effect of "abnormal" floods become devastating and result in appreciable damage to crops and houses, severe bank erosion with consequent loss of homesteads, schools and land, and loss of human lives, livestock and fisheries.

Mapping

One of the most important tools for landscape planning is maps. Not only is mapping one of the most prominent ways to describe the landscape characteristics of a site, but it is also often the only way to get a wider view of the location. The comprehensive study on Jamuna river basin was completed in a sequential manner with the preparation of maps and sections, . To learn more about the natural characteristics of Jamuna river basin and how they influence and complement each other, these maps were created considering six aspects of the chosen site of Jamuna river basin. These maps were created to understand the current landscape features based on topography, geology, hydrology, biodiversity (flora and fauna), current infrastructure including road network, drainage, electric line, gas line and human-induced settlement, livelihood opportunities, and other factors. All the maps were drawn by using the software AutoCad and Adobe Illustrator.

SWOT Analysis of the Site

The strength of our site is the floodplain beside jamuna river basin. The benefits of the floodplain are: fish and wildlife habitat protection, natural flood and erosion control, surface water quality maintenance, ground water recharge, biological productivity, and also, high quality recreational oppurtunities such as fishing, bird watching, boating.

STRENGTHS

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THREATS

Literature Review

City Planning Concept: Garden City

Analyzing established planning theory in the context of urban planning is a necessary step in moving forward with landscape planning. To have a better knowledge of how planning theory and its principles helps to design a region, a detailed analysis of "Garden City" concept has been carried out. At the same time, to check whether the garden city concept could be applied in the study area, the detailed review of the concept has been showed. In 1898, Ebenezer Howard initiated the 'Garden City Movement in the United Kingdom. Howard's plan for garden cities was a response to the need for improvement in the quality of urban life, which had become marred by overcrowding and congestion due to uncontrolled growth since the Industrial Revolution.

The Garden City Movement

The Garden City movement, which began as a response to the congested, polluted circumstances in turn-of-the-century London and other industrial towns, proposes an idealized planned city that combines elements of town and country. Ebenezer Howard initiated the 'Garden City Movement' in the United Kingdom in 1898.

Garden City Concept

Howard's solution to the related problems of rural depopulation and the runaway growth of great towns and cities was the creation of a series of small, planned cities that would combine the amenities of urban life with the ready access to nature typical of rural environments.

01 The merits and demerits of both town and countryside.

02 The vitality of towns into the life of the countryside.

03 Incorporating the advantages of town and country life.

04 Make the countryside more attractive to future residents and investors.

The Three Magnets Proposed by Ebenezer Howard

Garden City Concept

The garden city described herein is the garden city model Howard portrayed in his book. A true Garden City on an actual site would be different from the one he describes.

City Layout: Garden City is built in the center of a 6,000 acres' land, and the whole city covers about 1,000 acres. In the city center, there is a 5.5-acre circular garden and public buildings like city halls, public library, lecture hall, theatre and museum surround the garden. On the outer ring, there is another public park called the Central Park, that covers a 145-acre area. In this park, there is laid a landmark building "the crystal palace," it is a commercial center for local businessman and retailers. In addition, the crystal palace can be used as shelter during the rainy season in regards to London's weather. On the outer ring, there are residential areas, where affordable housing is laid facing the city parks.

Park, Green Spaces and Green Belts: Parks and green spaces are highly recommended in Howard's Garden City. Parks, buildings, and roads make up the city structure. A 5.5-acre park is located in the center of the city, and on the outside ring, there is another 145-acre central park that separates the public administrative areas from the residential areas. The central park serves as a gathering place, where people can trade with each other and carry out other outdoor activities. On the further outside circle, Grand Avenue separates the inner town areas which are mainly for people to meet and live, from the outer town areas which are for manufacturing and railways. The Grand Avenue also provides an additional 115- acre green space. The parks built along Grand Avenue can be seen as the prototype of today's Green Belts. Grand Avenue serves as a visual boundary that keeps the smoke and noise from the manufacturing areas away from people and their living spaces.

The Layout of Garden City Cocept Proposed by Ebenezer Howard

Diagram 01

Diagram 02

Garden City Concept

Traffic System : The principle of the traffic design in Garden City is to encourage pedestrians and limit the use of auto cars in the inner city, and create a convenient railway system for business and commerce.

Circular Network System of Garden City

Boulevards

There are six magnificent boulevards—each 120 feet wide—beginning at the center of the city and extending to the circumference. There are multiple concentric ring avenues going around the city. At the outskirt of town, the 420-feet wide Grand Avenue is the main arterial for the city. Railways connect Garden City with other cities.

The Layout of Boulevards

Garden City Concept

Resident's life: Work and Recreation : Residents of Garden City enjoy the freedom to participate in various trades and occupations. The free market allows people to own their own business, lease their land, and dispense their produce to whomever they desire. The people engaging in agriculture can sell their products to people living inside the town, and also sell to potential customers overseas. The convenient traffic systems are built to support city residents' businesses. City dwellers live in well-built houses facing the boulevards and city parks. The residential areas are designed to be compact but satisfying: they come in different architectural styles with kitchens and gardens. Street lines are compatible with the surrounding environments. Along and on the outer skirts of Grand Avenue, there are playgrounds, gardens, churches, and schools designated to enrich people's lives. On the fringes of the Garden City, there are factories, warehouses, dairies, coal yards, timber yards, etc. Their location on the outer circle of the city makes it is earlier to load and unload.

Application of Garden City in Chengdu City

Chengdu, is the capital of Sichuan Province in Southwest China and is located at the western edge of the Sichuan Basin and sits on the Chengdu Plain. Chengdu's garden city project is based on the regional development concept. It is not restricted to city core areas but extends to the urban areas on the fringes. Like Howard suggested in his garden city idea, each garden city is restricted with limited population and size. When growth continues, there can be form city group. Chengdu adopted the development mode that takes Chengdu main urban districts as the center, and incorporating with cities around. The form of the urban and rural space layout is multi-centers, urban clusters and networking traffic system.

Howard's Garden City and Chengdu's Garden City have shared goals: 1) To preserve the natural environment and to create a garden-like living and working environment. 2) To accelerate social justice 3) To integrate urban and rural development.

Locational Map of Chengdu

Source: https://www.researchgate.net/publication/306523432

Adaptation of Howard's Garden City: A number of cities surrounding a central garden city

Application of Garden City in Chengdu City

Chengdu's urban build-ups moved out of the core of the city along railways, highways. Urban build-ups radiated out from the city like spokes on a wheel. The city is not restricted to city core areas but extends to the urban areas on the fringes. Chengdu's garden city project principles: Garden-like city form, Internationally functioning city, Modern industry system, Stable society, Harmony between man and nature, Infrastructure: comprehensive and function as a whole. Chengdu's traffic system covers whole western areas and radiating to the whole nation. There is a network road system between city centers with the surrounding counties in the city as well as effective and high-functioning subway system

City Center, Six Radial Boulevards, Green Belt

Chengdu Greenway Layout

Chengdu's Traffic System

Case Study

Nanjing City: A Planned City Development beside River

We have studied the master plan of Nanjing city which helped us in understanding how a city grows beside river conserving the natural environment and ecology. Nanjing, capital of China's eastern Jiangsu province, is roughly 300km up the Yangtze River from the city of Shanghai. The key findings from the master plan of Nanjing city: 1) Regional coordination, urban– rural interactions and harmonious development, 2) Compact development in metropolitan, 3) Development groups segregated by metropolitan green land, 4) Enhance the comprehensive function of three new urban districts as future modern centres, 5) Greenspace planning based on landscape ecology principles, 6)A star-shaped configuration of the city–countryside interface with a curvilinear and convoluted outline that provides a long contact boundary and generous penetration of nature into urban areas, 7) Four urban development fingers at the metropolis scale, 8) Six green corridors that link the current and planned clustered development areas at the city scale.

CHINA

JIANGSU PROVINCE

NANJING

NANJING METROPLOTAN CITY

Case Study

Nanjing City: A Planned City Development beside River

URBAN FORM OF EXPANSION OF NANJING

Grid iron of compact core and Five primary green wedges at the metropolis scale

Six green corridors

Four urban development fingers at the metropolis scale

Treets with existing large mature trees and roadside amenity strip

Case Study

Nanjing City: A Planned City Development beside River

From the master plan of Nanjing, we have incorporated some strategies in the planning scheme of our selected site:
1) Urban development fingers to conserve green space, 2) Compact grid iron settlement pattern, 3) Green network along roads, 4) Green space planning based on landscape ecology principles

PRPOSED MAJOR GREEN WAYS OF NANJING

HUMAN SETTLEMENT OF NANJING METROPOLITAN AREA

Industrial Area

Grid Iron pattern in Residential Areas

Regeneration of Planning Strategies

We have done comprehensive study of our site and identified the key issues which affects the ecology. addressing the existing issues, we have prepared planning strategies for the site. Our proposed strategies has been reviewed by our supervisors and externals. We have evaluated and changed the strategies many times before proposing the final planning scheme for the site.

Proposal of Planning strategies

We have proposed ecology based planning strategies for the site incorporating landscape planning with existing situation. The planning scheme includes three phase planning within 30 years:

- Short term plan: 2021-2025 (5 years)
- Middle term plan: 2026-2035 (10 years)
- Long term plan: 2036-2050(15 years)

We have proposed the planning strategies under five planning aspects which include:

1. Nature Consrvation
2. Ecology
3. Transportation
4. Land use
5. Energy

03.COMPREHENSIVE STUDY

Topography

The site's topography map reveals that maximum area of the site is almost flat having very gentle slope. There are few high areas existed in the site. Distinct colors indicate different elevation value ranges within the research region, ranging from 0 to 30 meters (above mean sea level). The majority of the land in our research region is less than 20 meters above mean sea level. A tributary of the Jamuna River runs through the area. The floodplains are large, flat region of land located on each side of a river during its lower course. Both erosion and deposition contribute to the formation of the floodplain. Because the floodplains along the river have a lower elevation of 15 m, they are more susceptible to flooding during the monsoon. The sand dune on the site's southwest side has a very low elevation with only 10 meters above mean sea level. As a result, it is submerged beneath water during the wet season. The grounds on the northeast side of the site have a higher elevation of 15 to 20 meters. On the raised area on the river's east bank, there is located jamuna fertilizer industry. On the elevated areas, there are settlements and other developments located at the northwest site.

TOPOGRAPHICAL MAP OF THE SITE

Geology

Most of the land of the selected site consists of loamy soils and floodplain mainly consists of silt loamy soil. Loamy soils are a combination of sand, clay and silt particles. The clay and silt particles improve moisture retention while the sand minimizes compaction and improve drainage and infiltration of water and air. This is why, the area is considered to be ideal for growing crops. We have also studied the present condition of soil fertility of our selected site. Soil fertility does not mean only the status plant nutrients in the soil but it is the combination of soil physical properties such as soil texture, bulk density, aggregate stability; chemical properties such as pH, EC, CEC, plant nutrients; and biological properties such as soil organic carbon, microbial biomass carbon, microbial biomass nitrogen, soil biodiversity etc.

GEOLOGICAL MAP OF THE SITE

Geology

Soil Reaction (pH) Status

Most of the lands of the study area are slightly acidic. Continuous use of urea fertilizer and also the use of Sulphur as fertilizer is identified as the main cause of lowering of soil pH in the selected site. Soil acidification is affecting soil productivity and ultimately crop production of the study area.

SOIL REACTION pH STATUS MAP

Soil Organic Matter Status

Maximum lands of the study area contain very low level of organic matter. But soil organic matter is a key factor in maintaining long-term soil fertility since it is the reservoir of metabolic energy, which drives biological processes in nutrient availability. The unawareness of the farmers on incorporation of organic manures to their farm specially in vegetable farming may be reason of lowering the level of organic matter in the study area.

SOIL ORGANIC STATUS MAP

Geology

Phosphorus Status

Phosphorus is an essential macronutrient that plays important role in all crop biochemical processes such as photosynthesis, respiration, energy storage, transfer, cell division, cell enlargement and nitrogen fixation. Maximum lands of the site contain low amount of phosphorus. It may be because of increasing cropping intensity in the study area and decrease of soil pH which restricts phosphorus availability in soils.

PHOSPHORUS STATUS MAP

Potassium Status

Most of the lands of the study area contain low level of potassium. But Potassium is very necessary for crop production as it increases soil productivity and consequently increases root growth. Increasing cropping intensity and inadequate replenishment of potassium through fertilization can be the main reason for lowering the potassium level in soil.

POTASSIUM STATUS MAP

Geology

Sulfer Status

Most of the lands of the study area have high level of Sulphur which makes the soil of the study area very fertile for crop production as Sulphur is essential for the growth and development of all crops. It increases crop yields and improves production quality.

SULFER STATUS MAP

Zinc Status

Maximum lands of the study area contain very low level of zinc. It may be because of increasing cropping intensity and inadequate replenishment of zinc through fertilization. The inadequate supply of Zinc is reducing the crop yields of the study area because zinc acts as Zinc is plant micronutrient which is involved in many physiological functions.

ZINC STATUS MAP

Geology

Boron Status

Most of the lands of the selected site contain low level of Boron. The reduction of Boron content in soil is reducing the soil productivity of the study area and the reduction is occurring because of increasing cropping intensity and inadequate replenishment of boron through fertilization.

BORON STATUS MAP

Magnesium Status

Magnesium is present in chlorophyll which is the key for photosynthesis and is responsible for activating more plant enzymes than any other plant nutrient. Maximum land of the selected site has very high level of magnesium which is good for the site.

MAGNESIUM STATUS MAP

Geology

The Soil Section of the Site

After overall analysis about the soil fertility condition of the study area, it can be depicted that the soil's present nutrition condition is critical for ensuring adequate crop production in the study area as maximum chemical components of soil are not present in a satisfactory amount.

SOIL SECTION

Hydrology

In dry season, some of the water bodies from west and north-western part dries up. During wet season, floodplain is submerged due to over flow of river.

DRY SEASON

WET SEASON

Hydrology

Sectional exploration across the jamuna river and floodplain: Dry Season

Hydrology

Sectional exploration across the jamuna river and floodplain: Wet Season

Biodiversity and Ecology

Bio-diversity and ecology of an area is a good indicator for understanding a healthy habitat. The outstanding feature of the study area is its great diversity of flora and fauna and enormous variation in both vertical and horizontal distributions. But now-a-days, land-use change, pollution, resource exploitation have been a major threat to for destroying the biodiversity and ecology of the study area. A detail study has been conducted on the existing ecology and the wildlife diversity of

Flora Community

The flora species of the study area belongs to four communities, as shown in the map. The homestead cover is claimed to have the most diverse flora species. Azadirachta indica, Ziziphus mauritiana, Syzygium cumini, Moringa oleifera, Alstonia scholaris, Saraca asoka are some of the common trees that grow in homestead zone. Moreover, different kind of herbs and shrubs that are associated with homestead include Abroma Augustum, Calotropis Gigantea, Senna Alata, Catharanthus Roseus,Datura metel, Persicaria lapathiofolia etc. Mikania micrantha, Mimosa Pudica, Piper Longum, and Aristolochic indica are the dominant climber species in this part of the study area. Lagerstroemia speciosa, Dillenia Indica , Pongamia pinnata, Ficus Virens, Ficus racemosa, Barringtonia acutangul are the most common trees that grow naturally at the edge of the river. Only shrubs and herbs bloom abundantly in the floodplain. The most common shrub and herb species found in the floodplain are Typha domingensis, Saccaharum spontaneum, Arundo donax, Chrysopogon Zizanioides etc. All these are perennial grass, growing upto three meters in height, with spreading rhizomatous roots. Kans grass quickly colonizes exposed slit plains created each year by the retreating monsoon floods, forming almost pure stands on the lower portions of the floodplain. Thus, Kans grass help to reduce soil erosion in the floodplain. Last but not the least, the area is surrounded by agricultural crop species because of the availability of fertile land. Floods in Bangladesh many a times are considered highly productive. These floods are regarded as “normal” and bring potential moisture and fresh sediments to the floodplain to make the land fertile and increase agricultural productivity.

Identified plant commumnities

01
Floodplain

02
Water Edge

03
Homestead

DISTRIBUITON AREA OF FLORA COMMUNITY

Biodiversity: Flora Community

Floodplain

DISTRIBUITON AREA OF FLORA COMMUNITY IN FLOODPLAIN

Biodiversity: Flora Community

Water Edge

DISTRIBUITON AREA OF FLORA COMMUNITY IN WATER EDGE

Biodiversity: Flora Community

Homestead

DISTRIBUITON AREA OF FLORA COMMUNITY IN HOMESTEAD

Sectional exploration across the Jamuna river and floodplain

Biodiversity: Flora Community

Saccaharum spontaneum
Wild sugarcan
Kash

Chrysopogon Zizanioides
Vetiver grass
Binna Ghash

Typha domingensis
Southern caltail
Hogla

Crataeva nurvala
Three leaved caper
Borun

Arundo donax
Giant cane
Nolkhagra

Plants of Floodplain

Barringtonia Acutangula
Indian oak
Hijal

Pongamia Pinnata
Indian beech
Karoch

Ficus racemose
Joggodumur

Ipomoea fistulosa
Pink morning glory
Dholkolmi

Bombas ceiba
Red silk-cotton
Shimul

Plants of Water Edge

Averrhoa carambola
Carambola
Kamranga

Ziziphus mauritiana
Indian jujube
Boroi

Moringa oleifera
Drumstick tree
Shojna

Cassia fistula
Golden shower tree
Shonalu

Terminalia chebula
Chebulic myroban
Horitoki

Plants of Homestead

Vulnerable Plants

Sectional exploration across the Jamuna river and floodplain

Sectional exploration across human Induced settlements

Existing Agriculture

The agricultural land of the study area, has been divided into four types, as shown in map. The homestead vegetation has taken over a very small portion of agricultural land (15-20%) which is found mainly around the human habitats. Generally, different kind of fruit trees such as Jackfruit, banana, tetul, bangi, kodbel, latkol and vegetables are cultivated in homestead by the residents of surrounding houses.

Highland which is generally considered as the floodwater free area occupies 60-70% of the study area. Boro Dhan is the dominant crop of these highlands. In addition, AUS either alone or followed by early rabi crops is the usual practice of highland. Jute replaces aus on 10-25% of floodplain ridge soils (Soil survey of Jamalpur, 1967). Sugar-cane is grown naturally on these highlands. Jackfruits are also very common in highland. Other crops and vegetables of the highlands are maize, groundnut, mustard, black gram, potato, garlic etc.

Floodplain contains about 30-40% of the study area. Aus followed by transplants Aman is the major practice on shallowly flooded land followed by rabi crops on some soils. Mixed Aus and broadcast Aman or broadcast aman alone are widely grown on more deeply flooded land, and are often followed by rabi crops. Lastly, 5% of the land is occupied by sand dune where mainly pumpkin cultivation is practiced.

AGRICULTURAL MAP

Biodiversity: Fauna Community

TThe study area contains a variety of unique habitats of wild animals. This wildlife diversity increases the natural beauty as well as help to keep natural balance as they are important biotic component of the ecosystem. Many species of wild animals' act as an important biological pest control agent e.g., insectivore and rodentivore. However, environmental degradation has been occurring in the study area at a faster rate due to the rapid increase of human activities, interference to the wilderness areas, over exploitation, deforestation and natural calamities like soil erosion, flood, etc. Consequently, the existing fauna community in the study area are now in a vulnerable condition and many of them has already become extinct. It is necessary to have the baseline data of all information of wildlife of a habitat in order to make any management plan for their conservation. For this reason, a detail study has been conducted on wildlife diversity, status and their ecology in the study area.

The study area harbors a wide variety of mammals, reptiles, amphibians, fishes, and bird species. These species are distributed within the three communities of four different ecosystems. Through the following maps, their distribution zone has been illustrated.

Although the site has offered habitat for a variety of species, many of them are currently fragile or have become extinct in recent years. For instance, Dolphins and Gharials are one of the most unique and threatened species in the selected site. The damming and diversion of the rivers on which they depend are threatening their habitats. The illegal extraction of sand from the river bank is also destroying their nest habitats. Gharials often die after being caught in fishing nets. Despite being a protected species under the Bangladeshi law, river dolphins are also deliberately hunted for extracting oil from the dolphin's body.

Food web of three different ecological communities has also been studied to show how the extinction of any singe species can disrupt the whole ecosystem of the study area.

Geographical distribution of amphibians

The population of Bufo melanostictus showed the highest density and Rana cyanophlyctis showed the lowest density within the area (Rahman,2014). Of the amphibians, some species such as Bufo melanostictus, Rana alticola use aquatic and terrestrial habitats, some (Hoplobatrachus tigerinus, Microhyla ornate) on aquatic and semi-aquatic habitats like river, pond, ditches, wetland, water edge, etc. and other species (M. rubra, Euplyctis cyanophlyctis) on the terrestrial habitats like, bush, open place, human habitation, cultivated land, tall tree, hole, etc. for foraging, nesting and roosting activities.

GEOGRAPHICAL DISTRIBUTION OF AMPHIBIAN

Geographical distribution of reptilians

The most prevalent reptile species seen in the study area are the H. brookiie and Hemidactylus flaviviridis. Only three species of reptile (Xenochorphis piscator and Varanus bengalensis, and Gavialis gangeticus) use aquatic and terrestrial habitats, and maximum species such as Mabuya carinata, H. bowringii , Gekko gecko, V. flavescens etc use terrestrial habitats like bush open place, human habitation, cultivated land, tall tree, hole, etc. as feeding, nesting and roosting sites .

GEOGRAPHICAL DISTRIBUTION OF REPTILIA

Geographical distribution of mammalia

The geographical distribution of mammals within the study area is illustrated on this map. The population of Rattus rattus showed the highest density and Lepus nigricollis showed the lowest density in the study area (Rahman, 2014). A total of two species of mammals (Delphinus, and M. booduga) use aquatic and terrestrial habitats and fourteen species such as Canis aureus, Felis chaus, Tylonycteris pachypus, Calloscirus pygerythrus, Herpestes auropunctatus, Pipistrellus coromandra etc use terrestrial habitats like bush, open place, human habitation, cultivated land, tall tree, hole, etc. for display of feeding, nesting and roosting activities.

GEOGRAPHICAL DISTRIBUTION OF MAMMALIA

Geographical distribution of aves

A wide variety of birds are observed within the study area of which maximum species are resident and a few are winter migrant. The population of Passer domesticus showed the highest density and Sterna aurantia showed the lowest density (Hasan, 2014). Near the water edge, Nycticorax nycticorax , Ardeola grayii, Egretta intermedia, Bubulcus ibis are mostly seen because of the presence of wide variety fishes, tiny snakes, frogs, and lizards. Other common birds in the study area are Streptopelia decaocto, S. albifrons, Gyps bengalensis, Milvus migrans, Eudynamys scolopaceus etc.

GEOGRAPHICAL DISTRIBUTION OF AVES

Geographical distribution of fishes

An wide variety of fish species are seen in the study area. Different varieties of fish species are observed in the different depth of the river. Also, the type of fishes varies according to wet and dry season. Inland fisheries production in the study area is strongly related to the flood sequence. Floodplains inundated during monsoons are nutrient-rich and play a significant role as nurseries for many larvae and juvenile fish species (Welcomme 1985, Bayley 1988, Junk et al. 1989). Spawning on the floodplains, on the other hand, begins in May with the onset of southwest monsoon and continues until the end of July (Tsai & Ali 1985, de Graaf et al. 1999).

GEOGRAPHICAL DISTRIBUTION OF FISHES

Biodiversity: Fauna Community

Sectional exploration across the jamuna river and floodplain

Migratory Birds

Ciconia episcopus
White-necked stork
(Asian Woollyneck)

Clanga hastate
Indian Spotted Eagle

Phalacrocorax carbo
Great Cormorant

Vulnerable Species

Mabuya dissimilis
Common Skink
Anjoni

Egretta garzetta
Little Egret
Jotti Bok

Gavialis gangeticus
Gavial
Gharial

Platanists gangetica
Dolphin
Shushuk

Catla catla
Indian Carp
Katol

Varanus flavescens
Yellow Monitor
Holdy-Gui Shap

Felis chaus
Jungle Cat
Ban-biral

Vulpes bengalensis
Bengal Fox
Khek-shial

Lissemys punchata
Indian Flapshell Turtle

Canis aureus
Asiatic Jackal
Shial

Bufo melanostictus
Common Toad
Kuna Bang

Biodiversity: Fauna Community in Floodplain

Food web in the ecosystem of floodplain

Biodiversity: Fauna Community Water Edge

Food web in the ecosystem of water edge

Biodiversity: Fauna Community

Sectional exploration across human induced settlements

Canis aureus
Asiatic Jackal
Shial

Felis chaus
Jungle Cat
Ban-biral

Bufo melanostictus
Common Toad
Kuna Bang

Varanus bengalensis
Bengal Monitor
Gui Shap

Tylonycteris pachypus
Club-footed Bat
Chamchika

Columba livia
Rock pigeon
Jalali Kabutor

Calloscirus pygerythrus
Badami-Katbirali

Existing species in the human induced settlements

Biodiversity: Fauna Community

Food web in the ecosystem near human induced settlements

EXISTING INFRASTRUCTURE

Infrastructure

MAP OF EXISTING INFRASTRUCTURE

Human Induced Settlements

MAP OF EXISTING HUMAN SETTLEMENTS

Human Induced Settlements

Settlement patterns

01 CLUSTERED PATTERN

02 LINEAR PATTERN ALONG ROADS

03 SCATTERED PATTERN IN FLOODPLAIN

N

0 1km

- Mosque
- Market
- Police Station
- Kacha Road
- National Highway
- Union Road
- Railway
- Post Office
- Railway Station
- Tree
- Green Space
- River
- Residential Building
- Embankment
- School
- College
- Store
- Industry
- Floodplain
- Hospital

Human Induced Settlements

Land use zones

01 INDUSTRIAL ZONE
(JAMUNA FERTILIZER INDUSTRY)

02 COMMERCIAL ZONE

N

0 1km

Mosque
Market
Police Station
Kacha Road
National Highway
Union Road
Railway
Post Office
Railway Station
Tree
Green Space
River
Residential Building
Embankment
School
College
Store
Industry
Floodplain
Hospital

04. PLANNING STRATEGIES

Incorporating Sustainable Development Goals for Proposing Strategies

The 2030 Agenda charts out a set of 17 Sustainable Development Goals (SDGs) explicitly combining the economic, environmental and social dimensions of sustainability (United Nations 2015). The SDGs cover a diverse range of issues such as poverty (SDG1), education (SDG4), inequality (SDG10), and climate change (SDG13), in separate goals. These goals, however, do not exist independently from each other; rather, the SDGs and associated targets all interact at a deeper level, through inextricable links.

The selected site from the Brahmaputra-Jamuna river basin provides significant ecological benefits in the form of freshwater provision. However, human activities such as agriculture and urbanisation, together with imbalanced and unsustainable economic development have heavily stressed the area's capacities. The area already faces decreasing quantity and quality of natural resources, which are expected to further drop and degrade in the future. Floods and other disasters are made more likely in the area by the more extreme weather patterns caused by long-term global Climate change. Balancing the interactions between human and the environment, especially land use change and water and other ecosystem services, will thus be important to ensure the selected basin area's sustainability. This is why, the following sustainable development goals have been considered while developing the landscape of the basin area.

Proposal for Initial Planning

The existing planning strategies of human settlements, infrastructure, and economic activities did not incorporate the ecological aspects and sustainable planning. Consequently, there exists an imbalance among the planning strategies and landscape characteristics of the site. The issues discovered through mapping, literature research, and a case study addressed the urgent need to include the study region into a comprehensive landscape plan. Based on issues observed in topography, geography, hydrology, biodiversity, infrastructural trends, and habitation patterns, initial proposals have been developed.

i.First Reflective Remarks

After evaluating the existing infrastructure at the chosen location, it is discovered that there is an manmade embankment beside the river that is subjected to control flood. The embankment not only obstructs the normal flow of the river, but also the process of siltation on the floodplain. The natural flow of a river normally transports sediments to the floodplain. The amount of sediments on a floodplain significantly surpasses the sediment load carried by rivers. As a result, floodplains act as primary storage sites for sediments as they traverse from their source to their final depositional environment. The floodplain becomes fertile due to sediments, which encourages agricultural production. Because there is an embankment, sediments are carried back with the flow of the river, causing the river's depth to fall and river water to overflow the bank. As a result of the embankment construction, the site experiences periodic flooding. One of the first approaches considered in dealing with this issue is the demolition of the constructed embankment.

ii.Second Reflective Remarks

Analyzing existing human settlements reveals that there are dispersed settlements on the floodplain. The settlements on the floodplain grew in a linear pattern along the existing roads. The characteristics of floodplains are greatly influenced by existing infrastructure and human activities. Intensive human usage of floodplains poses a threat to the floodplain's natural balance. Floodplains are habitat to a variety of ecosystems that are both diverse and productive. Floodplain deterioration is ubiquitous, connected to habitat fragmentation and associated process disturbance, posing a threat to the fluvial ecosystem's overall integrity. This deterioration is mostly due to human interference, and it has led to a significant and substantial reduction of freshwater biodiversity. To conserve the floodplains, a proposal is given to relocate the existing infrastructure and human settlements from the floodplain.

01.First Iteration of Planning Strategies Based on Remarks

Human activities including as flow management, bank stabilization, and intensive land use have had a significant impact on rivers and their floodplains. Floodplain biodiversity is at risk as a result of these changes. Several approaches have been established to address these issues, including the conservation of the floodplain and the prevention of the river's natural flow. The constructed embankment will be removed from the floodplain, and a buffer zone along the floodplain's edge will be established. The buffer zone will aid in the prevention of soil erosion and flood damage, as well as promote groundwater recharge and protection of biodiversity.

Proposal for Initial Planning

iii.Third Reflective Remarks

In the selected site, the settlement patterns have been studied thoroughly. It is revealed that the settlement patterns are mostly dispersed and scattered and grew linearly along the roads in an unplanned way. One of the major problems of dispersed settlement is providing facilities and utility services. Also, there would not grow a sense of community in dispersed settlements. To remove the problems of scattered settlements, initially a compact settlement pattern was proposed for the site. But, there are some drawbacks too in addressing compact settlements. As the site is developed beside a river, a compact core of settlements is against the linear direction of river. Also, pollution increases in compact settlements due to intensive human activities. The proposed planning strategies should incorporate the natural features of the site.

iv.Fourth Reflective Remarks

Due to the dispersed character of the settlements, there are insufficient community facilities such as schools, colleges, and religious organizations in the chosen location in comparison to the current population. Furthermore, present facilities will be insufficient to support the expanding population in the future. Furthermore, the site lacks a lively commercial hub to facilitate the massive agricultural and fish production. There is also a dearth of cultural and recreational activities at the chosen site, which are vital in maintaining an area's distinct characteristics.

02. Second Iteration of Planning Strategies Based on Remarks

To address the issues of dispersed settlements, modification of existing settlement patterns is one of the approaches to guide future developments. Before proposing the strategies, projection of future population has been done so that the site can accommodate the future population fulfilling their needs. While modifying existing settlements, a balance between linear and compact patterns of settlements was maintained. Settlements are encouraged to grow in a linearly along roadways, forming clusters. As the site expands beside the river, the linear expansion of clustered settlements would compliment the linear orientation of the Jamuna River. The dwellings in clustered settlements are designed in such a way that there is adequate open space to avoid the disadvantages of compact layout and congestion. In addition, the residences will share a communal courtyard that will be used for a variety of purposes. This will help inhabitants to create a sense of community and build strong social capital. Native materials (Nolkhagra, Hogla) will be used as an alternative to expensive materials in the construction of buildings in the settlements. This will also aid in the preservation of the site's unique characteristics and culture.
In addition, based on the projected population, further community amenities have been suggested for the site. To facilitate the commercial activities, a commercial hub between the existing railway and highway has been proposed in the north side of the site considering easier transit of agricultural products and fishes. In the selected site, sungrass (Chhan) is available in huge amount. Promoting craft business using

Proposal for Initial Planning

sungrass (Chhan) will aid the residents as an alternative economic activity as well as it will uphold the tradition of the site. To keep the area functionally vibrant and promote strong relationship among inhabitants, arranging boat racing competitions during wet season is proposed.

v.Fifth Reflective Remarks

In the east side of the river, there is a railway and a national highway across the area. A portion of the railway and highway is located the floodplain.These mass transits affect the natural characteristics of floodplain. Floodplains have been identified as sensitive and fragile ecosystems. They have been drastically altered from their natural state due to intensive human interventions and are one of the world's most threatened ecosystems.

03.Third Iteration of Planning Strategies Based on Remarks

The relocation of segments of the railway and roadway that were in the floodplain has been recommended as a strategy. They will be shifted away from the floodplain and reconstructed. The floodplain will be conserved and ecosystems will be protected as a result of this strategy. This is a long term approach as relocating and reconstructing the portions of railway and highway can be costly and time consuming. Establishment of embankment and settlement on floodplain levelling surface which hampers natural siltation process. Ground surface of floodplains will be raised gradually to conserve floodplain and developments will occur on upper ground level.

Selection of the Final Planning Strategies

Through iteration process, the planning strategies have been selected for the study area. While proposing the planning strategies, several concerns have been addressed such as protecting natural resources and the environment, as well as managing lands in a sustainable manner. The landscape planning takes into account the interconnection of human habitats, living environments, and natural areas as well as different land uses.

Three Phase Planning Scheme

We have proposed ecology based planning strategies for the site incorporating landscape planning with existing situation. The planning scheme includes three phase planning within 30 years:

01 SHORT TERM

5 Years Planning Scheme within 2025

02 MIDDLE TERM

10 Years Planning Scheme within 2035

03 LONG TERM

15 Years Planning Scheme within 2050

Planning Aspects

We have done comprehensive study of the selected site and identified the key issues. Addressing the existing issues, we have proposed the strategies under the following five aspects.

PROPOSAL OF PLANNING STRATEGIES

Key Issues and Proposed Strategies

Planning Aspect: Nature Conservation

Issues		Strategies
Infrastructure in Floodplain	1	Floodplain Conservation: Buffer on the edge
Embankment along River	2	Embankment Exclusion
Industrial Pollution	3	Green Industry

Floodplain Conservation

Existing Issues:

It is seen from the existing map that, an embankment has been constructed along one side of the river. This embankment alters the water flow of river on another side of the river. Consequently, the natural flow of river is getting hampered. Moreover, it is also seen from the map that, some paved roads, a portion of railway network and a national highway has been constructed on the floodplain. Settlements have also grown along these roads on the floodplain. Natural floodplains provide flood risk reduction benefits by slowing runoff and storing floodwater. They also provide other benefits of considerable economic, social and environmental value that have been overlooked when local land use decisions have been made. Considering these issues, some strategies have been proposed which will be implemented gradually from 2025 to 2050.

MAP SHOWING EXISTING SITUATION OF THE SITE

Floodplain Conservation

Proposed Strategies:

Floodplain conservation has been taken as a first strategy to conserve the nature. To conserve the floodplain and to maintain the natural flow of river, all the infrastructures which have been constructed on the floodplain will be removed. But the unpaved roads won't be removed from floodplain as these don't cause any noteworthy harm to floodplain as embankments and paved roads. At the same time, buffer along the edge of the floodplain will be provided considering the following benefits of buffer: 1. Buffer control erosion and flood. 2. Recharges groundwater and protect water quality 3. Provide shades and habitat for wildlife. On the floodplain, only different kind of herbs and shrubs grow naturally. But if these herbs and shrubs are destroyed and reduced by manmade activities then these recommended herbs and shrubs will be re-planted on the floodplain. Some influential people encroach floodplain and use it as agricultural production as these floodplains are considered as very fertile land. These people overuse chemical fertilizer for crop production which hardens the soil, decrease fertility of floodplain and pollute air and water of the selected site. The strategies that have been taken considering this issue is that this floodplain will not be given to any private ownership. Rather, lease activity will be conducted on floodplain by government. Also, strict laws will be enforced regarding using excess amount of chemical fertilizers on floodplain. When floodplain will be managed wisely, then it will work as natural levee built up by many floods because of the thin and fine sediments deposited at river edge and over the floodplain.

2025: By 2025, the embankment on the floodplain will be demolished. The paved roads and the settlements which have been established along these roads will be removed from floodplain. Also by 2025, 20% growth of buffer along the edge of the floodplain will be noticed.

PROPOSED MAP FOR 2025

Floodplain Conservation

2035: By 2035, 60% growth of the buffer along the edge of the floodplain will be noticed.

2050: By 2050, the railway line and the national highway will be relocated. At the same time 100% growth of buffer along the edge of the floodplain will be completed.

PROPOSED MAP FOR 2035

PROPOSED MAP FOR 2050

Floodplain Conservation

Sectional exploration across the jamuna river and floodplain

Existing Issue: Establishment of embankment and settlement on floodplain levelling surface which hampers natural siltation process

Proposed Strategy: By 2050, gradually raising ground surface to conserve floodplain and developments will occur on upper ground level.

Floodplain Conservation

Buffer zone

Saccaharum spontaneum
Wild sugarcan
Kash

Chrysopogon Zizanioides
Vetiver grass
Binna Ghash

Pongamia Pinnata
Indian beech
Karoch

Craataeva nurvala
Three leaved caper
Borun

Trewia nudiflora
False white teak
Pitali

Arundo donax
Giant cane
Nolkhagra

Recommended Plants in the Buffer Zone

Floodplain Conservation

Existing Situation

1. An embankment is constructed along one side of the river.
2. Roads, a railway and a national highway has been constructed on the floodplain.
3. Settlements have also grown along these roads on the floodplain.

2025

1. Embankment on the floodplain will be demolished.
2. The roads and the roads will be removed from floodplain.
3. 20% growth of buffer along the edge of the floodplain will be noticed.

2035

1. 60% growth of the buffer along the edge of the floodplain will be noticed.

2050

1. The railway line and the national highway will be relocated.
2. 100% growth of buffer along the edge of the floodplain will be completed.

Existing Situation

2025

2035

2050

N

0 1km

Green Space
River
Floodplain
Tree
Kacha Road
National Highway
Union Road
Railway

Industry

Existing Issues:

There is a fertilizer industry in the selected site. The waste water of the industry is dumped directly to the Jamuna river through surface drain outlet and effluent water discharge outlet without any treatment. Consequently, water quality of the Jamuna river has been deteriorated with respect to pH, alkalinity, solid content and ammonia. For that reason, fish population reduces significantly. This water is now not suitable for drinking, fishing and irrigation purposes. In addition, air quality of surrounding has deteriorated due to emitted ammonia, that's why except the bad nuisance of ammonia, yield of several fruit plants has been reduced to some extent.

Green Industry

Proposed Strategy:

Addressing these issues, some strategies have been proposed to convert this industry as a green industry.
Proposal for green industry in 2025:
1.An ETP will be installed to treat the waste water of Jamuna Fertilizer Industry.
2..For the greater interest of the industry as well for the environmental pollution it is necessary to control ammonia contamination of river water up to the allowable limit. For that purpose, occasionally released urea plant process condensate instead of direct discharged in to the surface drain should be store in a lagoon or pond. Where ammonia will partially evaporate and partially converted to nitrate by bacteria. After a certain period water from that lagoon will be discharged to the river by pumping.
3.Tall tree species in the outer rows and heavily branched with thick leafed of small to medium height trees in the inner rows are suggested for green belt, which will act as a buffer zone and will minimize air pollution.

Discharge pond (Control ammonia contamination)

Waste water treatment system(ETP)

Tall tree species in the buffer

Water reservoir

PROPOSED MAP FOR 2025

JFCL Industry in 2025

Key Issues and Proposed Strategies

Planning Aspect: Land Use

Issues		Strategies
Scatter Settlements	1	Planned Settlement: Modified Grid Pattern
Settlements near Floodplain	2	Linear Growth of Settlements
Scarcity of Community Facilities	3	Providing Community Facilities

Future Population Projection

Before taking the strategies, population has been projected for 2025, 2035 and 2050. The strategies will be taken in such a way that it can be able to accommodate the projected population of 2025, 2035 and 2050. Considering annual growth rate and density per sq. km, it is projected that in 2050 the population will be double.

Population Density
811 per Square Kilometres

Growth Rate
2.5%

Population 27,371

Population 32440

Population 40,043

Human Induced Settlements

Existing Issues:

From the existing human induced settlement map, it is seen that settlements in this site have mainly grown linearly along roads and railway networks. Settlements in some areas are also seen growing in a scattered pattern. After overall analysis of the existing human induced settlement map, it can be depicted that settlements of the selected site didn't grow with any planned way. There are some issues associated with such type of pattern. For instance, the linear growth pattern of settlements reduces the scope of creating social capital among the residents of the selected site. Scattered pattern creates difficulties and increases cost of providing utility facilities to the settlements. During monsoon, some areas get affected by floods. These floods damage the houses of that particular area and so the residents suffer. There are also some issues related to community facilities of the study area. Clarence Perry assumed one elementary school would be enough to support 5000 people (Park and Rogers, 2015). There are only two primary schools for serving the huge population which is not enough. The number of colleges are also not enough for supporting this huge population.

MAP OF EXISTING HUMAN SETTLEMENTS

Human Induced Settlements

Proposed Strategies:

Under the strategy of floodplain conservation it is mentioned that the paved roads, a portion of highway and railway network will be removed from the floodplain. Some settlements which have been grown linearly along the paved roads of floodplain will also be relocated from the floodplain. The relocated settlements will grow linearly along with the roads just as the existing condition but in a cluster pattern. Some houses will be clustered together around a common courtyard. Consequently, social capital will increase creating a sense of community among the residents of the houses. Moreover, some spaces will be provided for the relocated settlements which will be used for homestead vegetation, grazing land or for any other community activities. The scattered settlements will also be rearranged and follow the cluster pattern. As a result, the difficulties of providing utility services will be reduced and become cost effective at the same time. The growth of the settlements which have been established on the west side floodplain will be controlled for conserving the floodplain. Some new schools and colleges will be provided at suitable locations to serve the projected population in 2025, 2035 and in 2050. Colleges will be built beside the main roads for providing high accessibility to the students., but primary schools won't be allowed to be built beside the main road for ensuring the safety of children, rather some new access roads will be provided for primary schools connecting the main roads. Moreover, a commercial activity center will be provided between the railway network and highway for the advantage of transportation facility and also to make the commercial activities more vibrant. In addition, the service facilities of other community services such as hospital, post office etc will be increased gradually.

PROPOSED MAP FOR 2025

School
College
Store
Mosque
Market
Police Station
Hospital
Post Office
Railway Station
Green Space
River
Residential Building
Industry
Floodplain
Commercial Area
Courtyard
Buffer
Tree
N
0
1km
Kacha Road
National Highway
Union Road
Railway
Embankment

Human Induced Settlements

Proposed Strategies for 2035

50% of modified settlement pattern in the north side of the site.One new school with the existing five school to serve 32440 population.

PROPOSED MAP FOR 2035

Modified Settlement Pattern in the North Side of the Site

Kacha Road
National Highway
Union Road
Railway
Embankment
N
0 1km

School
College
Store
Mosque
Market
Police Station
Hospital
Post Office
Railway Station
Green Space
River
Residential Building
Industry
Floodplain
Commercial Area
Courtyard
Buffer
Tree

Human Induced Settlements

Proposed Strategies for 2050

100% modified settlement pattern. Two new schools and one college with the existing six schools and three colleges to serve 40643 population. Relocation of settlements ,police station and railway station with the relocation of railway network and national highway in the south side of the site.

PROPOSED MAP FOR 2050

Modified Settlement Pattern in the North Side of the Site

Relocation of Settlements ,Police Station and Railway Station in the South Side of the Site.

Kacha Road
National Highway
Union Road
Railway
Embankment
N
0 1km

School
College
Store
Mosque
Market
Police Station
Hospital
Post Office
Railway Station
Green Space
River
Residential Building
Industry
Floodplain
Commercial Area
Courtyard
Buffer
Tree

Strategies for Flood Management

Proposed housing design for settlements: This new housing design will be proposed for those houses which get damaged by flood during monsoon period.

Proposed housing material: Local housing material such as Nolkhagra or Hogla can be used as an alternative construction material for the houses of the study area which will reduce their house construction cost because Nolkhagra and Hogla grow naturally in floodplain as well as it will uphold the tradition of using local materials for house construction.

Source: https://www.researchgate.net/publication/287214157

Human Induced Settlements

Existing Situation

1. Scatter Settlements
2. Settlements near Floodplain
3. Scarcity of Community Facilities

2025

1. Relocation of settlement near floodplain.
2. 20% modified settlement pattern
3. Commercial center between national highway and railway network.
4. Three new schools and one college

2035

1. 50% of modified settlement pattern.
2. One new school with the existing five school

2050

1. 100% modified settlement pattern.
2. Two new schools and one college
3. Relocation of settlements, police station and railway station with the relocation of railway network and national highway.

Existing Situation

2025

2035

2050

N

0 1km

School
College
Store
Mosque
Market
Police Station
Hospital
Post Office
Railway Station
Kacha Road
National Highway
Union Road
Green Space
River
Residential Building
Railway
Embankment
Industry
Floodplain
Commercial Area
Courtyard
Buffer
Tree

Key Issues and Proposed Strategies

Planning Aspect: Transportation

Issues		Strategies
Infrastructure on Floodplain	1	Exclusion of Infrastructure near Floodplain
Lack of Suitable Transportation during Wet Season	2	Floating Boat Station as Alternative Transport
Scarcity of Access Road	3	Access Roads for Houses

Transportation

Existing Issues

The first issue related to the transportation of the selected site is that some paved roads, some portion of a national highway and a railway network have been constructed on the floodplain which cause damage to the floodplain and changes the natural flow of river. The second issue is that settlements don't have adequate amount of access roads. The third issue regarding transportation of the site is that during wet season when some areas get submerged by floodwater, the residents suffer immensely for moving one place to another.

Transportation

Proposed Strategies

The paved roads that have been constructed on the floodplain will be demolished as well as some portion of the railway network and the national highway that have been constructed on floodplain will be relocated from floodplain. The unpaved roads that have been built on the western part of the floodplain will be kept as it's existing condition. Moreover, Some new access roads will be provided for settlements. Boats will be proposed as an alternative transportation mode. For this, proposed some suitable locations of the floating boat stations have been proposed for both dry and wet season.

Proposed Map for 2025

By 2025, the paved roads will be removed from floodplain, 20% of the access roads will be constructed for the settlements, floating boat stations will be provided on the edge of the river and to get access to these stations some transient roads will be provided on the flood-plain.

Proposed Map for 2035

By 2035, 50% access road will be provided.

Proposed Map for 2050

100% of the access roads will be provided by 2050. Moreover, by 2050, the portion of railway network and the national highway that have been constructed on floodplain will be relocated away from floodplain.

River
Boat Station
National Highway
Village road
Union road
Railway
N
0
1km

Transportation Medium

01 National Highway (14.5m)

Alternative Transport: Boat

02 Union Road (7m)

03 Village Road (5m)

Accommodating River Dynamics for Transportation Medium

In dry season, the boat stations will be floated on the edge of the river. To easily get access to these floating boat stations some unpaved roads will be established on the floodplain maintaining the alignment with the river so that the river does not face any diversion. But in wet season when the floodplain and the unpaved roads will get submerged by flood, then the locations of these boat stations will be alternated from river edge to floodplain edge.

BOAT STATION IN DRY SEASON

BOAT STATION IN WET SEASON

Transportation

Existing Situation

1. Infrastructure on Floodplain
2. Lack of Suitable Transportation during Wet Season
3. Scarcity of Access Road

2025

1. Roads will be removed from floodplain
2. 20% of the access roads will be constructed for the settlements
3. Floating boat stations and to get access to these stations some unpaved roads will be provided on the floodplain.

2035

1. 50% access road will be provided.

2050

1. 100% of the access roads will be provided
2. The portion of railway network and the national highway that have been constructed on floodplain will be relocated away from floodplain.

Existing Situation

2025

2035

2050

N

0 1km

Kacha Road
National Highway
Union Road
Railway
Embankment
River
Boat Station

Key Issues and Proposed Strategies

Planning Aspect: Ecology Preservation

Issues		Strategies
Extinction of Biodiversity	1	Plantation of Extinct Trees at Buffer and Periphery, Fish Sanctuary
Scarcity of Green Space	2	Preserving Green Spaces at Periphery and Generating Green Network along Roads

Ecology

Existing Issues:

Extinction of biodiversity is the main issue related to the ecology of the selected site. The Information have been collected about the existing flora and fauna community of the study area and it's evident that the existing biodiversity of the site is at major risk. Many species of flora and fauna communities have already become extinct and the rest are in danger of becoming extinct. The residents of the site are cutting trees, herbs and shrubs for logging, farming, roads and human habitation. The fauna community which is dependent on this flora community is facing harder time finding shelter.

Dolphins and Gharials are one of the most unique and threatened species in the selected site. The damming and diversion of the rivers on which they depend are threatening their habitats. The illegal extraction of sand from the river bank is destroying their nest habitats. Gharials often die after being caught in fishing nets. Despite being a protected species under the Bangladeshi law, river dolphins are also deliberately hunted for extracting oil from the dolphin's body

Ecological Preservation

Proposed Strategies

To conserve the ecology, Some green space will be created at the eastern periphery of the selected site. The flora community which is becoming extinct or is in critically endangered situation will be planted at the provided green space of periphery and the buffer which will be provided at the edge of the floodplain. Any kind of human induced settlements and human activities won't be allowed at periphery to conserve the biodiversity at periphery. Buffer will also be provided along all the roads to make greenways. Air and noise pollution from transportation can be reduced by these greenway buffers. At the same time, as the greenery matures along the greenways, birdlife and other fauna can traverse such green corridors from one refuge to another in search for food and breeding sites.

Fish Sanctuary

During wet season floodplain provides necessary spawning habitat for the fishes. But the number of fishes are now depleting because of the overfishing by human. Addressing this issue some strategies will be provided at floodplain to protect the fishes. Also, during the spawning time of fishes, fishing won't be allowed. Some sanctuaries will also be provided at riverbank for dolphins and gharials. Any kind of river construction project such as embankment won't be allowed because they threaten to reduce river levels and fragment the dolphin population.

Source: A fish sanctuary of HILIP project | Flickr

PROPOSED MAP FOR 2025

Ecological Preservation

PROPOSED MAP FOR 2035

PROPOSED MAP FOR 2050

Ecological Preservation

Existing Situation

1. Extinction of Biodiversity
2. Scarcity of Green Space

2025

1. 20% growth of buffer along roads
2. 30% growth of green space at periphery

2035

1. 60% growth of buffer along roads
2. 80% growth of green space at periphery

2050

1. 100% growth of buffer along roads
2. 100% growth of green space at periphery

Existing Situation

2025

2035

2050

N

0 1km

Green Space
River
Floodplain
Tree
Kacha Road
National Highway
Union Road
Railway

Key Issues and Proposed Strategies

Planning Aspect: Energy

Issues		Strategies
Scarcity of Electricity	1	Solar panel
Scarcity of Gas	2	Biogas Plant

Energy

Existing Issues:

From the existing map of the selected site, it is observed that the energy is mainly consumed by residential buildings and for a fertilizer company. The only source of energy is electricity here which is provided by PDB (Power Development Board). In Bangladesh, the largest source of electricity production is natural gas and it is decreasing at an alarming rate today. Only a few percent of electricity production of Bangladesh derive from renewable resources. The existing map also provides information that the fertilizer company contains on site power station to fulfill its demand but the lack of considering renewable and eco-friendly energy production is neglected. To address these existing issues, phase wise strategies are taken.

Energy

Proposed Strategies

In order to preserve the natural gas and begin to practice renewable energy production, solar panel and bio gas plant are proposed.

2025: A solar panel and a biogas plant will be proposed in 2025. The location of solar panel will be given near the residential buildings for making the energy distribution easier. A biogas plant is proposed far from the floodplain because of the flood or natural calamities. Moreover, it is beside a union road for carrying the raw material of biogas plant. These two plants can serve 50% energy of the total area.

PROPOSED MAP FOR 2025

One biogas plant in the north side

One solar panel in the centre of the site

Solar Panel
Biogas Plant
Boating Station
Buffer
Sand dune
Kacha Road
National Highway
Union Road
Railway
Floodplain
Green Space
River
Residential Building
N
0
1km

Energy

Proposed Strategies

2035: Another solar panel is proposed at the southern corner of the site to provide renewable energy nearby residents. The location is fixed thinking of the distribution area. Now, these three plants can cover up 70% energy of the total area.

PROPOSED MAP FOR 2035

One biogas plant and one solar panel to provide energy for the north side

One more solar panel in the south side of the site

Solar Panel
Biogas Plant
Boating Station
Buffer
Sand dune
Kacha Road
National Highway
Union Road
Railway
Floodplain
Green Space
River
Residential Building

N

0 1km

Energy

Proposed Strategies

2050: The productivity and capability of the plants will be increased to meet the upcoming demands. Almost 100% renewable energy can be assured by this time.

PROPOSED MAP FOR 2050

Mechanism of solar panel

A solar panel is designed to absorb the sunrays as a source of energy for generating electricity. It is comprised of several solar cells made of silicon, phosphorus, boron. Those solar cells absorb photon to initiate the current. The whole process is called photovoltaic effect. In a well balanced solar grid connected configuration, a solar panel generates power during the day time and their necessary components such as battery, charge controller, inverter are properly maintained. The battery and inverter gets old quicker that's why their maintenance procedures should be done according to the rules. The panel can be sized to meet the electric demand of the residential requirements.

Mechanism of biogas plant

Biogas can be generated through the processing of different types of organic waste. The raw materials of biogas plant are biodegradable waste from enterprises, spoiled foods from shops and home, manure and field biomass from agriculture, sludge from waste water. Biogas plant will possess their own lorry and vehicle to collect those raw materials. Then these raw materials are crushed into smaller pieces and slurrified to prepare the anaerobic digestion process. Slurryfing refers to add liquid to the biowaste to make it easier to process. Warm conditions around 37 degree celcius will be needed to for microbes. The actual biogas production takes place in a large tank for three weeks. Finally the gas is purified by mitigating the carbon di oxide. After this , it is finally ready to convert electricity. Both gas and electricity are distributed after this process.

Source:https://www.researchgate.net/publication/338721542_Biogas_as_a_Source_of_Energy_and_Chemical

Drainage

Drainage and sanitation are as essential as any other utility services. Two types of water are generated from household. One is grey water and another one is black water. Grey water are not much polluted as black water. So, a connection of pipe surrounding the agricultural area, this grey water can be utilized for irrigation. Moreover, the byproduct of biogas plant named as bio slurry can be used in adjacent agricultural land also.

Agriculture

Existing Issues:

From the existing geology map of the selected site, we've found out that the site mainly consists of loamy soils which is ideal for growing crops. We've also studied the soil fertility of the selected site. Based on that study, it can be depicted that the soil fertility of the selected site is decreasing day by day. The reason behind such degradation is continuous use of urea fertilizer, increasing cropping intensity, unawareness of the farmers on incorporation of organic manure to their farm specially in vegetable farming. The farmers of this site follow the follow the same cropping pattern everyear for the same lands which is also a reason for decreasing the soil fertility of the selected site. Though in some agriculture lands polyculture farming is practiced, but still there are a lot number of agricultural lands where monoculture farming is practiced. This is another reason for the degradation of soil fertility. For the site, annual flooding is important as a number of crops grown in the monsoon period cannot flourish without water but when flash flood appears due to heavy rainfall, many families struggle to harvest their crops as the agricultural lands get submerged by floodwater.

Proposed Strategies

In order to increase the fertility of the soil, farmers will practice the crop rotation system and polyculture farming for agricultural lands which will enhance the soil properties, making it more suitable for crop production. Moreover, growing a variety of plants on the same land will increase the biodiversity. Moreover, farmers will be introduced with creating composit pits at home for converting organic matter into usable compost which will reduce the dependency on urea fertilizer. At the same time, the compost will increase the fertility of the soil.

For the floodplain Areas, flash flood tolerant BRRI dhan 79 is proposed because it can withstand 18-21 days of submergence without losing much yield. Beside this, floating bed vegetation will be an alternative method of cultivation for those agricultural lands which get submerged by floodwater and cultivation become totally impossible.

Proposed Map for 2025

Proposed Map for 2035

Proposed Map for 2050

Floodplain
Homestead Vegetation
Highland Cropping
Floating Bed Vegetation
Sand Dune
River
River (Wet Season)
Composit Pit

N

0 1km

Agriculture

Issue

Decreasing soil fertility

REASONS

01 Increasing cropping intensity

02 Use of urea fertilizer

03 Same cropping pattern

04 Monoculture farming

Strategy

Increasing soil fertility

APPROACHES

01 Compost Pits

02 Crop rotation system

03 Polyculture Farming

Alternative method during wet season

APPROACHES

Floating bed vegetation during wet season

Livelihood opportunities

In the selected site, majority of the population rely on agriculture and fishing as their main source of income. We have proposed some new livelihood activities for the residents of the site. A floating market will be constructed for making the economic activities more vibrant in the site. This floating market will provide new livelihood opportunity for the local people of the site. Sun-grasses grow naturally in the floodplain and beautiful crafts can be made with these sun-grasses. So, another livelihood opportunity can be created by promoting crafts business from sun-grass. The culture and tradition will be restored by the craft business as well. In addition, the solar panels and the biogas plants that we've proposed will also create new livelihood opportunity.

Recreational activities

For keeping the buffer zone of the floodplain functionally active, we've proposed some recreational activities. Some unpaved hiking trails will be provided along the buffer as a passive recreation. Bird watching activities can also be included as a passive recreational activity at buffer zone of the flood-plain edge. And as an active recreation, boat racing has been proposed during wet season.

01 Walking Path, Bird Watching

02 Boat Racing

IMPLEMENTATION OF PLANNING STRATEGIES

Planning Strategies Implementation within 30 Years

PROPOSED MAP FOR 2025

PROPOSED MAP FOR 2035

PROPOSED MAP FOR 2050

Solar Panel
Biogas Plant
Boating Station
Buffer
Sand dune
Kacha Road
National Highway
Union Road
Railway
Floodplain
Green Space
River
Residential Building
School
College
Store
Mosque
Market
Police Station
Hospital
Post Office
Railway Station

N

0 1km

Research outcome

The main focus of the present study was to propose planning strategies addressing the issues related to the existing landscape of Brahmaputra-Jamuna river basin. This was done by a) a 5*5 square kilometer area selection from Brahmaputra-Jamuna river basin as a study area, b)perceiving the area in terms of topography, hydrology, geology, existing infrastructure, human induced settlement, existing flora as well as fauna communities and last but not the least the aspirations of the study area's people C) identifying key strengths of the selected area, c)proposing planning strategies considering SDG goals to achieve that strengths which have been revised again and again, d) conducting a study on a planned river based city and incorporating some planning strategies of that city that could go with the study area, e)and lastly, implementing the final planning strategies on the study area's existing map.

Project Framework

Research outcome

Following the major conclusions drawn from the planning strategies

Benefits and Challenges of Nature Conservation related Strategies:

a. Floodplain conservation and converting the existing fertilizer industry into a green industry are the two strategies that have been taken under the nature conservation aspect. To conserve the floodplain and to maintain the natural flow of river, some of the infrastructures which have been constructed on the floodplain will be removed and some will be relocated. In addition, floodplain will be gradually raised to hold back floodwater instead of holding back the floodwater with the help of embankment and encouraging to start the development just beside the river destroying the floodplain. Natural floodplains provide flood risk reduction benefits by slowing runoff and storing floodwater. Floodplain also provide habitat for diverse range of wildlife. Conserving the floodplain, these benefit that will be achieved. At the same time, buffer will be provided along the edge of the floodplain considering the benefits of buffer such as controlling erosion and flood, providing shades and habitat for wildlife.

b. Proposal for Green industry:

1.Installation of ETP and providing discharge ponds to control river water pollution.

2.Creating buffer zones with tall tree species around the industry to control air pollution.

Through these strategies, SDG goal 6 (Clean water and Sanitation) goal 9 (Industry, Innovation and Infrastructure), goal 13 (Climate Action), goal 14 (Life Below Water), and goal 15 (Life on Land) will be achieved. At the same time, implementing these strategies will also bring numerous challenges. Time, cost and convincing the stakeholders about removing the embankment and relocating the existing paved roads as well as installing ETP for industry are one of the major challenges regarding these strategies. Though cost is a big issue but the economic loss that the strategies will bring is much lower when compared with the considerable social and environmental loss that are happening due to prevailing infrastructures and industry.

Benefits and Challenges of Land-use related Strategies: Settlements will be relocated from the floodplain and the relocated settlements will grow linearly along with the roads just as the existing condition but in a cluster pattern. Some houses will be clustered together around a common courtyard. Consequently, social capital will increase creating a sense of community among the residents of the houses. The scattered settlements will also be rearranged and follow the cluster pattern. As a result, the difficulties of providing utility services will be reduced and become cost effective at the same time. Moreover, a commercial activity center will be provided between the railway network and highway for the advantage of transportation facility and also to make the commercial activities more vibrant. Through these strategies SDG goal 11 (Sustainable Cities and Communities) will be achieved. But these strategies also possess some challenges. Time and cost are needed to relocate the settlements from floodplain. The suffering of people of these settlements is a major challenge for these strategies as convincing them for relocation is not an easy task. If people become aware about the ecological, social and environmental loss more than the economical loss that will be caused by settlement relocations, then these strategies will be beneficial for the study area.

Benefits and Challenges of Transportation related strategies: The paved roads that have been constructed on the floodplain will be demolished as well as some portion of the railway network and the national highway that have been constructed on floodplain will be relocated to conserve the floodplain discussed before in the nature conservation aspect. The unpaved roads that have been built on the western part of the floodplain will be kept as it's existing condition. Moreover, some new access roads will be provided for settlements. Boats will be proposed as an alternative transportation mode. For this, some suitable locations of the floating boat stations have been proposed for both dry and wet season. SDG goal 9 (Industry, Innovation, and Infrastructure) and goal 11 (Sustainable cities and Communities will be achieved). But along with these benefits, time, cost, the sufferings of people and convincing stakeholders are some of the challenges associated with these strategies.

Benefits and Challenges for Energy Related Strategies:

Benefits of Ecology Preservation related strategies: To conserve the ecology, some green space will be created at the eastern periphery of the selected site. The flora community which is becoming extinct or is in critically endangered situation will be planted at the provided green space of periphery and the buffer which will be provided at the edge of the floodplain to preserve the ecology. Buffer will also be provided along all the roads to make greenways. Air and noise pollution from transportation will be reduced by these greenway buffers. At the same time, as the greenery matures along the greenways, birdlife and other fauna can traverse such green corridors from one refuge to another in search for food and breeding sites. During the spawning time of fishes, fishing won't be allowed. Some sanctuaries will also be provided at riverbank for fishes, dolphins and gharials. These strategies will help to achieve SDG goal 14 (Life Below Water) and goal 15 (Life on Land).

Benefits and Challenges of Agriculture Related Strategies: In order to increase the fertility of the soil, farmers will practice the crop rotation system and polyculture farming for agricultural lands which will enhance the soil properties, making it more suitable for crop production. Moreover, growing a variety of plants on the same land will increase the biodiversity. Moreover, farmers will be introduced with creating compost pits at home for converting organic matter into usable compost which will reduce the dependency on urea fertilizer. At the same time, the compost will increase the fertility of the soil. For the floodplain Areas, flash flood tolerant BRRI dhan 79 is proposed because it can withstand 18-21 days of submergence without losing much yield. Beside this, floating bed vegetation will be an alternative method of cultivation for those agricultural lands which get submerged by floodwater and cultivation become totally impossible. Through these strategies SDG goal 2 (Zero hunger) and goal 13 (Climate Action) will be achieved but then in order achieve these goals water use will be intensified, affecting access to clean water and sanitation (Goal 6). Moreover, making popular these new technology to the local farmers is a time dependent task.

Benefits and Challenges of Livelihood Related Strategies: A floating market will be constructed for making the economic activities more vibrant in the site. This floating market will provide new livelihood opportunity for the local people in the study area. Sun-grasses grow naturally in the floodplain and beautiful crafts can be made with these sun-grasses. So, another livelihood opportunity can

be created by promoting crafts business from sun-grass. The culture and tradition will be restored by the craft business as well. In addition, the solar panels and the biogas plants that have been proposed will also create new livelihood opportunity. Through these strategies, SDG goal 8 (Decent work and Economic Growth) will be achieved. But making people interested to these new livelihood opportunities will be really a challenging task.
The present study shows that the landscape of the study area is very much transient. Landscape is complex and far-reaching. People have strong ties to landscape and use them in various ways. Thus, landscape is interweaving with climate change and ecology, development, economies, politics and culture. Landscape changes as a result of these relationships that human-nature interaction. So, the proposed planning strategies have not been made fixed in any way. Rather the strategies will be changed and grown according to the transient landscape of the study area in different times which will make the landscape planning more sustainable for future and satisfy the social, economic and environmental priorities.

Benefits and Challenges of Energy Related Strategies: In Bangladesh, electricity is generated from natural gas. Fuel consumption has increased rapidly. So the environmental degradation is a concerning factor now. Only a few percent of electricity production of Bangladesh derive from renewable resources. But addressing these issues, the main obstacles are distributing the energy line and convincing stakeholders to get use to with renewable energy source.
The proposed strategies will decrease fuel consumption and the socio-economic and environmental return will encourage stakeholders to increase the use of renewable energy sources. Moreover, the biogas plant will recycle the waste and these energy plants will increase employment opportunities,Thus cycle of the economy will be rounding effectively.

Recommendation for present study

1.Regular patrolling by trained persons should control unwise and illegal exploitation of flora and fauna communities.
2.Plantation of indigenous fruit-trees with the sharing involvement of local people may increase food availability for wild animal, particularly for frugivores.
3.Trapping and shooting must be prohibited.
4.Oil pollution and movement of fishing boats should be reduced.
5.Use of highly poisonous insecticides in the agricultural fields should not be allowed.
6.Transient walkways such as bamboo bridges can be constructed to increase the accessibility of the residents.
7.Establishment of wildlife training centers is necessary where local people would be trained up and can play an effective role to aware people about the value of wild animals and their importance. Wildlife Protection Law 1974 should be strictly implemented through the local enforcement agencies. Char land areas must be protected for the migratory birds, fishes and other animals.

Recommendation for future study

The present study, by no means can be considered as a comprehensive one covering all aspects of landscape planning. However, within its limitations and scope this study has certainly provided a basis and has focused on various important environmental, social and economic issues which should be considered for detailed study in the future.
The following recommendations are made for further study in this relevant field:
I.A detail study about ground water quality of the study area may be under taken to identify impact of industrial or household pollution on ground water and proposing planning strategies accordingly.
II.A detail study and investigation may be carried out over increasing the accessibility of river water in the irrigation process through canals without changing the natural flow of river.
III.A study regarding the intensity of drought in the study area and proposing the suitable planning strategies for reducing the impacts of drought.
IV.A further study on relocating the population living on the floodplain which get submerged every year by floodwater.
V.A detail study and investigation about the gender inequality within the area and proposing plan-

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APPENDIX

Generated Maps through Planning Process

Floodplain Area

Common characteristics

Tropical and sub-tropical	17-28 °C	300mm to 5000mm
Region	Average Temperature	Average Rainfall
Full sunlight to partial shade or No shade	4 to 9.5	Sandy Loam and clay with moist but well drained soil
Light	Average PH	Soil Type
Free or Free, seasonally waterlogged	Acid, Alkaline or Neutral	Heavy, light, medium
Soil Drainage	Soil Reaction	Soil Texture
Drought, Saline, Shallow or strong wind, controls erosion, waterlogged soil	100m to 2700mm	
Tolerance	Altitude	

Floodplain Area

Tree

Salix tetrasperma
Panibaj
Indian Willow

Pongamia Pinnata
Karoch
Indian beech

Craataeva nurvala
Borun
Three leaved caper

Trewia nudiflora
Pitali
False white teak

Barringtonia Acutangula
Hijal
Indian oak

Vulnerable plants are marked red.

Floodplain Area (Shrub)

Typha domingensis
Hogla
Southern caltail

Saccaharum spontaneum
Kash
Wild sugarcan

Arundo donax
Nolkhagra
Giant cane

Hemarthria protensa
Chailla ghash

Lippia Alba
Vhuokra
Burhy midgrass

Cyperus corymbosus
Golmethi
Jointed flatsedge

Chrysopogon Zizanioides
Binna-ghas
Vetiver grass

Schumannianthus dichotoma
Murta
Common donur

Asparagous racemosus
Satomuli
Buttermilk root

Floodplain Area (Shrub)

Saccharum fusca
Ikor

Cynodon dactylon
Durba ghash
Bermuda grass

Cyperus teuispica
Baddali Ghash
Slender spiked sedge

Cyperus rotundus
Mutha ghash
Purple nut sedge

Vulnerable plants are marked red.

Waterside Area(Water edge/In water)

Common characteristics

Tropical and sub-tropical	15-30 °C	500mm to 4500mm
Region	Average Temperature	Average Rainfall
Full sunlight, Semi shade or No shade	4 to 8	Tolerate drought and strong winds
Light	Average PH	Tolerance
Sandy, Loamy, Clay	Acid, Alkaline or Neutral	Free or Impeded, Seasonally waterlogged
Soil Type	Soil Reaction	Soil Drainage
Heavy, light, medium		
Soil Texture		

Waterside Area(Water edge/In water)

Tree

Ficus Benghalensis
Bot
Banyan

Ficus religiosa
Ashoth
Bodhi tree

Ficus hispidia
Kakdumur
Hairy fig

Ficus Virens
Pakur
White fig

Ficus racemose
Joggodumur

Bombas ceiba
Shimul
Red silk-cotton

Barringtonia acutangul
Hijol
Indian oak

Pongamia pinnata
Koroch
Indian Beech

Crataeva nurvala
Barun
Three leaved caper

Vulnerable plants are marked red.

Terminelia catappa
Kath badaam
Almond

Erythrina variegata L
Parijat
Tiger's claw

Aphanamixis Polystachya
Rayna
Shan lion

Lagerstroemia speciose
Jarul
Giant creepe

Dalbergia sissoo
Shishu
North Indian rosewood

Salix tetrasparma
Panibaj
Indian willow

Anthocephalus chinensis
Kadam
Bur flower tree

Dillenia Indica
Chalta
Elephant applr

Diospyros malabarica
Gaab
Indian persimon

Waterside Area(Water edge/In water)

-Shrub

Ipomoea fistulosa
Dholkolmi
Pink morning glory

Phyllanthus reticulatus
chitki
Black honey

Solanum filicifolium
Til begun
Hoe nightshade

Aquatic

Salvinia Natans
Tilokpana
Floating ferm

Ipomoea Acuatica
Kolmilota
Water Spinach

Pistia Stratiotes
Topa pana
Water lettuce

Monochoria Hastata
Boronukha
Leaf pndweed

Dryoptris sp.
Dekhishak
Monkey bruh vine

Polycarpon Prostratusm
Gimshak
Ghima

Aponogeton spp.
Ghechu
Cupe powdered

Nymphaea Nauchali
Shaluk
Blue water lily

Nymphaea
Pubesces
Shapla
Water lily

Waterside Area(Water edge/In water) -Herbs

Ipomoea Acuatica
Kolmilota
Water spinach

Ludwigia Adscendens
Keshordam
Creeping water

Alternanthera Philoxeroids
Maloncho
Alligator weed

Alternanthera Sessilis
Shachi
Sessile joyweed

Marsilea Quadrifolia
Shushni
Sleaved clover

Enhydra fluctuans
Helencha
Haurkuch

Homestead Plant Community

Common characteristics

Tropical and sub-tropical	20-35 °C	500mm to 4000mm
Region	Average Temperature	Average Rainfall
Full sunlight, Semi shade or No shade	5 to 8	Tolerate drought and strong winds
Light	Average PH	Tolerance
Sandy, Loamy, Clay	Acid, Alkaline or Neutral	Free or Impeded
Soil Type	Soil Reaction	Soil Drainage
Heavy, light, medium		
Soil Texture		

Homestead Plant Community

Tree

Azadirachta Indica
Neem Gach

Ziziphus mauritiana
Boroi
Indian jujube

Syzygium cumini
Jaam
Java plum

Averrhoa carambola
Kamranga
Carambola

Cocos nucifera
Narikel
Coconut

Areca catechu
Supari
Areca palm

Magnifera Indica
Aam
Mango

Cassia fistula
Shonalu
Golden shower tree

Terminalia chebula
Horitoki
Chebulic myroban

Moringa oleifera
Shojna
Drumstick tree

Mirnusops Elengi
Bokul
Medlar

Syzygium Cumini
Kalo jam
Black Berry

Saraca Asoca
Ashok

Magnolia champaca
Champa
Champaca

Alstonia Scholaris
Chatim
Devil's tree

Homestead Plant Community (Shrub)

Abroma Augustum
Ulotkombol
Cotton abroma

Justica Adhatoda
Bashok
Malabar nut tree

Lawsonia Inermis
Mendi
Hena

Calotropis Gigantea
Akondo
Crown flower

Catharanthus Roseus
Noyon tara
Three leaved verbana

Hibiscus Rosasinensis
Joba
China rose

Indian heliotrope
Nishinda
Vitex Negundo

Ricinus Communis
Verenda
Castor bean

Senna Alata
Dadmordon
Ringworm shrub

Homestead Plant Community(Herb)

Amaranthus Virdis L.
Khuitashak
Slender amaranth

Amaranthus Spinosus
Katakhura
Spiney pigweed

Archyranthes aspera L.
Apang

Heliotropium Indicum
Hatishura
Indian heliotrope

Solanum Nigrum
Katabegun

Physalis angulata
Bon-tepari
Angular winter cherry

Persicaria lapathiopholia
Bishkatail
Pale persicaria

Datura metel
Dhutura
Thorn apple

Phyllanthus amarus
Vui-amla
Phyllanthus

Homestead Plant Community(Climber)

Mikania micrantha
Asamlota
Bitter vine

Mimosa Pudica
Lojjaboti
Sensitive plant

P*iper Longum*
Pipul
Long pepper

Aristolochia indica
Isshormul
Indian birthwort

Habitat Name	Average Depth	Available Fish Species
Main Channel	**Dry season:** >60 feet **Wet season:** >90 feet	*Sperata aor, Bagarius, Labeo Calbasu, Rita, Wallagu attu, Tenualosa ilisha, Paramugil parmatus, Jamuna ailia, Rhinomugil corsula, Silurus argentata, Labeo rohita, Catla catla, Pangasius, Chitala, Otolithoides pama. Caridean shrimp, Awaous guamensis*
Second Level Channel	**Dry season:** 30-40 feet **Wet season:** 60 feet	*Jamuna ailia, Sperata aor, Bagarius, Tenualosa ilisha, Rita, Silurus argentata, Rhinomugil corsula, Labeo Calbasu, Wallagu attu, Pangasius, Labeo rohita, Catla catla, Labeo bata*
Third Level Channel	**Dry season:** 10-30feet **Wet season:** 30-50 feet	*Jamuna ailia, Rhinomugil corsula, Labeo Calbasu, Sperata aor, Bagarius, Wallagu attu, Salmostoma acinaces, Pangasius, Cyprinus carpio, Cirrhinus cirrhosus*
Embayment(Kole)	**Dry season:** 5-10 feet **Wet season:** 30-40 feet	*Puntius chola, Aspidoparia morar , Caridean shrimp, Mystus cavasius, Rhinomugil corsula, Eutropiichthys vacha, Setipinna phasa, Jamuna ailia, Cyprinus carpio , Tenualosa ilisha, Awaous guamensis, Tenualosa toil, Chaca chaca*
Charland Channel	**Dry season:** 1-3 feet **Wet season:** 3-6 feet	*Aspidoparia morar, Mystus cavasius, Salmostoma acinaces, Chaca chaca, Jamuna ailia, Caridean shrimp, Awaous guamensis, Channa striata, Puntius chola*
Bankside	**Dry season:** 1-10 feet **Wet season:** 30-60 feet	*Sperata aor, Bagarius, Awaous guamensis, Rita, Mastacembelus armatus, Labeo dyocheilus, Labeo Calbasu, Jamuna ailia, Eutropiichthys vacha, Setipinna phasa*
Flood Plain(in chars)	**Dry season:** 1-3 feet **Wet season:** 3-8 feet	*Chaca, Puntius chola, Aspidoparia morar, Caridean shrimp, Jamuna ailia, Mystus cavasius, Carassius, Awaous guamensis*

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Source: Environmental Assessment for River Management Improvement Program

Existing Fish Species

Sperata aor
Long-whiskered catfish
Air

Bagarius bagarius
Dwarf goonch
Baghair

Labeo Calbasu
Orange-fin labeo
Baus

Rita rita
Rita
Rita

Wallagu attu
Helicopter catfish
Boal

Tenualosa ilisha
Hilsha herring
Ilish

Paramugil parmatus
Broad-mouthed mullet
Baspatari

Ailiichthys punctate
Jamuna ailia
Kajuli

Rhinomugil corsula
Corsula
Khorsholla

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Existing Fish Species

Silurus argentata
Clupisoma garua
Ghaura

Labeo rohita
Indian Rui
Rui

Catla catla
Indian Carp
Katol

Pangasius pangasius
Yellowtail catfish
Pangas

Chitala chitala
Clown Knifefish
Chitol

Otolithoides pama
Pama croaker
Poa

Caridean shrimp
Prawn
Chingri

Awaous guamensis
Bailla

Labeo bata
Bata
Bata

Existing Fish Species

Salmostoma acinaces
Silver razorbelly minnow
Chela

Cyprinus carpio
Common carp
Carp

Cirrhinus cirrhosis
Mrigal
Mrigel

Puntius chola
Swamp barb
Puti

Aspidoparia morar
Aspidoparia
Piali

Mystus cavasius
Gangetic mystus
Gulsha

Eutropiichthys vacha
Bacha
Bacha

Setipinna phasa
Gangetic hairfin anchovy
Fesha

Tenualosa toil
Toli shad
Chanda

Existing Fish Species

Chaca chaca
Squarehead Catfish
Chikasi

Channa striata
Striped snakehead
Kora

Mastacembelus armatus
Zig-zag eel
Baim

Labeo dyocheilus
Ghira

Carassius carassius
Crucian carp
Small Carp

Existing Amphibians

Bufo melanostictus
Common Toad
Kuna Bang

Hoplobatrachus tigerinus
Bull Frog
Shonabang

Euplyctis cyanophlyctis
Skipper Frog
Kotkoti bang

Vulnerable

Rana alticola
Boulenger's Frog
Pana bang

Microhyla ornate
Ornata Microhylid
China Bang

Microhyla rubra
Red Microhylid
Red china Bang

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Existing Reptilians

Hemidactylus flavivirdis
House Gecko
Tiktiki

Calotis versicolor
Common Garden Lizard
Rokto-chosa

H. Brookii
Spotted House Lizard
Tiktiki

Mabuya dissimilis
Common Skink
Anjoni

Mabuya dissimilis
Cheekered Keelback Snake
Dhora-shap

Amphiesma stolatum
Stripped Keelback Snake
Dhora-shap

Lissemys punchata
Indian Flapshell Turtle

Existing Reptilians

Vulnerable

H. Bowringii
Bowring's House Lizard
Tiktiki

Gekko gecko
Wall Gecko
Takkhak

Mabuya carinata
Stripped Skink
Anjoni

Varanus bengalensis
Bengal Monitor
Gui Shap

Aspideretes gangeticus
Indian Softshell Turtle

Existing Reptilians

Endangered

Varanus flavescens
Yellow Monitor
Holdy-Gui Shap

Chitra indica
Indian narrow-headed
softshell turtle

Critically Endangered

Gavialis gangeticus
Gavial
Gharial

Existing Aves

Ardeola grayii
Pond heron
Kana Bok

Egretta garzetta
Little Egret
Jotti Bok

Bubulcus ibis
Cattle Egret
Go Bok

Milvus lineatus
Large Pariah Kite
Cheel

Sterna aurantia
River Tern
Gang-cheel

Sterna albifrons
Little Tern
Khudey-gangcheel

Streptopelia chinensis
Spotted Dove
Tila-ghugu

Columba livia
Rock pigeon
Jalali Kabutor

Cuculus varius
Common Hawk-cuckoo
Choggelo kokil

Existing Aves

Eudynamys scolopaceus
Koel
Kokil

Centropus sinesis
Crow-pheasant
Kanakuwa

Athene brama
Spotted Owlet
Phuti-pencha

Apus affinis
House Swift
Ghorani-nakkati

Ceryle rudis
Lesser Pied Kingfisher
Pakra Machranga

Alcedo atthis
Common Kingfisher
Choto Machranga

Alcedo meninting
Blue-eard Kingfisher
Mach-ranga

Halcyon smyrnensis
White-breasted Kingfisher
Shet buk Machranga

Merops philippnus
Blue-tailed Bee-eater
Nilez suichora

Existing Aves

Upupa epops
Hoopoe
Holudh-pakhi

Megalaima haemacephala
Crimson breasted Barbet
Choto basanta Bauri

Megalaima asiatica
Blue-throated Barbet
Nilgiri-basanta bauri

Dendrocopos macei
Fulvous breasted pied wood pecker
Badami buk Kaththokra

Dinopium benghalense
Lesser-golden back wood pecker
Sonali pit kaththokra

Lanius schach
Black-headed Shrike
Kalashir-koshi

Hirundo rustica
Common Swallow
Ababil Pakhi

Oriolus oriolus
Golden Oriole
Sonali-holud Pakhi

Oriolus xanthornus
Black-headed Oriole
Holdey Pakhi

Existing Aves

Vulnerable

Egretta intermedia
Intermediate Egret
Maijala Bok

Milvus migrans
Pariah Kite
Bhuban-cheel

Gyps bengalensis
White-backed Vulture
Shakun

Amaurornis phoenicurus
White-breasted Water Hen
Dahuk

Existing Aves

Endangered

Nyctocorax nycticorx
Night Heron
Nishi Bok

Streptopelia decaocta
Ring Dove
Raj-ghugu

Streptopelia tranquebarica
Red Turtle Dove
Lal-ghugu

Psittacula Krameri
Rose-ringed Parakeet
Tia

Clamator jacobinus
Pied Crested Cuckoo
Jhuti Kokil

Tyto Alba
Barn Owl
Laxmi-pencha

Critically Endangered

Gallicrex cinerea
Water-cock
Kora

Migratory Birds

Phalacrocorax carbo
Great Cormorant

Charadrius dubius
Little Ringed Plover

Charadrius mongolus
Kentish Plover

Glareola lacteal
Little Indian Pratincole

Motacilla alba
White Wagtail

Calandrella raytal
Sand Lark

Hirundo rustica
Barn Swallow

Cryle rudis
Pied Kingfisher

Sterna aurantia
Little Egret

Migratory Birds

Vulnerable

Ciconia episcopus
White-necked stork
(Asian Woollyneck)

Clanga hastate
Indian Spotted Eagle

Clanga clanga
Greater Spotted Eagle

Endangered

Dendrocygna javanica
Indian Whistling Duck

Vanellus duvaucelii
River Lapwing

Sterna aurantia
River Tern Sterna

Existing Mammalians

Suncus murinus
Whit-tailed Shrew
Chika

Pipistrellus coromandra
Pipistrelle
Chamchika

Pteropus giganteus
Flying-fox
Badur

Tylonycteris pachypus
Club-footed Bat
Chamchika

Rattus rattus
Brown Rat
Indur

Mus musculus
Little Field Mouse
Nengti indur

M. Booduga
Little Field Mouse
Metho-indur

R. Norvegicus
Short Tail Rat
Dhamshi Indur

R. Fulvescens
House Rat
Ghashua Indur

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Existing Mammalians

Vulnerable

Canis aureus
Asiatic Jackal
Shial

Felis chaus
Jungle Cat
Ban-biral

Lepus nigricollis
Black-naped Here
Khargosh

Calloscirus pygerythrus
Irrawaddy Squirrel
Badami-Katbirali

Endangered

Platanists gangetica
Ganges River Dolphin
Shushuk

Vulpes bengalensis
Bengal Fox
Khek-shial

Herpestes auropunctatus
Small Mongoose
Choto-beji

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Zooplankton

Order: Cladocera

Alona setulosa

Bosmina longirostris

Ceriodaphnia lacustris

Order: Protozoa

Arcella crenulata

Paramecium caudatum

Vorticella

Order: Copepoda

Cyclops scutifer

Macrocylops albidus

GLOSSARY

Buffer: A zone with a specified width surrounding a spatial feature called buffer

Floating bed vegetation: The planted floating-bed system is an innovative variant of wetlands with substrates-rooted plants and free-floating aquatic plant systems, which consists of aquatic or terrestrial plants, growing in a hydroponic manner with buoyant frames floating on the surface of water bodies.

Floating Market: A floating market is a market where goods are sold from boats

Landscape: A landscape is the visible features of an area of land, its landforms, and how they integrate with natural or man-made features.