LANDSCAPE DEVELOPMENT FOR BRAHMAPUTRA RIVER EDGE AT KACHARI GHAT, GUWAHATI

MASTER OF ARCHITECTURE

(LANDSCAPE)

MINISHREE BARKACHARY

2017MLA009

SCHOOL OF PLANNING AND ARCHITECTURE, BHOPAL

NEELBAD ROAD, BHAURI, BHOPAL - 462030

MAY, 2019

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Submitted

in partial fulfillment of the requirements for the

award of the degree of

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Department of Landscape

School of Planning and Architecture, Bhopal

Declaration

I_____, Scholar No._____ hereby declare that the thesis entitled_____, _____ submitted by me in partial fulfillment for the award of Master of Landscape Architecture, in School of Planning and Architecture Bhopal, India, is a record of bonafide work carried out by me. The matter embodied in this thesis has not been submitted to any other University or Institute for the award of any degree or diploma.

07th May, 2019 Minishree Barkachary

Certificate

This is to certify that the declaration of Minishree Barkachary is true to the best of our knowledge and that the student has worked under the guidance of the following panel.

RECOMMENDED

Asstt. Prof. Sonal Tiwari

Department of Landscape

ACCEPTED

Prof. Sanjeev Singh

Head, Department of Landscape

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I dedicate this Thesis to my Grandmother

Late Dewali Barkachary

LIST OF CONTENTS

LIST OF FIGURES

ABSTRACT

Today, in global world when issues related to the habitat the importance of the matter may be negotiated in public or public community. When it becomes to our environment, sustainability is may or may not be taken care off by people. Reason why the natural disaster, public action on nature are hugely increasing. Going through this level is somehow effecting on mother earth and the result of this activity is quick impact on future. Moreover, every country is facing the natural disaster in every year in the globe. In this regards, the place effected by flood; now a day, it seems common in every year. This issues not only effecting the flood prone areas, but it is effecting in land, water, flora-fauna and environment as a whole in miso level.

The human intervention with river and their connection associates with tremendous experience of the diversity of the components. These areas often referred spiritually by the people of rural and urban settlements for ecological, cultural, historical and habitants of the riverfront areas. The different phases of the river which effects to the riverine and changes the land, ecosystem and habitat can create the issues on its nature. The behavior of river also changes the pattern of natural resources, human sprawl, and ecosystem. The need for human to connect with this nature is may be either nature dominating or human dominating to create a suitable landscape to survive on any environment.

The mighty Brahmaputra river flows across the state of Assam separating it into two parts. The largest city Guwahati lays along the bank of the river. The life of an urban settlement including with many historical places, temples, commercial market place, a river island, Ghats and ferry ports, is laying along on its edges.

The Guwahati city is the largest city in the State of Assam, India. The present city of Guwahati was formed on the southern bank of the river Brahmaputra. Historically, this edge of river Brahmaputra was an important administrative and trade Centre. Since 1970, the city has been started growth with and become a major hub for commercial, institutional, industrial, and trading center. The edge of this area is traditionally being used in different types of cultural and social public amenities such as public park and recreational space, open gym, children’s play area, ferry port for water transport system, cruise, also kite festival and chat puja during winter season. Today Guwahati has developed into a major urban area of the region. The place is facing urbanization is disturbing the ecosystem, soil erosion, misuse of the river edges and is major threat in future development/sustainable development in this area.

In this thesis, the main focus is done on the various research to study the physical profile of the Brahmaputra river and its relation with human as well as the city. This thesis intends to study and understand the effective methods for landscape development. Giving a thought to existing challenges at the site to develop landscape strategies (CLDP) and finally proposed landscape design solution at the Brahmaputra river edge. The proposed design idea is to provide the space in correct manner for the present activities also to improve the area with natural way without harming our ecosystem.

The aim of study is to explore of riverfront design with a kind landscape model which meets the needs for sustainable development. This aim of research will be of vital importance to the sustainable development of urban environment, economics, and social relation of the water and city. Landscape approach to the affected areas to sustainable place making for ecosystem and urbanism.

Key words

River, Landscape, River edge, Season, Flood, Urban, Recreational, Ghaat, Water transport, Ecosystem.

1.0 INTRODUCTION

1.1.0 Background

1.1.1 River Brahmaputra

The Brahmaputra basin is different from other river of the India, especially considering the complex geopolitics involved and potential threats to regional stability. The river basin is covering 580,000 sq. km. across other four countrie- China, India, Bhutan and Bangladesh; and it has occupying 50%, 34%, 8% and 8% respectively. Brahmaputra river is considered fifth largest river in the world by its character of flow. There is no water agreement in Brahmaputra river basin (Samaranayake, et al., 2016). The average discharge of this river is approximately 20,000m3/s (Immerzeel, 2008). Brahmaputra river has an average annual sediment load about 735 million metric tons, and a specific flood discharge of 0.149 m3/s/km2 (Datta and Singh 2004).

The Brahmaputra river is widening as soon as enters to the valley in Assam and is long and broad; it is 640 km long and the width varies from 64 km to 90 km (Datta and Singh 2004). The north side of the valley is bounded by high Himalayan mountain ranges, in the east by the Patkai hill ranges, in the south by the lower hill ranges and in the west it is contiguous with the plains of Bangladesh (Singh, et al., 2004).

Figure 1. Origin of Brahmaputra river *Source: civilsdaily.com*

The main channel of the river is traverses in three different countries: China, India and Bangladesh. The main stream of the river is originating from the great glacier mass of Chema-Yung-Dung in Tibet, Kailas the southern range. The elevation that area is 5,300m above sea level.

1.1.2 Brahmaputra river Basin

The hydrological character of the Brahmaputra River is distinguished by two hydrological regimes; that are extremely large and variable flows. The annual regime of flow of river in Brahmaputra basin is basically controlled by climatic conditions. The Brahmaputra Rivers is flowing from the Himalayas range of glacier; therefore, it experiences two high-water seasons - one in early summer it is caused by snow melt in the mountains, and one in late summer and is caused by runoff from monsoon rains.

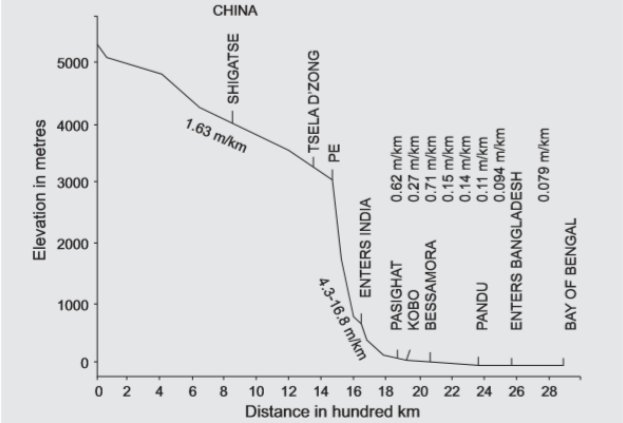


Figure 2. Long profile of Brahmaputra river

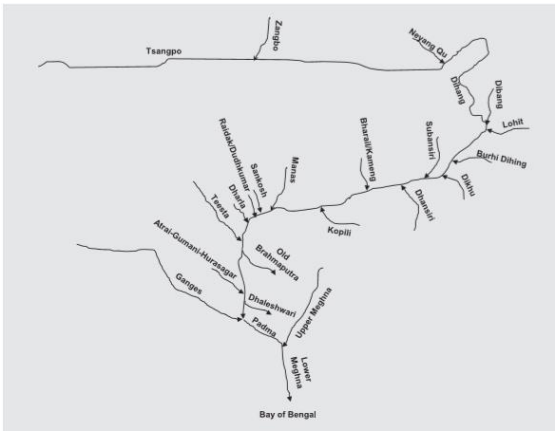


Figure 3. Tributaries of Brahmaputra river

Source: unacadecy.com

The profile of the land form, the Brahmaputra basin has an acutely flood-prone region in area. As a typical area of effect of flood, there is large scale of erosion of riverbank and high flood season. The seasonal effect of flood is synonymous with breach of embankment; this edges are not sturdy enough to withstand heavy pressure of high flood water. The tidal flow of water that inundates the crop fields also brings silt and sandy soil in agricultural field, rendering the cultivatable lands unsuitable for immediate cultivation. Also, Assam faced with many water problems. It causes flood during the monsoon season and creates various issues and problems. Along the flood it also causes the soil erosion, crops; these floods caused by long and heavy spells of rain and causes very severe loss of lives and property and shamble the economy of the state.

1.1.3 River edge and Erosion

Erosion and sedimentation are natural phenomenon and processes in every river bank area, but often are in conflict with our use of the shorelines and river banks. The most noticeable problem created by erosion is the loss of waterfront i.e. river bank's property (Bakhteri, 2014). River banks' erosion is caused primarily by high flow velocity, wind driven waves and to a minor extent by wakes from operating boats in some parts. Wind velocity, duration, and the expanse of open water (fetch) the wind blows over are the predominant factors generating waves that attack and erode the river banks (Bakhteri, 2014). The basic progression of erosion resulting from wave action includes:

i. Attack by waves.
ii. Erosion of a bank causing undercutting.
iii. Slumping of the bank.
iv. Removal, transportation, and deposition of the bank sediments along the shoreline.

2.0 SITE INTRODUCTION

2.1.0 Location and site boundary

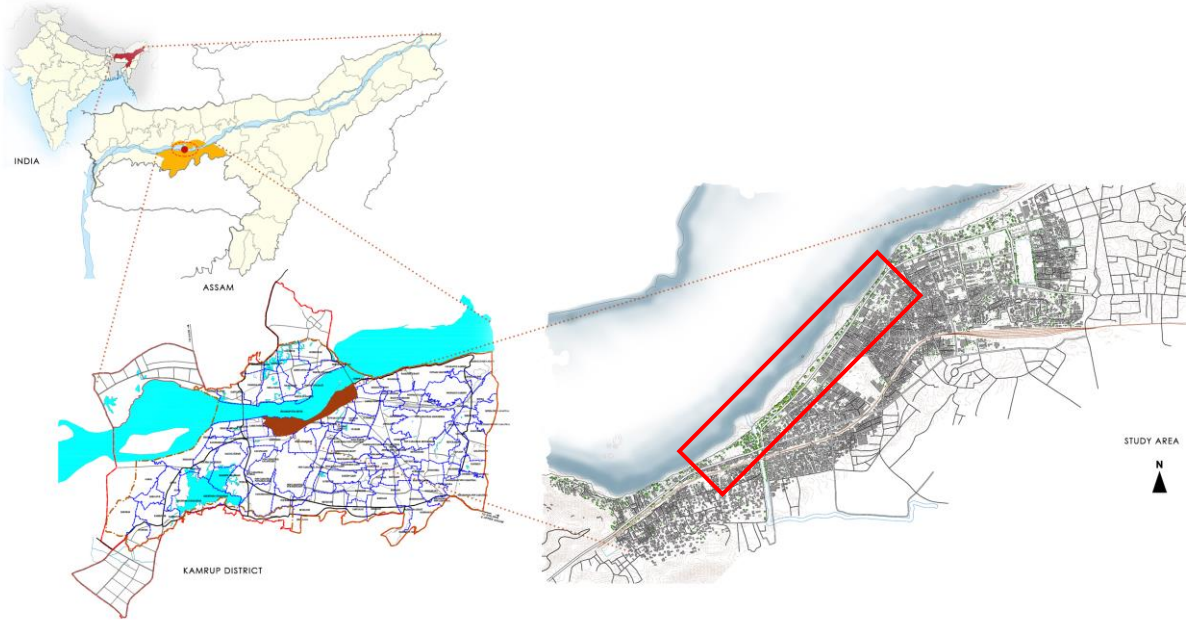


Figure 4. Location Map of State Assam and Site in India

- LATITUDE : 23°N to 32°N
  LONGITUDE : 82°E to 97°50'E
  ELEVATION : 3,000-5,000m M.S.L (under Tibetan plateau)

- SITE AREA : 71 Acres (287327 Sq. m.)
  LENGTH : 2.0 KM

The mighty Brahmaputra river flows across the state of Assam separating it into two parts. The largest city Guwahati lays along the bank of the river. The life of an urban settlement including with many historical places, temples, commercial market place, a river island, Ghats and ferry ports, is laying along on its edges.

The area is located along the south bank of the river and spans across a part of the central area of Guwahati with distinct natural features and historical mythology as well as the place has old settlement in the city

2.2.0 History and evaluation of Guwahati City

Traditionally, Guwahati has been an important administrative and trading center and a river port. The ancient city of Guwahati, witness on puranas was mentioned about the Guwahati city known as Pragjyotishpura in their historical scriptures and compositions (Guwahationline, 2019). The area is known for some existing historical places such as the *Kamakhya* temple, *Basistha* temple, *Navagraha* temple bounded surrounding the city at bank of the Brahmaputra river.

The ancient Guwahati city was the main place for authority, civil and military administrative area of Ahom kingdom, the ruler of Assam before 600 years ago. During that time, they resided in the present day Fancy Bazaar and Bharalumukh area of Guwahati. The present campus of Deputy Commissioner was the residential quarter of the Borphukan for above hundred years during the rule of the Ahom (Guwahationline, 2019).

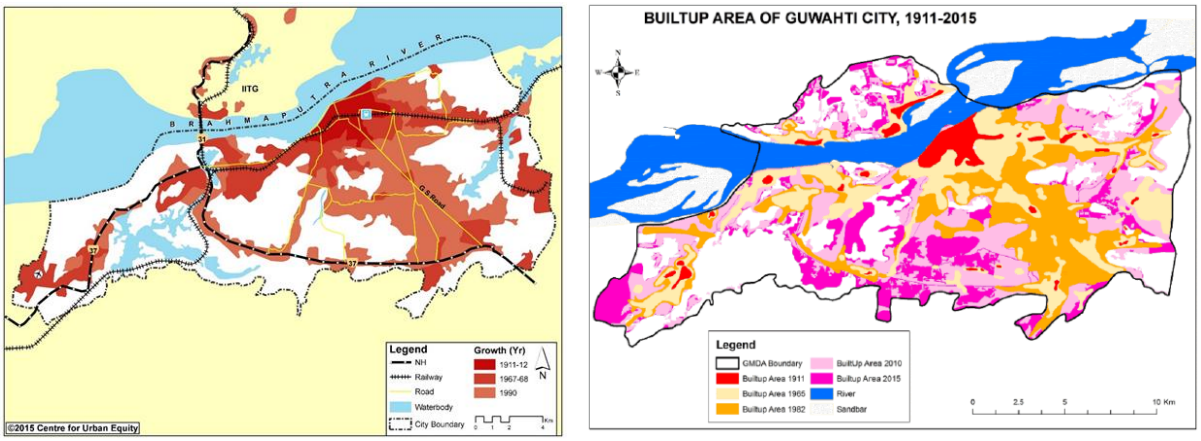


Figure 5. Map showing - (a) Urban sprawl and (b) population growth of Guwahati city

Source: GMDA

The settlements have been started growth from the south bank of the Brahmaputra river in the city, the area near Bharalumukh to Uzan bazar. Then since the year 1911, when the population growth increased the city and urban sprawl have been spread and extended the city. The area has developed by the major commercial hub by the trading system, Indian oil refinery, local resource, traditional market, transportation facilities and educational institutions. In 1972, the division of the states between Assam and Meghalaya also effected on the population growth. The State Administration Board of Assam is shifted from Shillong to Guwahati city at Dispur, this has been growing the city very rapidly in population as well as the socially and commercially of the city.

3.0 LITERATURE REVIEW

3.1.0 Flood line of Brahmaputra river basin

The Brahmaputra river has severe experience of floods on yearly basis. The immense floods cause due to the passage of river through the wettest region of India. this floods brings death and devastation to the entire valley of Assam and also to the neighboring country of Bangladesh.

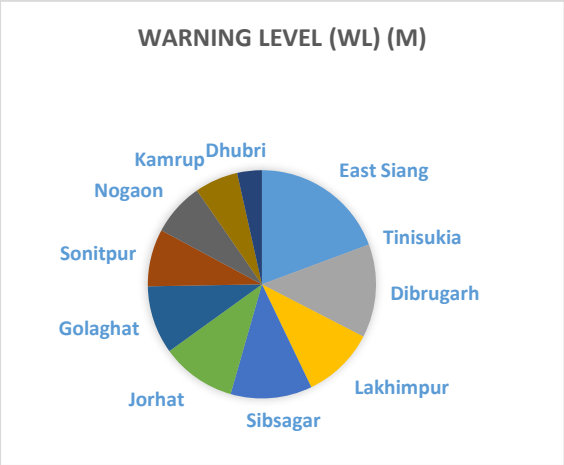
On 15th August 1950, the entire Assam region experienced a terrible earthquake. This earthquake altered the course and bed levels of many rivers in this region. The earthquake caused a sudden rise of bed levels at Dibrugarh and many other places by bringing down a large mass of debris, consequently changing the river's morphology (Dhar & Nandargi, 2000).

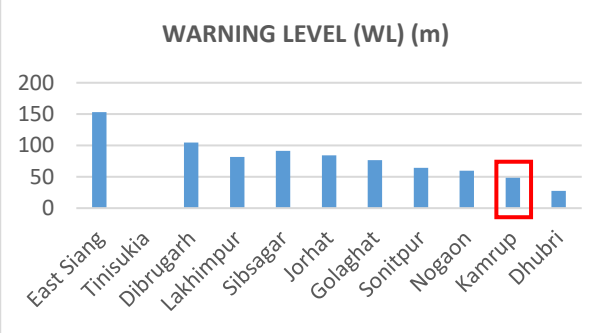
At that particular site, when the water level crosses the danger level (DL) is usually known for the flood at that area. A flood is the excess level of water that rises to overflow and submerged on the land. Major floods are those when water level is 1 m or more above the DL and if it is 5 m or more above the DL, that flood is said to be catastrophic (Dhar & Nandargi, 2000).

The highest floods recorded in the Brahmaputra basin in the Assam Valley during 1987–1998, during the monsoon months June–September (Dhar & Nandargi, 2000). The river is experienced the worst flood during the month of July and August. Since the late April and May month the considerable rainfall has started all over Assam valley, reason why the tributaries of river Brahmaputra cause quickly by the runoff with overflow. This exceed water is fall to the main stream and caused the valley by flood.

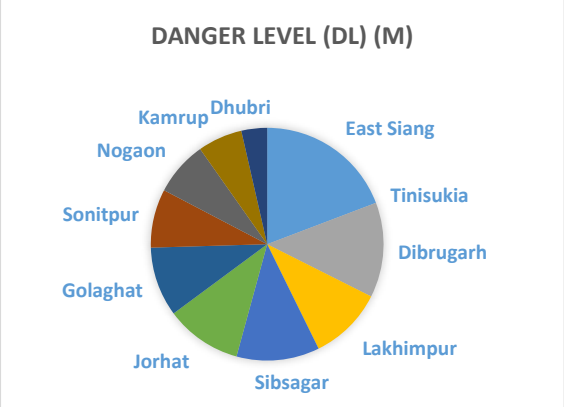
Table 1. Flood levels of Brahmaputra and its Tributaries

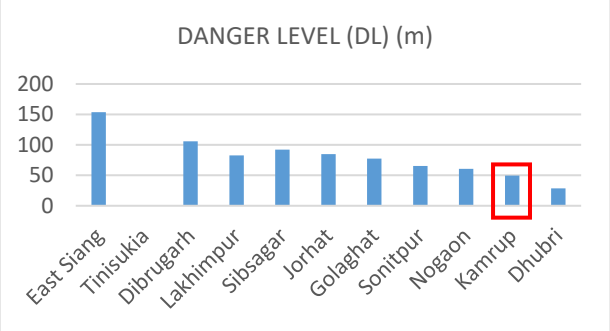
FLOOD FORECAST (Brahmaputra Basin)									
SL. NO.	**DISTRICT**	**SITE NAME**	**TRIBUTARY**	**WARNING LEVEL (WL) (m)**	**DANGER LEVEL (DL) (m)**	**HIGHEST FLOOD LEVEL(HFL) (m)**	**ATTAINED DATE**	**PRESENT WATER LEVEL (m)**	**TREND**
1	East Siang	Passighat	Siang	152.96	153.96	157.54	11-06-00	148.98	Steady
2	Tinisukia	Margherita	Buridehing	–	–	137.51	26-08-88	131.81	Steady
3	Dibrugarh	Dibrugarh	Brahmaputra	104.7	105.7	106.48	03-09-98	101.91	Steady
4	Lakhimpur	Badatighat	Subansiri	81.53	82.53	86.21	28-07-72	77.06	Falling
5	Sibsagar	Sibsagar	Dikhow	91.4	92.4	94.19	25-06-98	86.41	Falling
6	Jorhat	Neematighat	Brahmaputra	84.04	85.04	87.37	11-07-91	80.4	Steady
7	Golaghat	Numaligarh	Dhansiri	76.42	77.42	79.87	24-09-85	74.87	Falling
8	Sonitpur	Tezpur	Brahmaputra	64.23	65.23	66.59	27-08-88	59.16	Falling
9	Nogaon	Kampur	Kopili	59.5	60.5	61.79	20-07-04	54.31	Falling
10	Kamrup	Guwahati	Brahmaputra	48.68	49.68	51.46	21-07-04	43.78	Steady
11	Dhubri	Dhubri	Brahmaputra	27.62	28.62	30.36	28-08-88	25.39	Steady





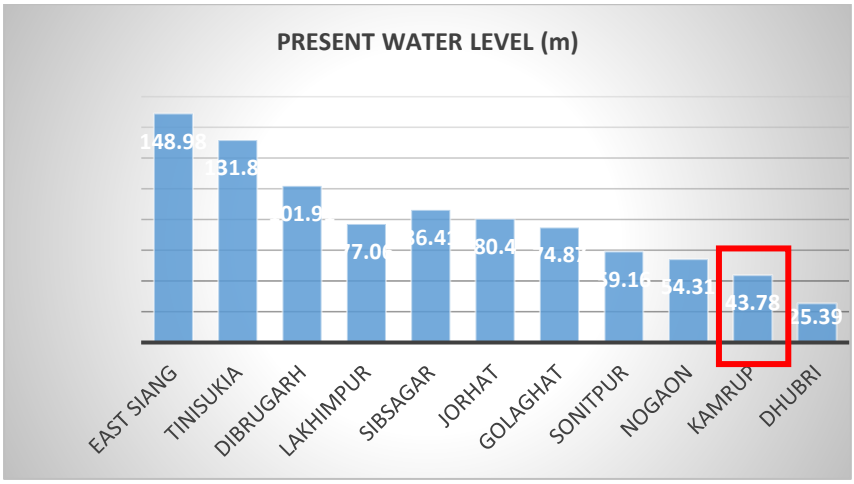
The Warning level at study area is 48.68 m.





The Danger level at study area is 49.68 m.

Figure 6. Graph showing the HFL at Study area



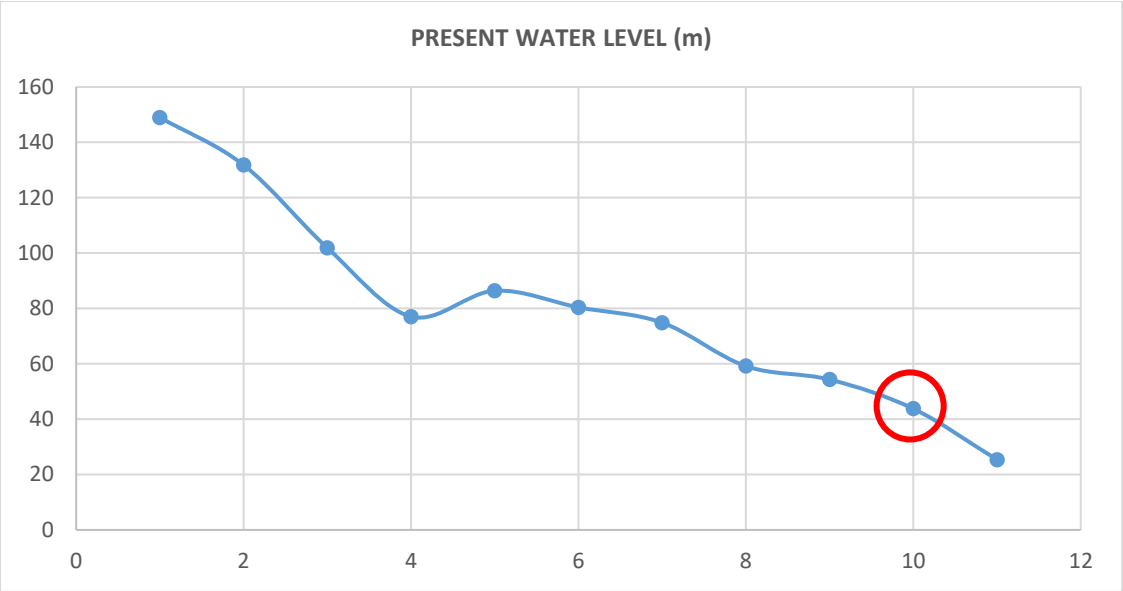


Figure 7. Graph showing the Present water level of the River

From the elevation and Flood line of the Brahmaputra river, the Flood line of the study area, Kamrup District is fall under the 43 to 51 m.

The High Flood Level of the study area is falls under 51.46 m.

Flood prone area of Assam is 39.58 % of the area of the state. Floods are caused mainly by two river systems – the Brahmaputra and the Barak. The geographical setting of the region, high intensity rainfall, easily erodible geographical formations aggravates the floods situation.
-Heavy Rainfall or some continuous spell of heavy rain, or in the upstream region of its main rivers.
-The soft rocks, in the absence of green top cover, easily gives way to gushing waters.
-Sediment load of Brahmaputra is highest in the world and thus it makes 40% of Assam's land as flood prone.
-Human-induced problems like destruction of wetlands, deforestation, and encroachments on river banks.

3.2.0 Issues and Debates

- River edge, soil erosion of the river edge
- Flood issues and the impact of the flood prone areas
- Human intervention of river and the city
- Ecosystem of the river and survival of the habitants
- Transition space between urban area and the river

The issues regarding the river edge and its impact on the ecological, cultural and environmental is to look forward that how to retain it with certain development. The key factors of issues and problems effecting to the areas is to find out for better understanding.

3.3.0 Soil Erosion and Its Control

Erosion and sedimentation are natural phenomenon and processes, but often are in conflict with our use of the shorelines and river banks. The most noticeable problem created by erosion is the loss of waterfront i.e. river bank's property.

a. Protection methods against river bank erosion

River banks' erosion is caused primarily by high flow velocity. There are a number of different ways of using trees or parts of trees to protect eroding river banks. The technique or combination of techniques that will work best depends largely on the energy of the river, flow energy level of the river (SEPA, n.d.).

b. **Side slopes of guide bund** - The side slopes of guide bund have to be fixed from stability considerations of the bund which depend on the material of which the bund is made and also its height. Generally the side slopes of the guide bund vary from 2:1 to 3:1 (H:V).

c. Approach embankment

Where the width of the river is very wide in an alluvial plain, the diversion structure is constructed with a restricted waterway for economy as well as better flow conditions. The un-bridged width of the river is blocked by means of embankments called Approach embankments or tie bunds.

d. **Groynes** or spurs are constructed transverse to the river flow extending from the bank into the river.

e. Marginal embankments

These are earthen embankments, also known as levees, which are constructed in the flood plains of a river and run parallel to the river bank along its length. The aim of providing these embankments is to confine the river flood water within the cross section available between the embankments. The flood water of a river is thus not allowed to spill over to the flood plains. This kind of protection against flooding has been provided for most of the rivers of India that are flood prone with low banks and have extensive flood plains in the last century.

f. Riprap Blanket

Blocky in shape rather than elongated, as more nearly cubical stones, the stone should have sharp, clean edges at the intersections of relatively flat faces. Cobbles with rounded edges are less resistant to movement, although the drag force on a rounded stone is less than on sharp-edged cubical stones. As graded cobble interlock is less than that of equal-sized angular stones, the cobble mass is more likely to be eroded by channel flow.

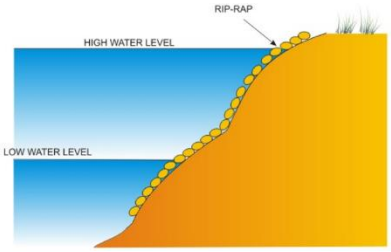


Figure 8. Section of Riprap Blanket

g. Trenchfill

A trenchfill revetment, is simply a standard stone armor revetment with a massive stone toe. It is normally constructed in an excavated trench behind the river bank, in anticipation that the river will complete the work by eroding to the revetment, causing the stone toe to launch down and armor the subsequent bank slope.

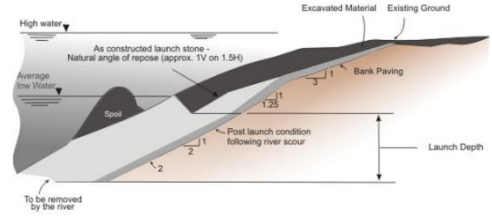


Figure 9. Section of Trenchfill

h. Vegetation (Fascine) Mattress

Wooden mattress is one of the oldest techniques of bank stabilization, even though it is seldom used now in developed regions. The mats may be made of poles, brush, or lumber. The material can be fastened together by weaving, binding, cabling, clamping, or spiking. The mattresses are sunk by ballasting with stone or other heavy materials. Some types of mat may be so buoyant that the ballast is a significant component of the protection, as well as a large part of the cost.

4.0 PROJECT INTRODUCTION

4.1.0 Synopsis

The mighty Brahmaputra river flows across the state of Assam separating it into two parts. The largest city Guwahati lays along the bank of the river. The life of an urban settlement including with many historical places, temples, commercial market place, a river island, Ghats and ferry ports, is laying along on its edges.

A riverfront is an interface between a settlement and the river. Thus riverfronts are sensitive zones, supporting the prevailing biodiversity, and creating a transition between human settlements and the water body.

The riverfront is located along the south bank of the river and spans across a part of the central area of Guwahati. This project is an attempt to develop a riverfront area that protects the existing biodiversity and the natural topography and also responds to function as a city level recreational space.

4.2.0 Aim

"To design a landscape proposal for rejuvenating the river edge."

"To design and develop a recreational place along the edge of urban area at Kachari Ghaat in Guwahati using landscape intervention."

"To develop a transition space for the betterment of the experience and enhance the edge between the river and dwellers."

4.3.0 Need and Importance of the Study

The site is the most active part of the city. It is connected the other bank of river to another by ferry terminals, also the most tourist attracted site for river island and temple Umananda. Existing park at river bank and open market Fancy bazar attach to the river edge is the most crowded area of the city.

- The site has a beautiful setting at the water's edge that has not been fully embraced.
- The site is well connected, yet there is a fragile pattern of urban life with few informal activities taking place.
- There are several historically and culturally significant monuments and in close proximity to the site. But it does not translate into a public space.
- Most of the activities are not considered as necessary activities, such as recreational and commercial spaces.

4.4.0 Objectives

- To identify the quality and value of space of existing Ghaat and Public park.
- To analyze the suitable solution to conserve and protect the Brahmaputra river edge.
- To design an effective Ferry terminal for both public and tourist to interlink the both sides of river edges.
- To establish an eco-friendly urban parks with public recreational spaces at city level.
- To enhance the inter-relationship between natural and cultural aspects.

4.5.0 Scope of the Study

This can be categories in three major parts-

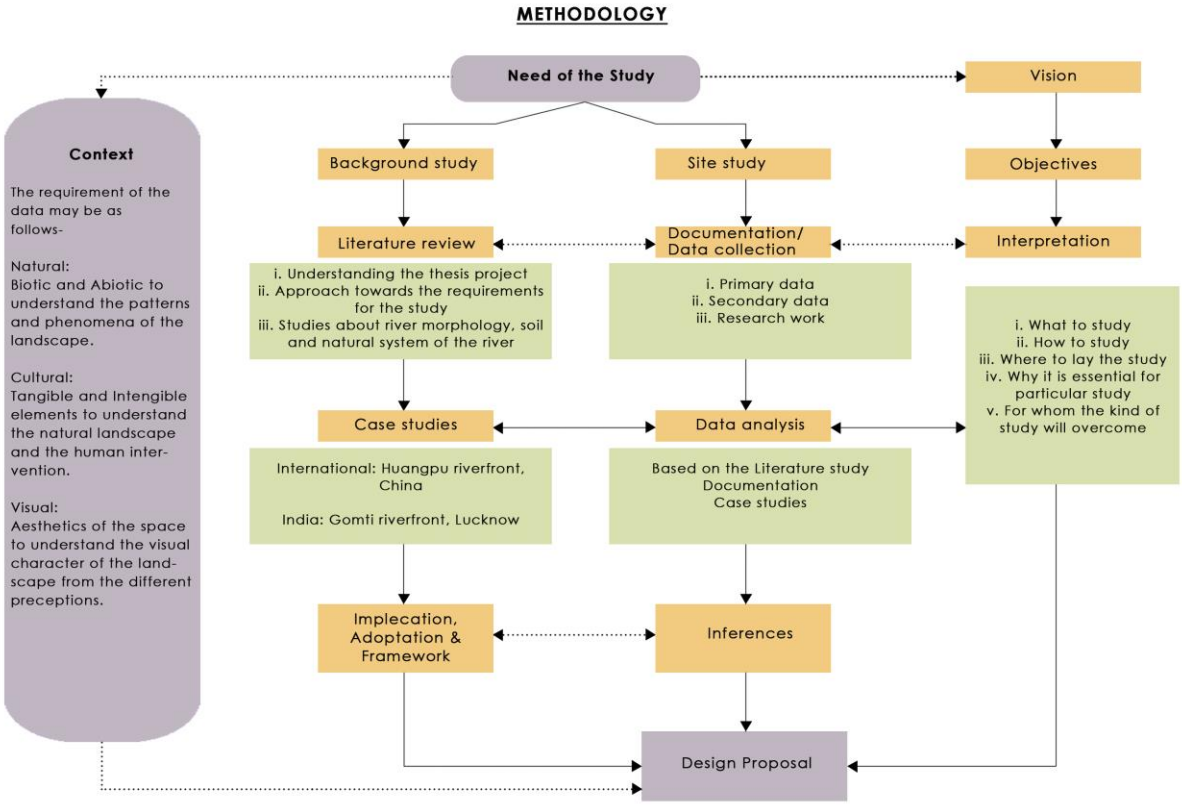
-**Studying Cultural landscape** and **Theories** for such varied disciplines,

- **Parameters** of the issues with respect to key activities, and

- **Synthesis framework** for future development.

I. **Identity**: The place itself represents a strong identity of importance of the place by historical period of time.
II. **Resources**: The mighty river Brahmaputra is the major source of the natural resources of the region. Diversity of Flora and Fauna, intervention of the habitants is monitoring in natural resources.
III. **Value**: The landscape value, economical value, social value, historical and religious value, and visual quality of the area.
IV. **Management**: The socio-culture activities, recreational, public parks, open areas, Ghaat, social togetherness, health hazardous is the management strategies of the area.
V. **Future development**: The opportunity for green parks and environmental sustainable development for future development program.

4.6.0 Methodology



4.7.0 Vision

"**The project aspires to deliver an integrated space by creating a corridor to define the identity of the space and revitalize the landscape between the transition**."

4.8.0 Expected Outcome

- Looking into the issues of the present riverfront and its misused activities, it is necessary to protect and revitalize the mighty river edge.
- Using techniques to control the eroded edge conditions, proper design for ferry terminals for every seasons, treatment for existing Bharalumukh canal which is directly connected to river Brahmaputra.
- Also, it is idea to connect the people with recreational spaces and other activities to relive the city and riverfront with landscape intervention.

"The intension is to design and deliver a transition space for river and human to divert the behavior of the present activity to develop a socio-activity space; also to enhance the visual."

5.0 Case Studies Identification

5.1.0 Gomti Riverfront Development, Lucknow, India

The Gomti river is an important tributaries of River Ganga. It is an alluvial river of the Ganga plain. It is a monsoon and groundwater-fed river originated near Mainkot, from a lake– 'Fulhar Jheel' in Madhotanda, about 30 km. east in Uttar Pradesh at an elevation of 185 m. This river flows from North-West to South-East direction.

The characteristic of the river is perennial. The river is characterized by sluggish flow throughout the year, except during the monsoon season, when heavy rainfall causes a manifold increase in the runoff. Majority of the surface area of the Gomti Basin is generally flat, sloping towards South and South-East with altitude varying from 200 m. to 62 m. above MSL.

Figure 10. Imagination of Architects for Gomti Riverfront development

(Source: IWRD, Domti riverfront development, UP)

5.1.1 Challenges:

- The Gomti has been stressed, particularly in and around Lucknow, for decades. There are three major issues:
- Embankments: High embankments were built around the river to protect the population of Lucknow after a major flood during 1970s, altering the Gomti's natural floodplain.
- Pollution: The Gomti has 40 natural drains, of which 23 are major. The drains, which carried surplus water into the river during the monsoon and recharged the underground water table, were reduced to carry residential and industrial sewage into the river.
- Development: The river's floodplains and fertile land were covered with residential areas, such as Gomti Nagar and Triveni Nagar. The Gomti began receding during the late 1970s, and was under major stress in 2016.

Figure 11. Existing Image of Gomti River

(Source: GRD, UP)

5.1.2 Design Strategies:

- Works of Beautification and development of a green belt along both sides of the Gomti River.
- Proper illumination of all the structures including barrage, bridges and along both banks in the proposed part of the Gomti River.
- Channelization of Gomti River by constructing Diaphragm Wall from Harding Bridge to Gomti Wier.
- Integrated development & beautification on the land to be reclaimed.

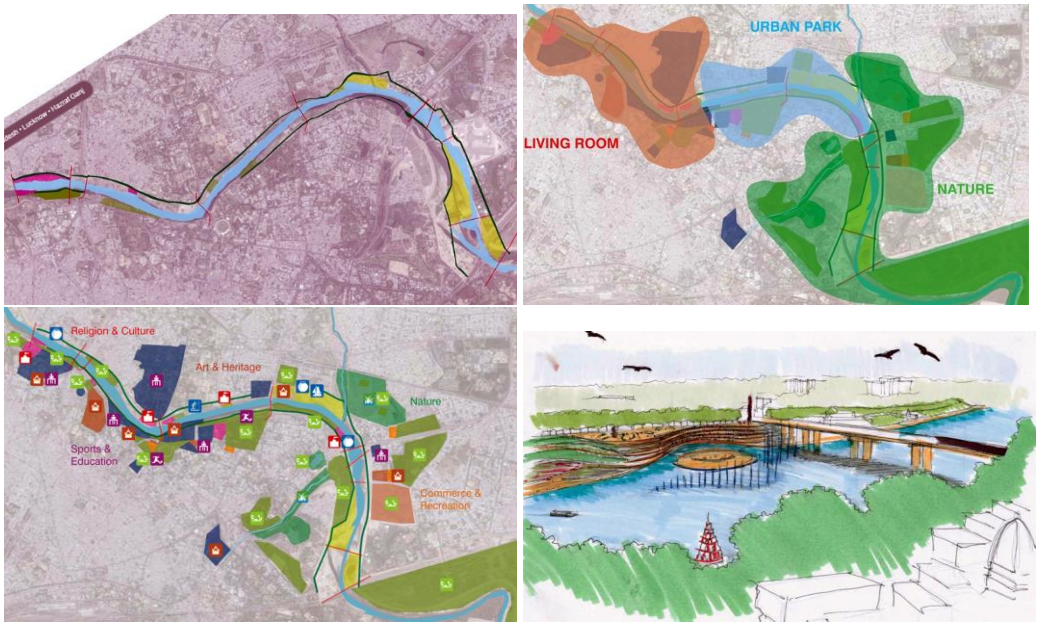


Figure 12. Maps and Expected outcome proposed designs of the Project

(Source: GRD, UP)

5.1.3 Objectives:

To handle the first storm of rainy season which carries the maximum polluted water. To develop the Riverfront by developing green belt on the banks of the River, under which facilities like cycle track, walking track, water sports facilities, water transport and tourism activities can be promoted.

5.1.4 Inferences:

- Creation of a Green Buffer between the city and the river, thus resulting in a natural and effective process of controlling pollution levels in the city and the river banks
- Creation of a public space for recreation that is sensitive to the riparian zone and the buffer zone along the length of the river in the city

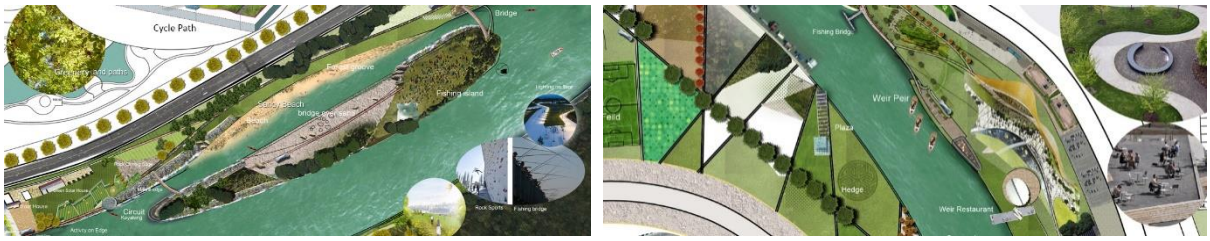


Figure 13. Proposed design by Architects *(Source: GRD, UP)*

5.2.0 Huangpu Riverfront Development, Shanghai, China

Houtan Park, is a regenerative living landscape developed along Shanghai's Huangpu river front. The park's constructed wetland, ecological flood control, reclaimed industrial structures and materials, and urban agriculture are integral components of an overall restorative design strategy to treat polluted river water and recover the degraded waterfront in an aesthetically pleasing way.

The site is a narrow linear 14-hectare (34.6-acre) band located along the Huangpu River waterfront in Shanghai, China. This brownfield, previously owned by a steel factory and a shipyard, had few industrial structures remaining and the site was largely used as a landfill and lay-down yard for industrial materials.

Figure 14. Proposed Design of Huangpu Riverfront Development *(Source: landscapeperformance.org)*

5.2.1 Challenges:

- Restoring Water Quality: Construction and Demolition waste and industrial waste polluted the river water prior to this intervention making it unsuitable for aquatic life and recreational use.
- Place Making - the need for public space: The eminent site design challenge was to transform this degraded landscape into a safe and pleasant public space.

- Improving Flood Control: There existed a 6m tall rigid and lifeless concrete flood wall which limited accessibility for the public. There was a need to develop a more accessible yet robust flood control system.
- Physical Constraints: The site itself was a challenge. The area is long and narrow locked between the Huangpu River and an urban expressway with water frontage is over 1.7 kilometers (one mile) in length but averaging only 30–80 meters (100-265 feet) in width.

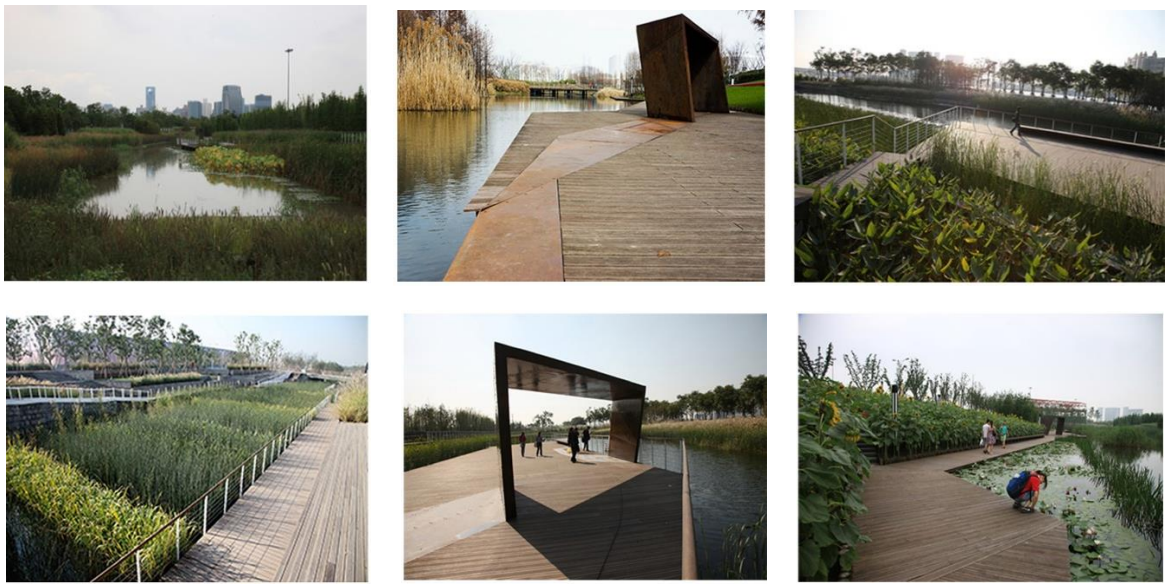


Figure 15. Image of Proposed riverfront project and outcomes - (a) Contaminated water inlet with a 300m long aqueduct, (b) Existing Dock reused as a Landscaped Platform, (c) Terraced Wetland, (d) Constructed Wetland, (e) Reused Steel Arbor, (f) Constructed Pond with cleansed water

(Source: landscapeperformance.org)

5.2.2 Design Strategies:

- Constructed Wetland and Regenerative Design:
  Through the center of the park, a linear constructed wetland, 1.7 kilometers (one mile) long and 5–30 meters (16.5–100 feet) wide was designed to create a natural treatment system to treat contaminated water from the Huangpu River.
- Flood Protection:
  The wetland also acts as a flood protection buffer between the 20- and 1000-year flood control levees.
- Heritage and Vision:
  Terraces were created to break down the 3–5 meter (15–18 foot) elevation change from the water's edge to the road, and to slow the runoff directed to the stream in the constructed wetland.
- Path Network:
  The pedestrian network is composed of a main loop, a series of perpendicular roads bisecting the wetland and a multitude of footpaths leading through the terraces.

5.2.3 Inferences:

- Layered Filtration through a terraced constructed wetland is an effective technique to treat sewage water in an Urban or Suburban context.
- Soft Edges are beneficial to conserve biodiversity in urban wetlands especially along riparian zones.
- Reuse of existing infrastructure help conserve and contextualize the landscape of river edges both in terms of ecological sensitivity and aesthetics

6.0 SITE DOCUMENTATION AND ANALYSIS

6.1.0 Climate

The area under study falls under humid, subtropical region characterized by warm humid climate with heavy rainfall and relatively cools winter, with rather scanty rainfall. Seasons can be categorized as humid, tropical monsoon climate with a prolonged monsoon season from May to September, a relatively cool, dry winter from October to February and a pre-monsoon period in March to May with occasional founder storms. Temperature ranges from 10.60°C to 32.0°C.

According to Barthakur (1986), the climate of the region can be divided into four seasons.

I. **Retreating Monsoon** –
   -Starts in early October to Winter in November.
   -clear sky and negligible rainfall (50mm).
   -Temperature goes down (22°C - 25°C)
   -Morning mist and fogs start appearing.
   -Relative humidity (RH) varies from 70 – 77%.

II. **Winters-**

-This season extends from December to February.
-Temperature goes down to 9.3°C.
-Rainfall is scarce and generally does not exceeds 30 mm.
-Occasionally foggy morning, clear sky and mist at night are the characteristics of this season.
-Sometimes thunderstorms occur in winter.
-RH per cent varies from 67 – 84%.

III. **Pre Monsoon-**

-This season begins from March to early May.
-Slight rise in temperature (28°C).
-Vanishing of fog, windy, occasional thunder-shower is the common features of this season.
-In the early hours of the day, the wind becomes strong, raises dust and occasional unpleasant dust storm begins reaching its peak in the afternoon.
-Foliage and flower begins to sprout in the deciduous forest.
-RH ranges between 68 – 73%.

IV. **Monsoon-**

-The monsoon begins towards the mid of April month and continues till the end of September.
-Generally the hottest months (33°C).
-Cloudy weather and continuous rainfall with frequent thunder showers.
-RH ranges from 82 – 94%.

6.1.1 Climate Data

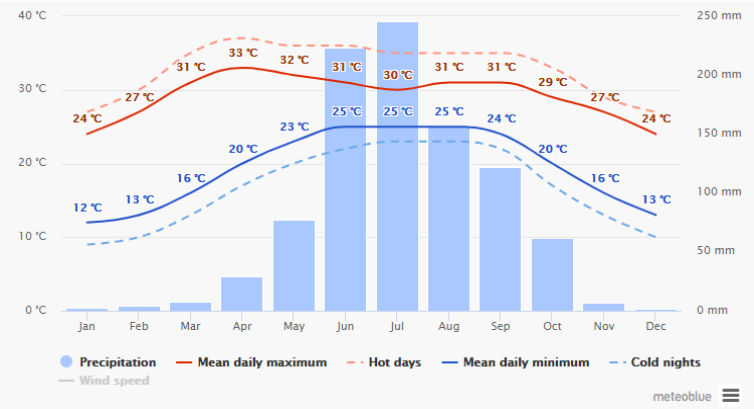


Figure 16. Average temperatures and precipitation

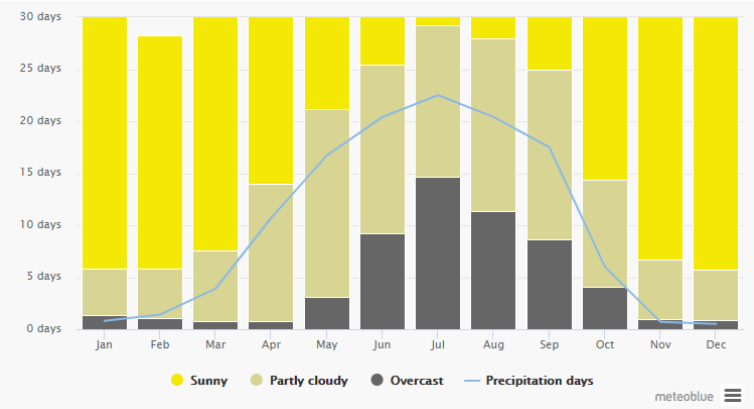


Figure 17. Cloudy, sunny and precipitation days

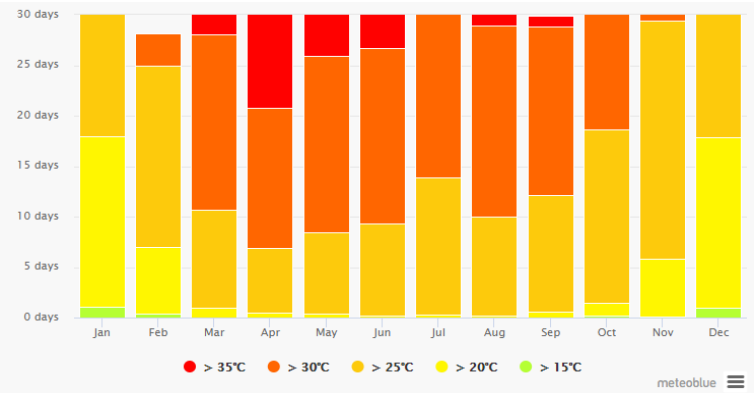


Figure 18. Maximum temperature

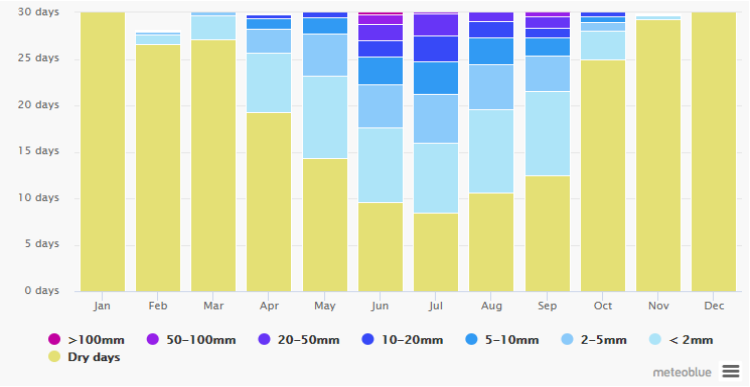


Figure 19. Precipitation amount

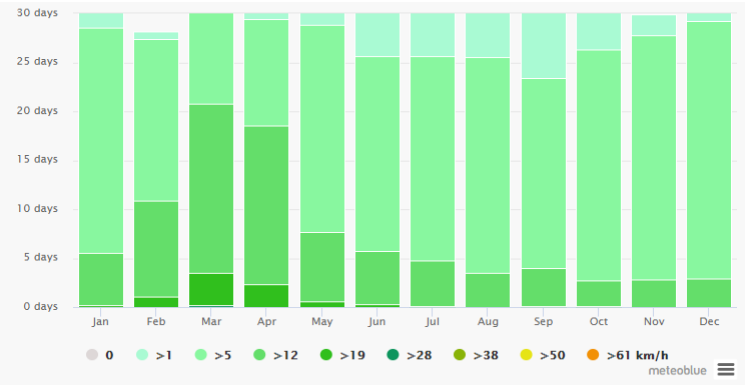


Figure 20. Wind speed

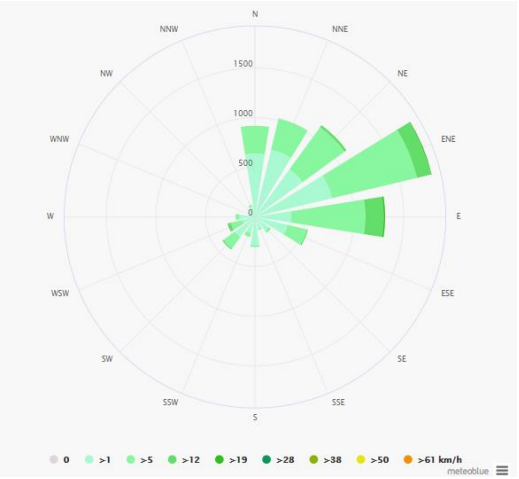


Figure 21. Wind rose

Average Climatic Data

- The Climate is **subtropical and humid** but the weather is **not extreme**.
- The minimum average temperature around **19°C**, maximum stays around **29°C**.
- During **winters** the temperature can get as **low as 10°C**.
- The high **humidity** is inherent and often rises past **80%** except during the winter season when it is **dry**.
- The **annual rainfall** received by the city is a healthy **1613 mm**.

6.1.2 Macro Climatic Zone

The Eastern Himalayas can be divided into the following climatic regions: arctic, sub-arctic, temperate, subtropical, and warm tropical. The forests are moist, dense, evergreen, semi-evergreen, or temperate. Precipitation is very high and the forest region is very humid. Sal forests and evergreen trees are found extensively all along the foothills of the Eastern Himalayas. Subtropical forests cover the hills up to an elevation of about 2000 m.

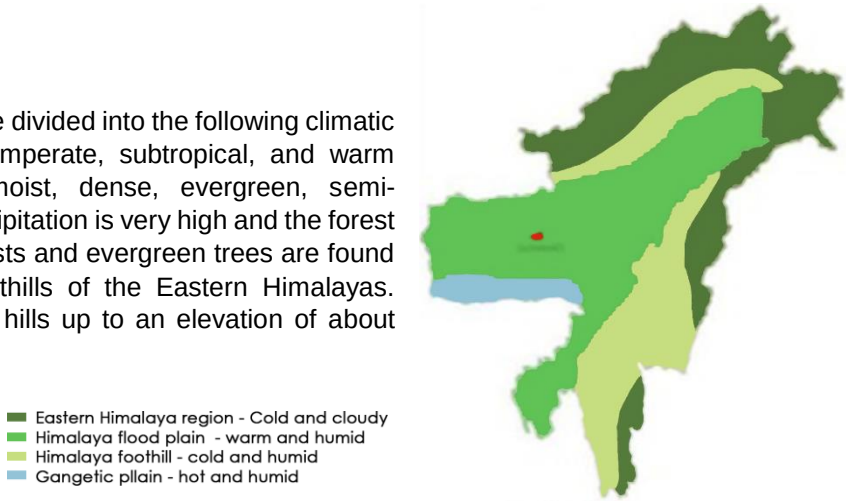


Figure 22. Macro climatic zone of Northeast India

Source: www.slideshare.net

6.1.3 Heat Island

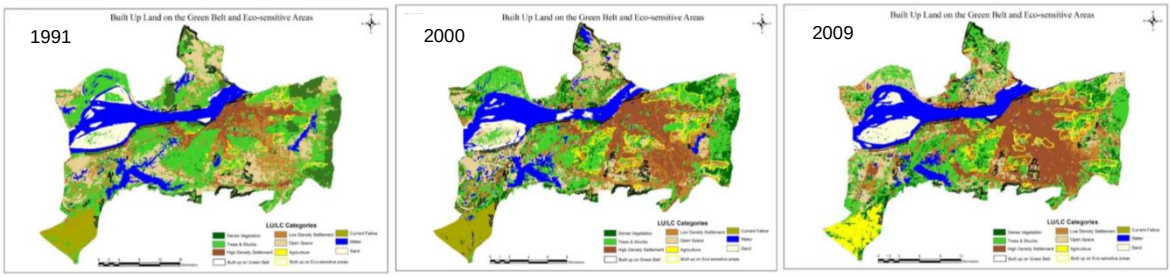


Figure 23. Maps showing the Built-up and loss of Green and Forest cover under the Administrative boundary of Guwahati city.

Source: www.ijsrp.org

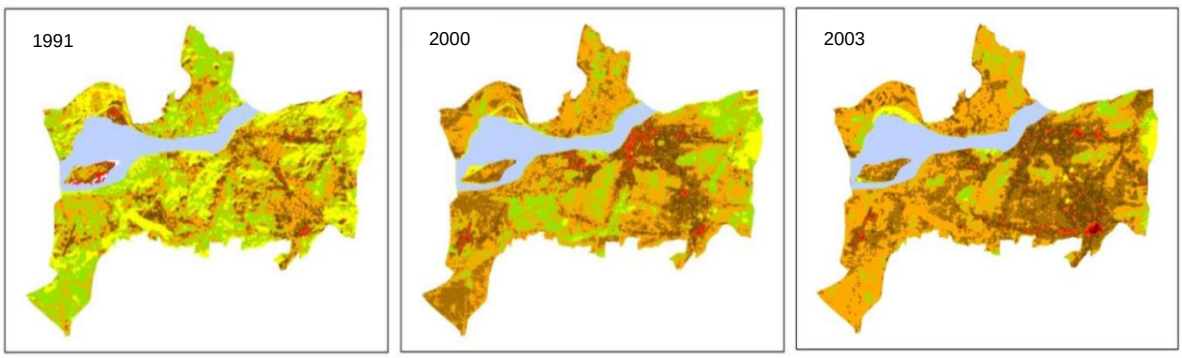


Figure 24. Land Surface Temperature (LST

Source: www.ijsrp.org

- The overall boundary area of Guwahati city has been decreased from 2006 to 2010. In that, Scrub land and Population increased rapidly, whereas, Dense vegetation class is decreased due to rapid urbanization which leads to environmental degradation.
- The low dense Settlement area decreased in 2000, as most of the low density areas were converted to high dense Settlement areas.
- The pressure of increased urban built up land with high and low settlement over the vegetation cover can clearly been seen in the land use/ land cover maps. The dense vegetative cover and the eco-sensitive zones has a declining rate since 2000 to 2009.
- During the last 20 years, the Guwahati metropolitan area has undergone phenomenal change in urban landscape that resulted in the loss of natural land cover. As a result, the surface temperature of the city has increased and a prominent urban heat island is formed in and around the settlement areas.

6.2.0 Geographical Information

6.2.1 Topography

The basin is of irregular shape: the maximum east-west length is 1,540km and the maximum north-south width is 682 km. The basin lies between 23°N to 32°N latitude and 82°E to 97°50'E longitude. The part of the Tibetan plateau falling under the basin has an elevation varying from 3,000 to 5,000m M.S.L and is dotted with numerous glaciers (Singh et al 2004). Immerzeel (2008) categorized the Brahmaputra basin into three different physiographic zones: Tibetan Plateau (TP), Himalayan Belt (HB), and the flood plain.

6.2.2 Geomorphology and Soil type

Physio-graphically, the district can be divided into three units; i.e. the hilly region in the south, the alluvial plain in the central and western part and the swampy areas along Brahmaputra plains. The distinguishable geomorphic units are as follows.

a) Flood plain of river Brahmaputra and its tributaries.

b) Younger alluvial plain which occupies major part of the area, having slightly higher elevation than flood plain.

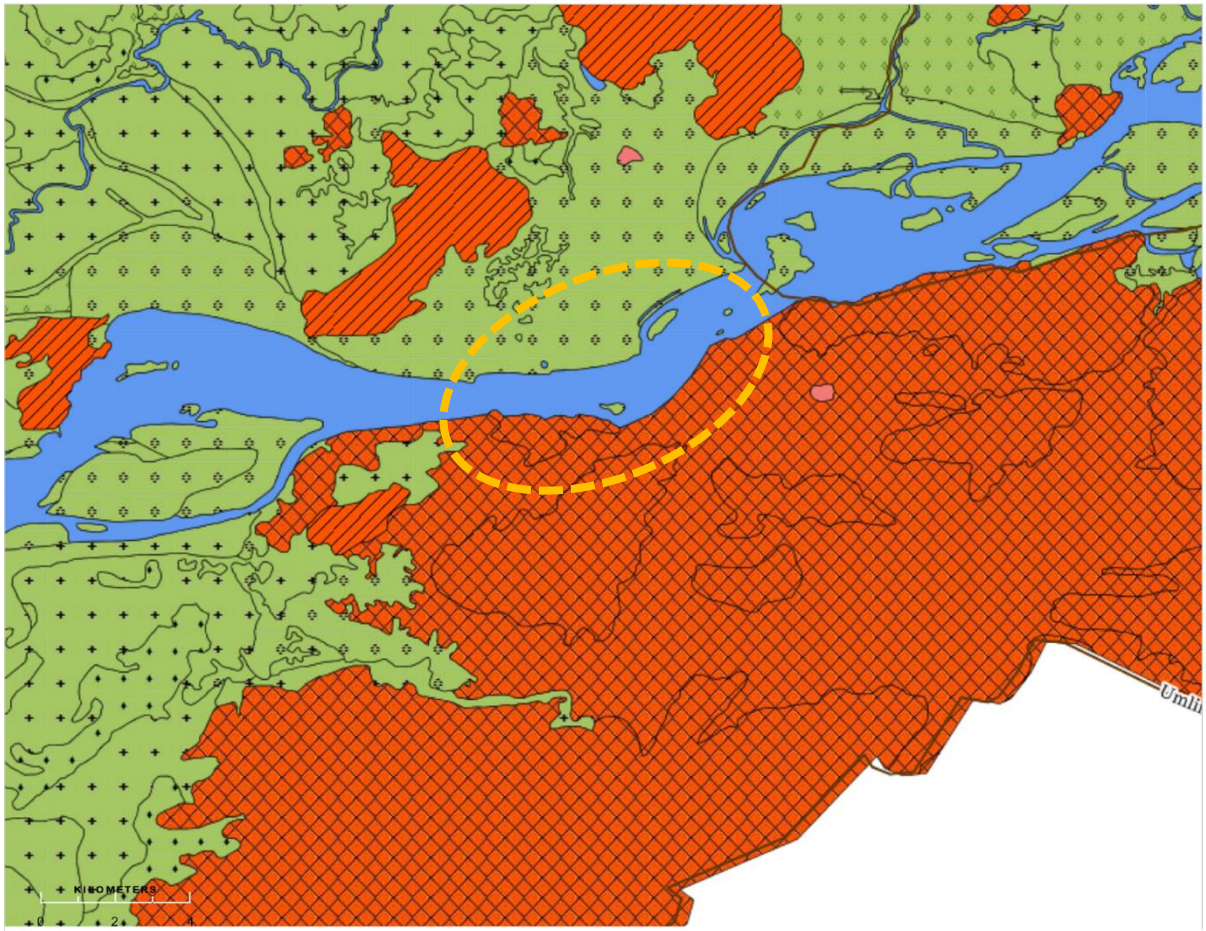
c) Older alluvium/valley fill, gently sloping plain, having higher elevation than the younger alluvial plain.

d) Piedmont, gently sloping plain along the foothills.

e) Inselberg occurs as very small isolated hills.

f) Denotational hills considering of granite, gneissic rocks.

The different rock formation occurring in the district has been subjected to various soil forming processes through agents of weathering and transportation during different geological ages. Soils comprising various proportions of sand, silt, clay and organic material in the district are grouped into three broad categories – a) newer alluvial soil, b) valley fill/older alluvial soil and c) soils over forest and hilly terrain.



Bhuvan

Scale 1:108,141 © GSI, Ministry of Mines & NRSC, ISRO, Dept. of Space, GOI

National Geomorphological and lineament Mapping on 1:50,000 scale using Resourcesat-1 LISS III data

Geomorphology
Structural Origin-Highly Dissected Hills and Valleys
Structural Origin-Moderately Dissected Hills and Valleys
Denudational Origin-Pediment-PediPlain Complex
Fluvial Origin-Older Alluvial Plain
Fluvial Origin-Younger Alluvial Plain
Fluvial Origin-Older Flood Plain
Fluvial Origin-Active Flood Plain
Waterbodies

Figure 25. Map of Geomorphology

Source: Bhuvan

The soil type is mainly **Alluvial** although in the higher elevations it is red laterite type. It is shallow and dry at most places but deep and moist soil is also found in some areas.

The Brahmaputra basin is categorized into three different physiographic zones:
Tibetan Plateau (TP), **Himalayan Belt** (HB), and the **Flood Plain** (FP).

6.2.3 Hill shad

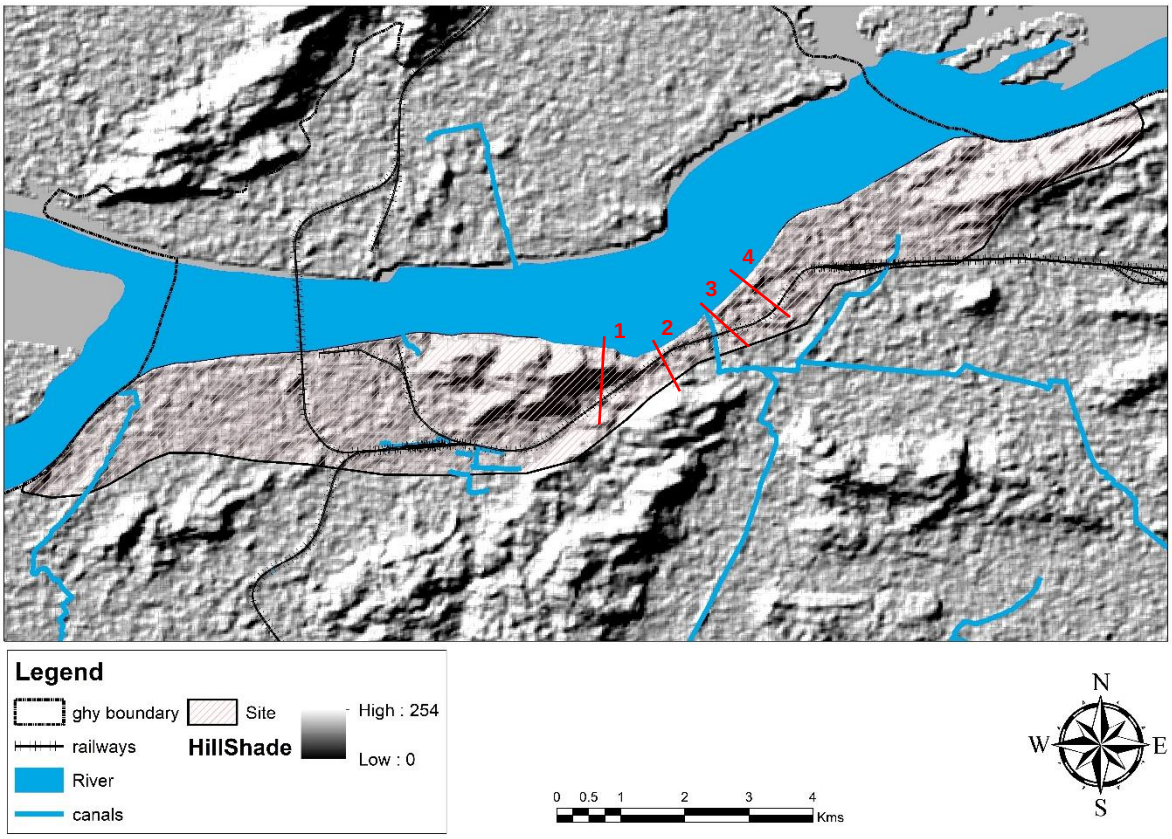


Figure 26. Map of Hill shad

The Southern and Northern part of Guwahati city are surrounded by hillocks. The central part of the city has small hillocks namely *Sarania* hill (193 m), *Nabagraha* hill (217 m), *Nilachal* hill (193 m) and *Chunsali* hill (293 m).

The study area falls under:

- **Structural origin** - Highly **Dissected Hills and Valleys**; and
- **Fluvial origin** - **Active Flood Plain** area on the site.

6.3.0 Hydrology

The area consists of two broad hydrogeological units – 1) Pre-Cambrian consolidated rocks and 2) Quaternary alluvium consisting of unconsolidated sediments (Plate-2). Pre-Cambrian consolidated rocks are confined to hilly areas and inselbergs, where ground water occurs in shallow weathered zone and this can be developed through open wells. The joints and fractures developed due to tectonic activities form potential water bearing zones and suitable for development through construction of bore wells.

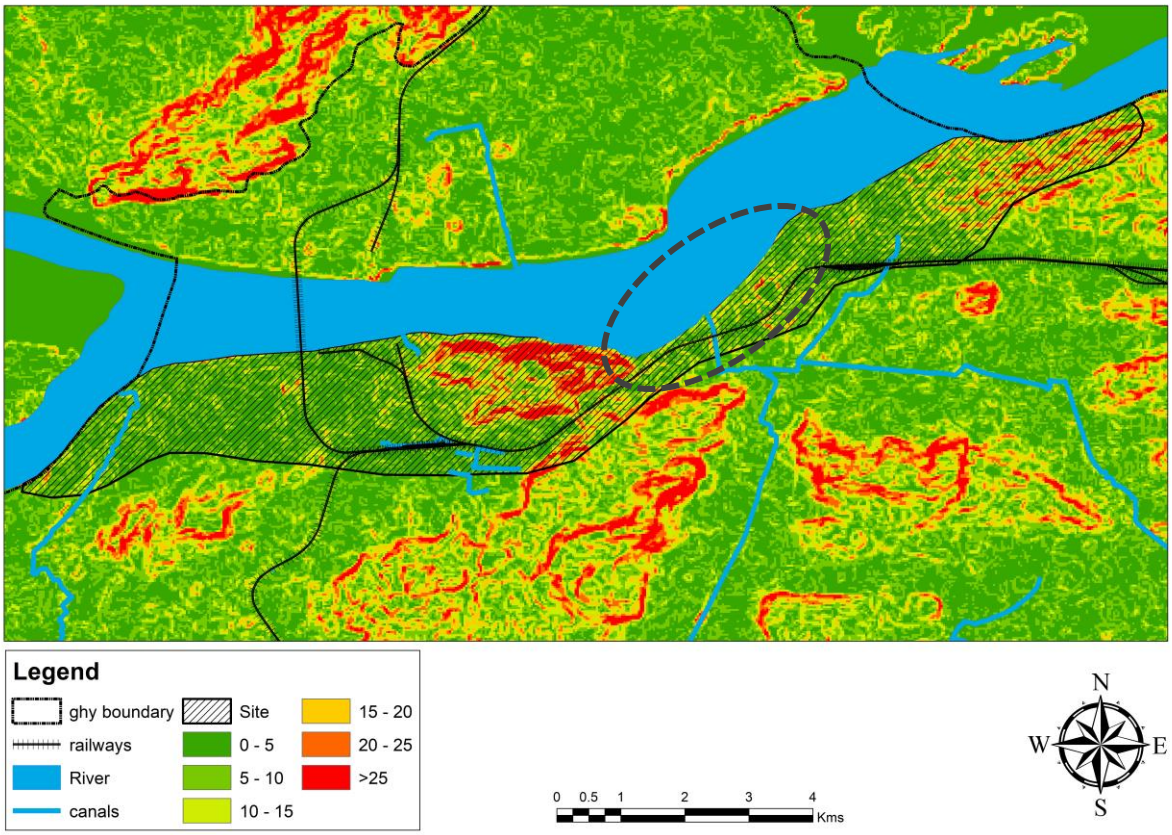


Figure 27. Map of Slope

There are mainly a small river Bharalu which flows through the entire Guwahati city, and perennial and seasonal streams, which drain into the mighty river Brahmaputra. The stream channel Bharalu is now called as dead river which is turned out as a canal. The poisonous drain water is finally meet directly at River Brahmaputra without any water treatment system.

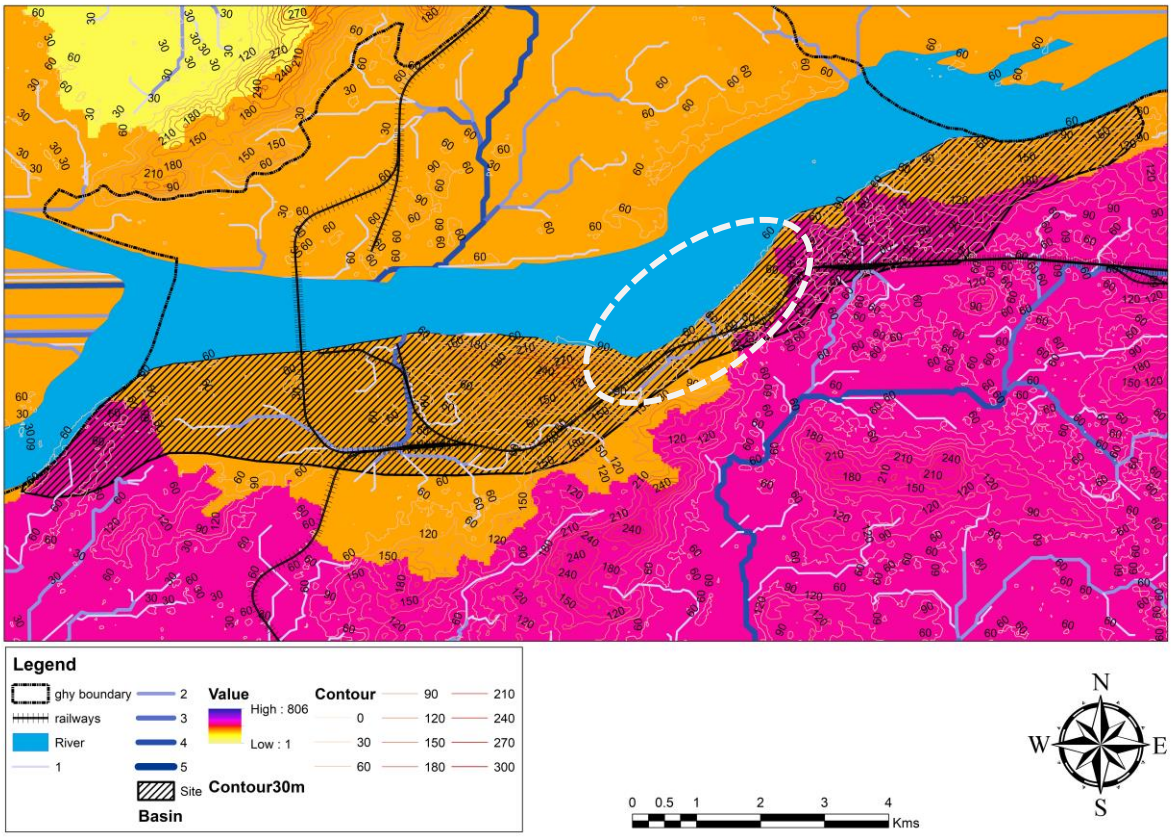


Figure 28. Map of Basin

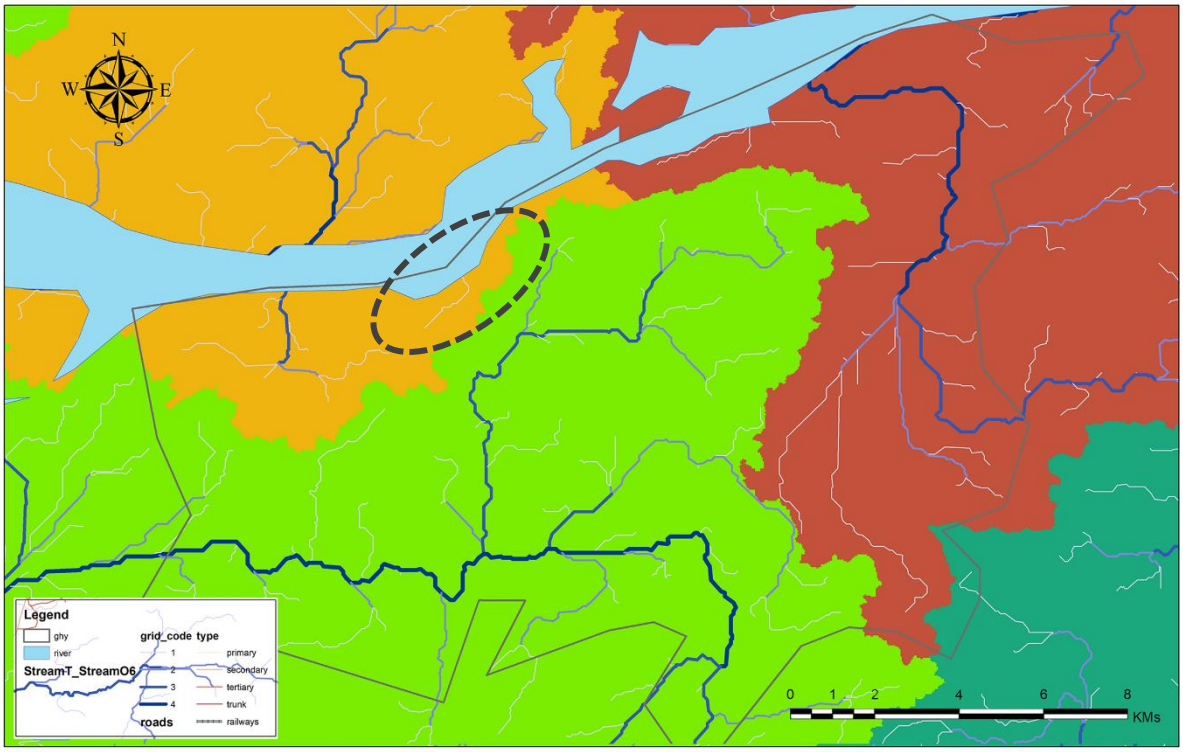


Figure 29. Map of Stream order

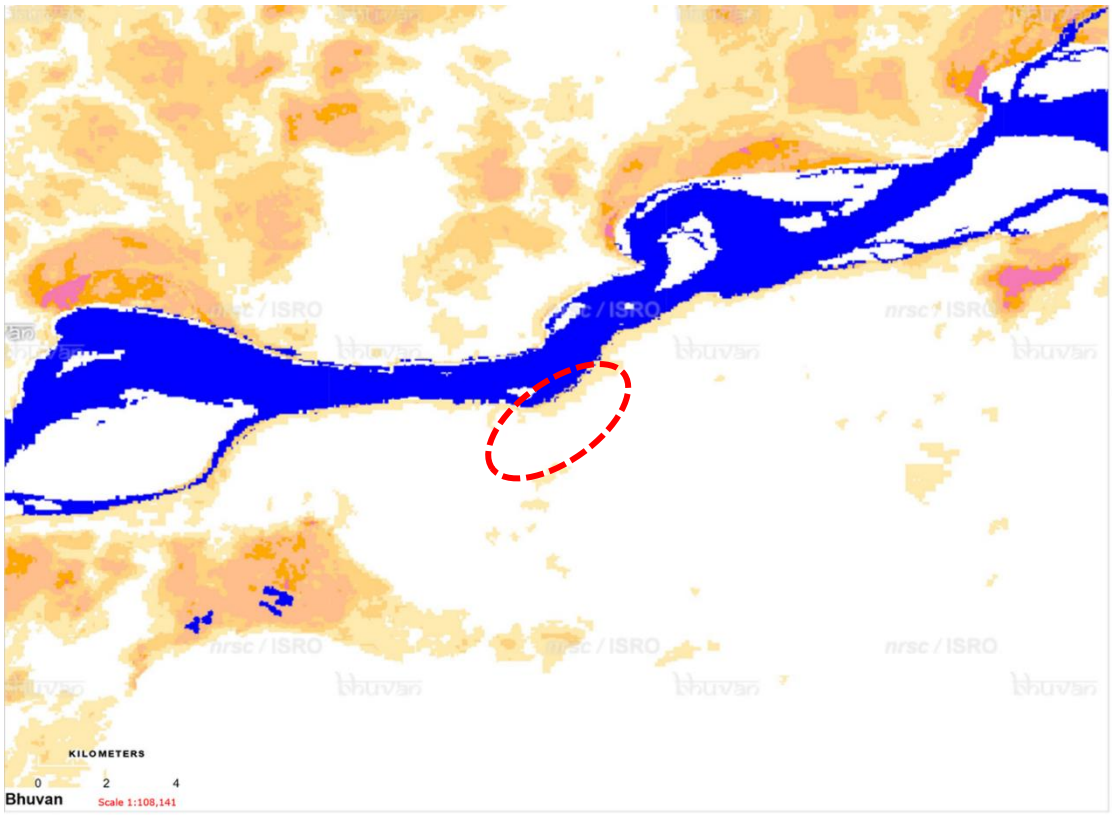


Figure 30. Map of Flood Hazard

- The profile of the site shows that the natural drainage system is towards the River Brahmaputra.
- The heart of the city is effected by the artificial flood during monsoon at present because of the poor planning and settlements.

6.4.0 Land cover and Vegetation

6.4.1 Eco-sensitive zone of Guwahati city

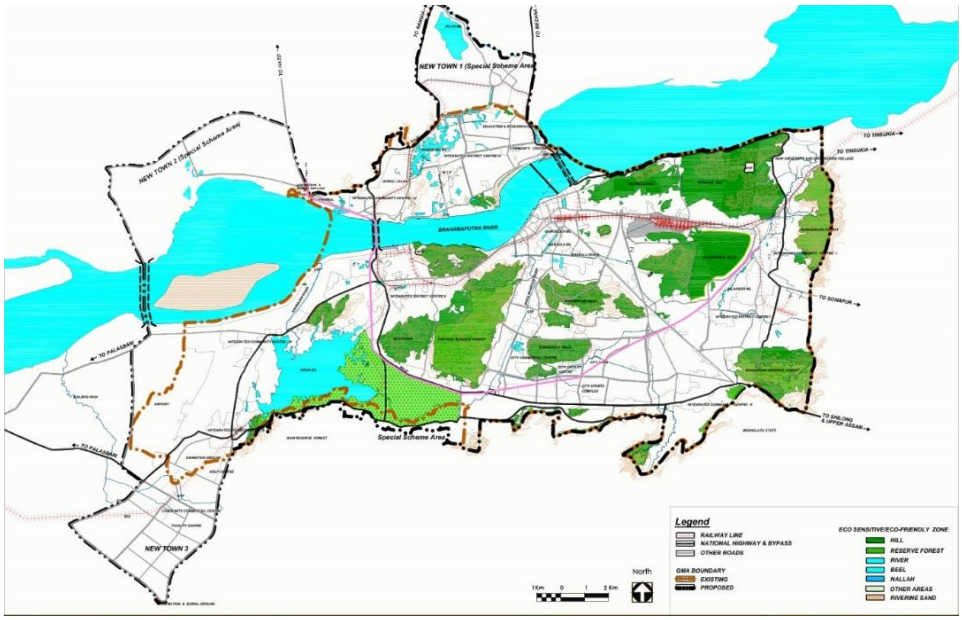


Figure 31. Eco-sensitive zone

Source: GMDA

Table 2. Forest and habited area

Year	Dense forest (Ha)	Degraded forest (Ha)	In habited areas (Ha)	Rate of forest loss (Ha yr^{-1})	Cummulative rate of loss of forest (Ha yr^{-1})
1911	6708.63	0	172.63	0	0
1967	6158.44	0	722.82	9.82	9.82
1986	5619.44	0	1261.82	28.37	14.52
2010	1722.84	1500.62	3657.80	99.83	35.20
2015	1438.49	983.27	4459.50	160.34	41.22

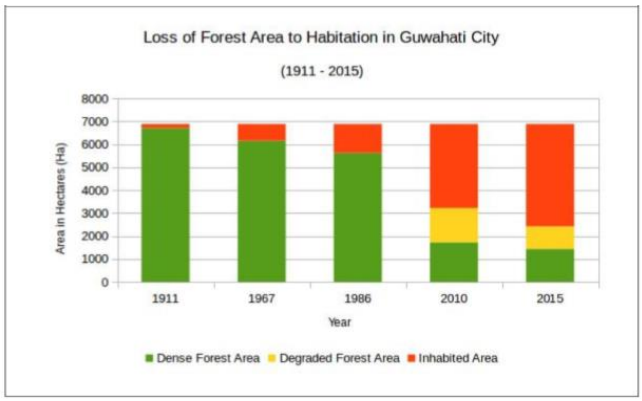


Figure 32. Loss of forest area to habitation in Guwahati city

Source: www.ijsrp.org

The overall boundary area of Guwahati city has been decreased from 2006 to 2010. In that, Scrub land and Population increased rapidly, whereas, Dense vegetation class is decreased due to rapid urbanization which leads to environmental degradation.

A most noticeable phenomenon that has arisen during 2000 is that the growth of new settlement areas along the national highway of the city increased during 2009. The low dense Settlement areas along the national highway have changed to high dense Settlement areas.

Population growth:
-The population of the region migrates to the city is in remarkable rate that we can see from the population growth

Decadal growth:
-The decadal population growth in Guwahati Metropolitan Area is nearly 37.85%.

6.4.2 Forest Type and Canopy Cover

Guwahati falls within the biogeographic Zone - Brahmaputra Valley of India, which has **1432 sq. km** of **forest area**, comprises of

• 69 sq.km of very dense forest,

• 609 sq.km of moderately dense forest and

• 754 sq. km of open forest.

- The forest in this region comprises of **Tropical Moist Deciduous type forests.**
- This forest is further divided into **Sal forest and mixed deciduous forest.**

Mostly, the forest area of the area under Kamrup District is dominated by famous “Khasi hill” and “Kamrup type of Sal forest” along with other valuable timber forest dominated by species such as *Michelia baillonii*, *Gmelma arborea*, *Lagerstroemia parviflora*, *Shorea robusta*, and many important wildlife species (Ltd., 2009).

The Moist Mixed Deciduous forest is a composed of large trees occupy with top canopy by *Schima wallichi*, *Bombax ceiba*, *Lagerstroemia parviflora*, *Chukrasie tubularis*, *Albizia lebbek*, *Stereospermum personatum*, *Albizia procera*, *Terminalia chebula*, *Sterculia villosa*, *Gmelma arborea* etc. Medium sized trees species which forms middle storey and this common trees are *Bauhinia acuminata*, *Holarrhaena antidysenterica*, *Phyllanthus embetica*, *Syzygium cumini*, *Garcinia peduncalata* etc. Some areas are containing with the middle storey trees occupied by bamboos called Dendrocalamus hamiltonii. The various types of bamboos are Bambusa pallida, Bambusa baccoa, Bambusa tulda. Also, the trees ans its species depend according to the type of soil and location varies like other species which is occur in damp locations, especially along perennial streams and edge of nallahs.

In the lower slopes, *Coffea bengalensis*, *Clerodendrum serratum*, *Phlogocanthus thrysiformis* etc. occurs under loose canopies. Ground cover is predominated by such species like *Chromolaena odorata*, *Phyllanthus fratemus*, *Justicia simplex*, *Paederia foetida*, *Costus speciosa*, *Sida cordifolia*, *Desmodium spp*. Different types of grass and sedges such as *Panicum sp*., *Carex sp*., *Cyperus spp*., *Oplismems burmanii.* Climbers are frequently found and most common species are *Clematis cadmia*, *Smilax macrophylla*, *Thunbergia grandiflora*, *Argyreia speciosa*, *Myriopleron externum*, *Combretum decandrum*, *Cissampelos pareira*, *Dioscorea alata* etc.

Fern is the most common species found in the region. The area near water of canal, in a damp area the ferns are easily grow. *Colocasia esculenta* is also one major plants found in this area.

On the Site area, the areas near Bharalu canal and the edge of the river Brahmaputra area found the large, deciduous and ever green trees with canopy cover. The slope and perennial area along the Bharalu canal is covered with mix of dense ground cover and climber. They together form the canopy and sub canopy layers respectively.

6.4.3 List of Vegetation Found on the Site

LIST OF TREES					
SL. NO.	COMMON NAME	SCIENTIFIC NAME	FAMILY	DESCRIPTION/TYPE	HEIGHT (m)
1	Indian bael	*Aegle marmelos*	Rutaceae	deciduous; branchlets cylindric, medicinal	12
2	Imli	*Tamarindus indica*	Febaceae	Leguminous tree, monotypic taxon, used as traditional medicine	18
3	Mango	*Mangifera indica*	Anacardiaceae	Fruit tree, ever green, tropical, cultivated for its edible fruits	35
4	Gulmohor	*Delonix regia*	Febaceae	Flowering, ornamental tree	20
5	Teak	*Tectona grandis*	Lamiaceae	Large, hardwood, flowering, tropical, deciduous tree, occurs in forest	40
6	Coconut	*Cocos nucifera*	Arecaceae	Large palm, with long pinnate leaves, fruit plant	30
7	Banana	*Musa acuminate*	Musaceae	Largest herbaceous flowering, fruit plant	8
8	Gular/Peepal tree	*Ficus glomerata*	Moraceae	Deciduous, semi ever green tree	30
9	Banyan tree	*ficus benghalensis*	Moraceae	Large tree, canopy cover, ecological value	40
10	Rubber tree	*Ficus elastica*	Moraceae	Large, stout trunk with aerial and buttressing roots	40
11	Siris	*Albizzia sp.*	Febaceae	widely cultivated, occurs in tropical subtropical region, used as forage, wood, medicine	30
12	Bakain/Chinaberry	*Melia azedarach*	Meliaceae	Deciduous, flowering, fragrant, good timber	12
13	Kadamba	*Neolamarckia cadamba*	Rubiaceae	Evergreen, tropical, ornamental, used as timber and paper making	45
14	Sissoo/Rosewood	*Dalbergia sissoo*	Febaceae	Fast growing, hardy deciduous, used as timber in constructions	25
15	Amaltas/Golden rain	*Cassia fistula*	Febaceae	Fast growing, deciduous leaves, yellow flowering, used to suppliment the diets of cattles	20
16	Semal/Cotton tree	*Bombax ceiba*	Malvaceae	Straight, tall trunk, deciduous, ripen fruits contains white cotton fibre, very good wood	20
17	Jamun	*Eugenia jambolana*	Myrtaceae	Evergreen, tropical, fruit tree, flowering plant, fruits are used for medicine	30


Aegle marmelos


Tamarindus indica


Delonix regia


Cocos nucifera


Bombax ceiba


Albizzia sp.

LIST OF SHRUBS					
SL. NO.	COMMON NAME	SCIENTIFIC NAME	FAMILY	DESCRIPTION/TYPE	HEIGHT (m)
1	Lantena	*Lantana camera*	Verbenaceae	Small perennial shrub, Flowering plant, Notorious weed	2
2	Datura	*Datura stramonium*	Solanaceae	Freely brunching herb,erect, Medicinal, toxic	0.6-1.5
3	Kochu/Taro	Alocasia sp.	Araceae	Perennial, broad-leaves, edible, cultivated in tropical subtropical place	
4					
5					


Lantana camera


Datura stramonium

LIST OF GRASS						
SL. NO.	COMMON NAME	SCIENTIFIC NAME	FAMILY	DESCRIPTION/TYPE	HEIGHT (m)	AREA COVER (%)
1	Phragmites	*Phragmites karkar*	Poaceae	Large perennial grass, found in wetlands,		
2	Congress grass	*Parthenium hysterophorus*	Asteraceae	Flowering plant, toxin		
3	Dub grass	*Cynodon dactylon*	Poaceae		0.1-0.3	
4	Barnyard grass	*Echinochloa crus-galli*	Poaceae	Wide spread, fodder crops,		
5	Johnson grass	*Sorghum halepense*	Poaceae	Occurs in crop field, pastures, stream banks, used for forage and to stop the erosion		

Phragmites karkar

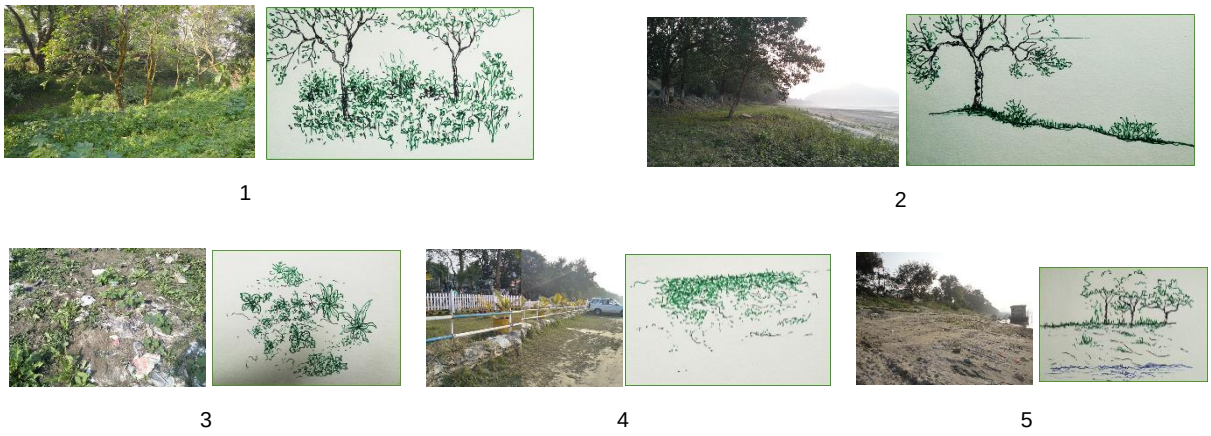
Echinochloa crus-galli

LIST OF GROUND COVER						
SL. NO.	COMMON NAME	SCIENTIFIC NAME	FAMILY	DESCRIPTION/TYPE	HEIGHT	AREA COVER (%)
1	Chick weeds	*Stellaria media*	Caryophyllaceae	Annual flowering plant, used as cooling herbal remedy	0.4	
2	Goat weed	*Ageratum conyzoides*	Asteraceae	Herb, flowering plant, medicinal plant, toxin	0.5-1.0	
3	Deccan grass	*Echinochloa colona*	Poaceae	Wild grass, tropical climate, occurs in roadsides and waterway or wetlands		

Stellaria media

Ageratum conyzoides

6.4.4 Types of Ground Coverage



1 2 3 4 5

Figure 33. Types of Ground cover near river edge

6.5.0 Fauna and Habitat

Variety of habitats found in Reserved Forest and Wildlife Sanctuary under the Guwahati Municipality Area. Forest and its habitats supports specific overlapping communities to each other. They linked by a very complex energy transformation system and food web relationships among the habitants. The Important wild animals and mammals which is found in this area are *Elephas maximus*, *Panthera tigris*, *Rusa unicolor*, Hoolock Gibbon (*Bunopithecus hoolock*), Capped Langur (*Trachypithe cuspileatus*), Assamese Macaque (*Macaca assamensis*), Rhesus Macaque (*Macaca mulata*), Leopard (*Panthera pardus*), Barking Deer (*Muntiacus muntjak*), Indian Mangoose (*Herpestes javanicus*), Wild Boar (*Sus scrofa*) etc.

Elephas maximus *Panthera tigris* *Rusa unicolor* Capped Langur *Herpestes javanicus*

Some list of Avifauna:

Avifauna			
Sl. No.	**Name**	**Scientific name**	**Apprx. No.**
1	Stork	*Ciconiidae*	
2	Blabk Stork	*Ciconia nigra*	
3	Cotton teal	*Nettapus coromandelianus*	
4	Esplugabous	*Bubulcus ibis*	
5	Xivitone	*Actitis hypoleucos*	
6	White vulgar	*Motocilla alba*	
7	Cargolet	*Troglodytes troglodytes*	
8	Capsule	*Sylvia atricapilla*	







Ciconiidae *Black Stork* *Cotton teal* *Bubulcus ibis* *Motocilla alba* *Traglodytes Traglodytes* *Sylvia atricapilla*

List of Aqua species

Aquatic Fauna			
Sl. No.	**Name**	**Scientific name**	**Apprx. No.**
1	Dolphin	*Delphinus*	54-48
2	**Types of fish**		
	Kurhi	*Labeo gonius*	
	Bhangon	*Labeo boga*	
	Rou	*Labeo rohita*	
	Boliora	*Aspidoparia morar*	
	Puthi	*Puntinus sophore*	
	Goroi	*Channa punctatus*	
	Chengeli	*Channa gachua*	
	Kawoi	*Anabus testudineous*	
	Tora (Spiny eel)	*Mastacembelus puncalus*	
	Ritha	*Rita rita*	







Delphinus *Labeo gonius* *Labeo boga* *Labeo rohita* *Aspidoparia morar* *Punthinus sophore* *Channa punctatus*

6.6.0 Activity and Users

The site has the oldest settlements where city has started with many historical and religious place. This area is the bounded by the hillocks and ancient temples and residence of Ahom ruler. The various activities and cultures has established in this area. Along the river edge, the human and its culture is depicted the importance of the place. At present scenario, the stretch around 7 km approximately, is situated in the heart of the city and it is the most active and multipurpose area for the people as well as tourist.

This area is the connecting the both sides of the river bank by water transport system. This is one of the old activity of the area. The smallest river island at the river and *Umanada temple* is always a tourist attraction place. Many people from other state also come to visit the temple. The most important place is the Nilachal hill and the *Kamakhya temple* which is famous for its mysterious history of the temple, which is always being over flow of the visitors and the devotes during *Ambuvasi mela* in the month of June every year. Also, there are other famous temples like *Navagraha temple, Shukreswar temple, Bhootnath* etc.

The old markets and shopping attraction place fancy bazar, Pan bazar, Lakhtokia, Poltan bazar are the most varieties of shopping area. These areas are always full with different categories of people like

students, family, adults, teenage, children and tourists. This area is also close to the Institutional area- Cotton University and Handique Girls College, Park, High Court, State Museum and Public Library. The different types of users from this public area come at the riverfront for recreational or to hang out with their family or friends.

Figure 34. Space of various activities at site

The Brahmaputra river Cruise and Floating restaurant is one of the most attraction place in the city. People can enjoy the Cruise at mesmerizing evening of the mighty Brahmaputra and also they can enjoy the sun sets, tradition music and cuisine. There is recently another new project has been launched by Guwahati Development Authority for Rope way from South Guwahati to North Guwahati city. This project is the longest ropeway in India, it is passing over the Brahmaputra river with scenic beauty of the river.

Figure 35. Image Brahmaputra river cruise and Rope way

6.7.0 Issues of the Site

Existing park: The existing parks along the river edges are not properly maintained and also it does not have visual connections from both main road and the river.

River edge: The present condition of the edge is not protected. It causes soil erosion every year.

Pollution: The area where Bharalu canal is meeting the river Brahmaputra is turned as the most poisonous and polluted area.

Visual activity: the public spaces like ferry port, river cruise and parks has no visual conection from the main road.

Parking: there is no parking for the pasangers and the tourist.

Ferry port: The existing ferry port has no proper walk way or jetty to the ferry for travelers and tourist.

Drainage: the drainage system is dump with garbage at the edge of the river.

Figure 36. site images

6.8.0 SWOT Analysis

STRENGHT

Environment- The edges are coverede with the old and large number of trees, it has shaded area.

Open space- The promenade of the river edge itself provides quality of open spaces

Activity- The entire edges from Uzan bazar to Kamakhya temple takes active participation by the people, tourist, locality with various activities on the river edge.

Cityscape- The river is flowing through the heart of the Guwahati city. The space is a live line of the city.

Infrastructure- The main MG road along the river edge is a transition space between river and the dense commercial area.

WEAKNESS

Environment- Noise pollution of vehicular and traffic from road.

Open space- A small strip promenade along the river edge, very poor quality of public space.

Activity- The edges are used for public realm, The edges are being used for different acivities because of the different phases of the river. These acivities are also effecting on profile of the edge.

Cityscape- The dense city setlement is on the edge.

Infrastructure- The main MG road is running along the egde of the river with very low buffer area between the river and the road. Controlled and limited pedestrian crossing.

Views- The view from the road to the promenade is neglegible.

OPPORTUNITY

Environment- Increasing more native vegetation with existing vegetation can minimise the noise pollution and urban heat island

Open space- The existing area of buffer area can be develope

Activity- The river edge is historically, culturally and socially attach to the people of the assam. The area has potential to bring back the identity of the tradition of Assam

Cityscape- The dense old city surrounded with historical precint can develop with the welcoming the tourist

THREAT

Environment- Increasing users and the population is maximising the natural elements in environment as well as polluting the river water quality

Open space- The existing buffer area is not maintained. instead, in present, the riperian zones during winter is also using for other activities

Activity- The waste water drainage is directly connected with river Brahmaputra. Solid waste materials, garbages from street vendors is dump on the edge

Cityscape- Due to population growth, increased the vehicles and traffic

Infrastructure- Land reclaimation by people to build the infrastructure for residence or offices

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