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Wildlife Conservation and Mangrove Interpretation Centre, Karamjal, Sundarban:

A Case Study of a Site-Specific Architectural Project in a Mangrove Forest

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ABSTRACT

This paper analyses the design process that addresses the ecological consideration and architectural factors with local indigenous materials so that nature-based tourism can be more encouraged and feasible towards sustainable development. The case study is the Sundarbans, which is a mangrove forest and coastal wetland with a complex ecosystem formed by a variety of plants and animals. Due to its diversity, ecosystem richness and uniqueness, this contiguous block has a huge impact on both local and global environment and is significant among researchers, conservationists and nature lovers. Karamjal, Bangladesh, one of the main entry points of Sundarban Reserve Forest is enriched with a diversified ecosystem. But now this site is deteriorating day by day with increasing unplanned build forms and visitors. For betterment of ecological setting and tourism facilities for global attention, Karamjal is indicative of better consideration both ecologically and architecturally. After analysis, a case study of site-specific design is proposed for improvement of this site.

Keywords: *Mangrove Forest, Sundarban, Ecological Consideration, Site Speci ic Design, Wildlife Conservation, Eco-tourism.*

INTRODUCTION

Bangladesh is a South Asian country full of lush greenery and waterways. The Sundarbans, an enormous mangrove forest is located in the lower Ganges river basin in south-western Bangladesh and south-eastern India (Figure 01). It was declared as a Natural World Heritage site in 1997 by UNESCO and Ramsar Site of International Importance in 1992 (Aziz, 2015) Sundarban has approximately 300 species of flora, 425 species of terrestrial fauna and 291 species of fish, some of which are threatened and endangered (Biswas, 2007).

The Sundarbans were declared as Sundarban Reserve Forest in 1876 under the Forest Act, 1865 to conserve all its unique flora and fauna (Aziz, 2015). Sudarban Reserve Forest (SRF) is managed under the direct supervision of Bangladesh Forest Division. Administratively it is divided into two divisions (Sundarban East and Sundarban West Division) and four ranges (Soronkhola Range, Chandpai Range, Burigualini Range and Khulna Range) (Figure 01). This forest has three wildlife sanctuaries (Sundarban East Wildlife Sanctuary, Sundarban West Wildlife Sanctuary, Sundarban South Wildlife Sanctuary). It has been a favourite eco-tourism destination for both national and international tourists, especially during the winter and spring seasons (Sarkar, 2017). There are several places and spots of tourist attraction. Those are Karamjal, Kotka, Jamtala, Kochikhali, Badamtala, Harbaria, Mrigamari, Kalagachi, Neelkamal, etc. (SRF-IRMP, Vol 01) (Figure 02).

Karamjal is one the main entry points for SRF (Sarkar, 2017). Visitors come here to feel the Sundarbans and to acquire knowledge about mangrove forests. In 2003, a "Wildlife Conservation and Ecotourism Centre" was established for breeding Deer and Crocodile along with tourism facilities but the recreational behaviour of visitors is worsening day by day. It was determined by interviewing 150 visitors (local and foreign) in the questionnaire survey, the question was, 'How would you describe the quality of the recreational benefits of nature-based tourism in Karamjal?' Most visitors answered "poor" or "very poor" (Sarker, 2017).

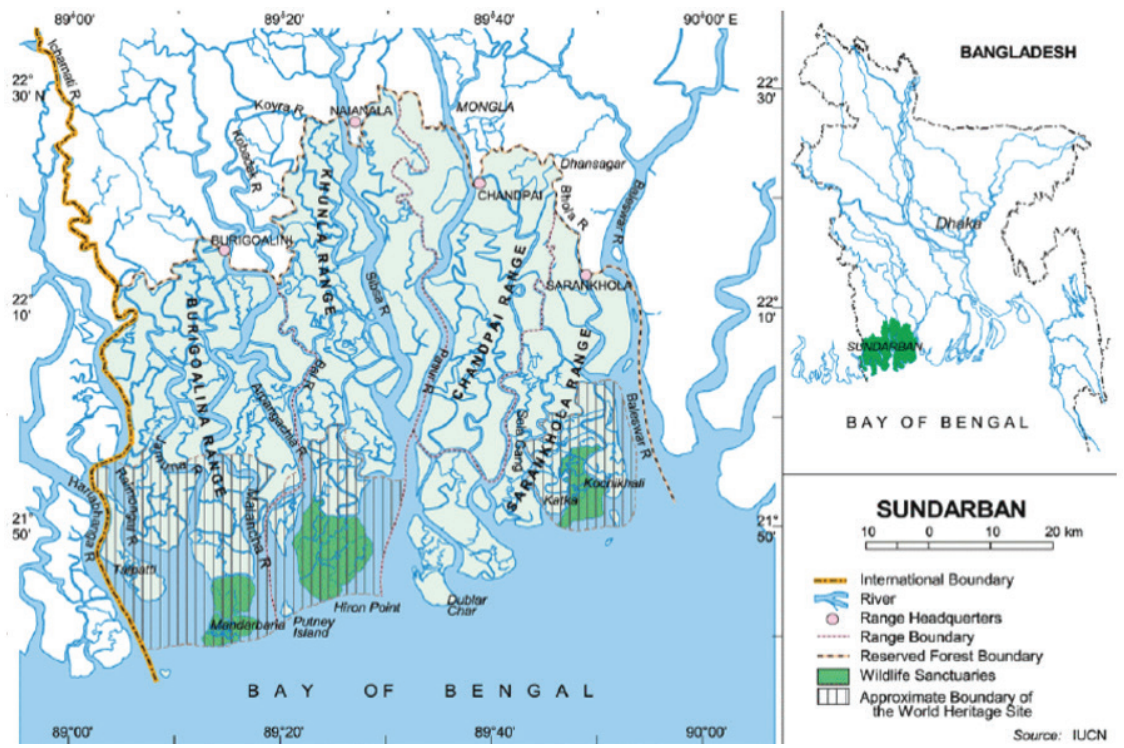


Figure 01:
Location map of Sundarban
(Source: (IUCN))

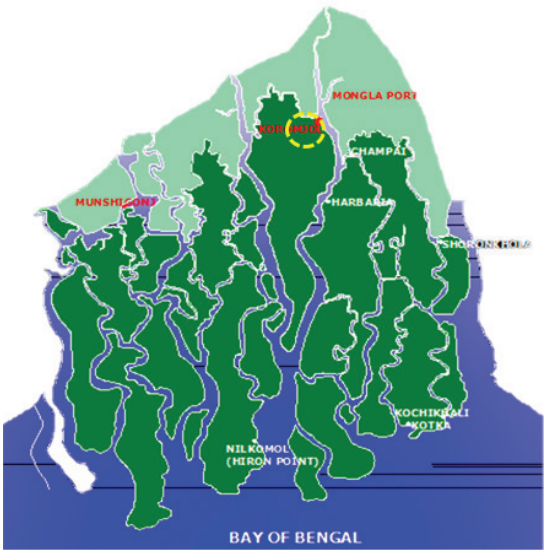


Figure 02:
Different tourist sports in Sundarban
(Source: Internet)

In that place, ecological balance was seemed to be disturbed with man-made structures. Half of the trail is constructed on stilts but most the pathway is designed on ground (Figure 03). Also, Deer Ground and Crocodile Shed was placed hampering the natural characteristic of the top soil (Figure 04 & 05). For this reason, the soil has become hard and it looks like general ground type rather than special mangrove soil pattern. Erosion on the bank of Passur river and Karamjal khal have clear problems. Wild spotted deer were being fed junk food from the snack food stand. Overflowing septic tanks and leakages with drains connected to the river. Bottles, packets, cigarettes and other trash were frequently seen on the ground (SRF-IRMP, Vol. 01).

In architectural perspective, there are no clear zoning and circulation pathways. Almost all the trail is broken drown and hand rails are hardly found anywhere. Moreover, materials used were not treated or seasoned for durability. A huge damage of infrastructure had been occurred during cyclone storm SIDR in 2007. The visitor centre was a small area with little or no information (SRF-IRMP, Vol. 01). The cafeteria isn't sufficient and found close most of the time and the wooden watch tower is almost collapsed. The ecotourism centre at Karamjal, Sundarban may be made more interactive (Nishat, 2019). The main subject area for local and international botany and wildlife ecology students, researchers and scientists is Sundarban (SRF-IRMP, Vol. 01).

Nature-based tourism has become increasingly important for sustainable development because of its potential to contribute to local and national economic development while also providing encouragements for nature and biodiversity conservation. Sundarban has the potential to attract a large number of visitors and be a source of earning through national and international tourism opportunities that may ultimately improve the livelihood of surrounding human populations (Das, 2013)

The Sundarban Forest Reserve has a unique ecosystem, exceptional scenic beauty and rich wildlife that can be a source of attraction for a variety of people and provide a convenient space for outdoor recreation. Ecotourism can be developed without causing damage to vegetation or wildlife.

Designing an architectural project in this area needs more sensibility to minimize the detrimental impacts on the sensitive ecosystem. To integrate ecological consideration, ecological building design criteria needs to be maintained in the design process. This

Figure 03:
Soil condition, Karamjal

Figure 04:
Deer ground, Karamjal

Figure 05:
Crocodile shed, Karamjal

paper focuses on coordination and combination of both ecological and architectural factors along with locally found materials for improving nature based tourism.

ECOLOGICAL CONSIDERATION

Ecological considerations while designing a building contains building materials which respect the environment, reduce energy consumption, use local and renewable resources instead of natural resources, create healthy indoors, use solar energy, natural ventilation and natural lighting, and which are reusable, recyclable and maintenance-free (Gültekin, 2011). As buildings have adverse effects on environment during their lifetimes, from construction until demolition, so to reduce these effects, ecological building design criteria should be adopted in designing the buildings. In ecological building design, solutions should be oriented to conserve the topographic structure of the land, ground and aboveground water levels, existing vegetation cover and aquatic/terrestrial creatures. Designs involving solutions inconsistent with the topographic structure of the land are not economical and could do harm to the micro-air conditioning of the land as they affect the flow of the water and the wind (Robert, 1995). While designing a building in ecologically enriched site, the main objective should be preservation of natural condition and existing ecology.

ARCHITECTURAL FACTORS

Some architectural factors are suggested for consideration to minimize the detrimental impacts on the sensitive ecosystem (Said, 1999). The factors include site planning, type of architecture, material selection and construction method.

Proper site planning means the layout of buildings is in relation to the intensity of human activity and building development. The architecture should be of low-rise building inserted among the tree stands, and spread throughout the site rather than concentrated in small areas. All architecture should be raised on stilts to allow free flow of tides, and possibly naturally ventilated so that visitors could experience and feel the real ambience of the mangrove forest setting (Figure 06). It also helps with the animal movement, and the tree roots can grow easily (Said, 1999).

Building gaps are very important in coastal site such as Sundarban. Because the narrow spaces between buildings is impermeable during storm (Figure 07). So for better storm run-off drainage, wider spaces should be provided (Garcia, 2006). The footprint of the structural system must allow to the wind and water flow direction (Figure 08). Local skills and knowledge should be sort from the surrounding communities that applied hand-held tool techniques to construct the buildings.

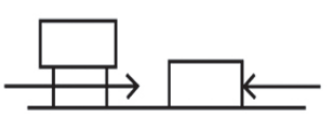


Figure 06:
Left: wave passes by thin posts without great damage to the building. Right: direct impact from a tidal wave occurs when building is at the ground-floor level

(Source: Garcia 2006)

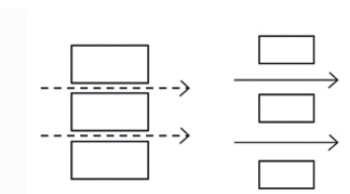


Figure 07:
Narrow gaps make spaces between buildings impermeable. Wider spaces should be provided

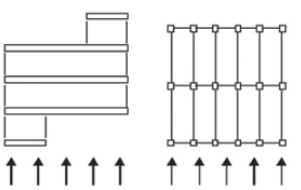


Figure 08:
Left: structural organization resulting in greater resistance to flow. Right: structural organization allowing the flow

STUDY AREA: KARAMJAL

Among the most attractive tourist spots in Sundarban, Karamjal is the most visited place by tourists. Currently it receives 81% of all visitors to the SRF (SRF-IRMP, Vol. 1). It is about 5 km from Mongla port. Boat is the only transportation media of that place (Figure 09). One can hire a Toller or steamer from Mongla. It takes 30-45 minutes to reach the destination.

Site Surroundings

The site area is almost 12 Acres. It stands beside the Passur River (east side). Karamjal Khal is situated on north side (Figure 10). Both west and south is surrounded with various trees. There is no road network and other utility facilities such as gas, electricity. Many small cracks are running beside the site. Spotted-deer are frequently seen nearby and various types of birds make the place enjoyable.

Topography of the site

The site is not flat-level is every space. The ground elevation of the site varies from 31 feet to 26 feet from sea level (Section is taken from google earth) (Figure 11).

Tidal surge

By the local Survey, on high tide, tidal surge in Karamjal in winter varies from 1 feet to 1 feet 2 inch, in monsoon 1 feet 8 inch to 2 feet 3 inch and pre monsoon 1 feet 6 inch to 2 feet. On the other hand, on low tide it varies from 6 inch to 8 inch, 8 inch to 1 feet 6 inch, 1 inch to 1 feet 4 inch. In the last heavy cyclone, tidal water level almost found 5 feet from the ground.

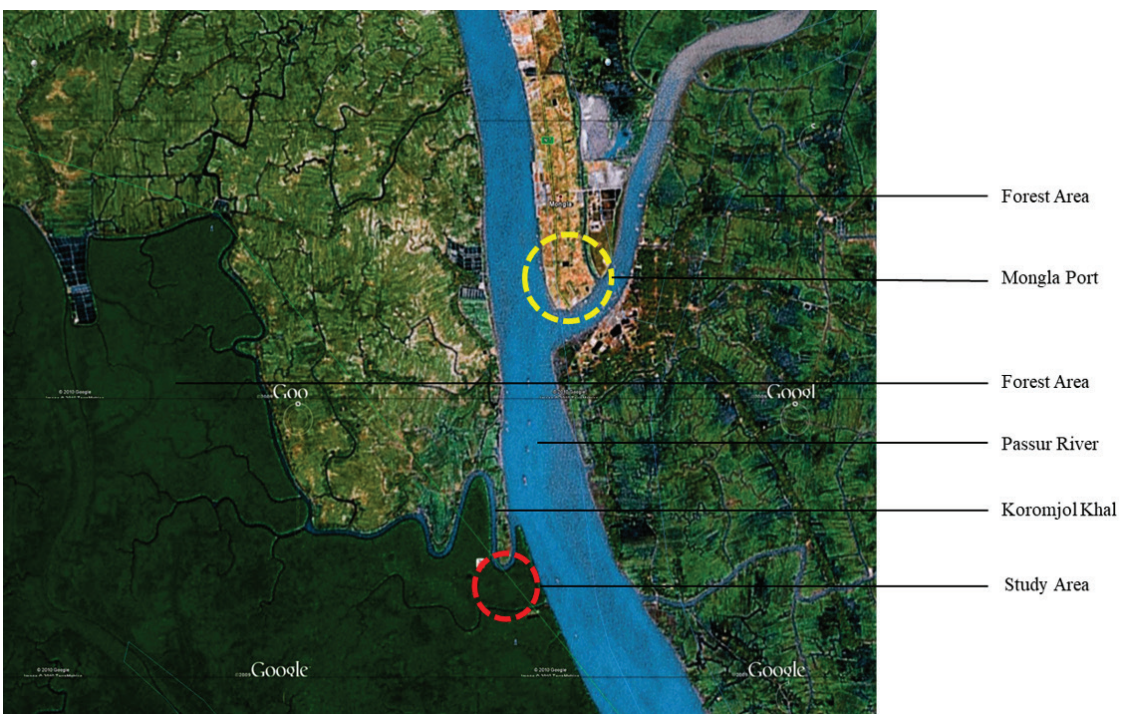


Figure 09:
Location of study area: Karamjal
(Source: Google Earth)

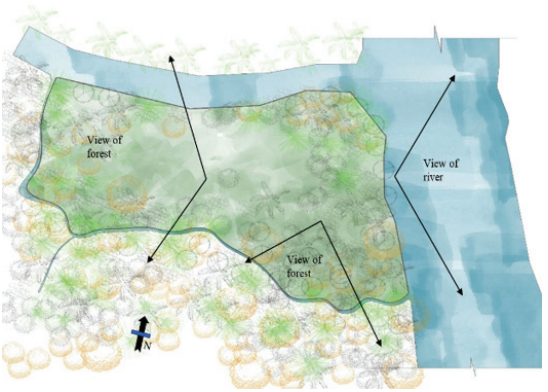


Figure 10:
Site surroundings
(Source: Author)

Karamjal khal and Passur river

View from Passur river

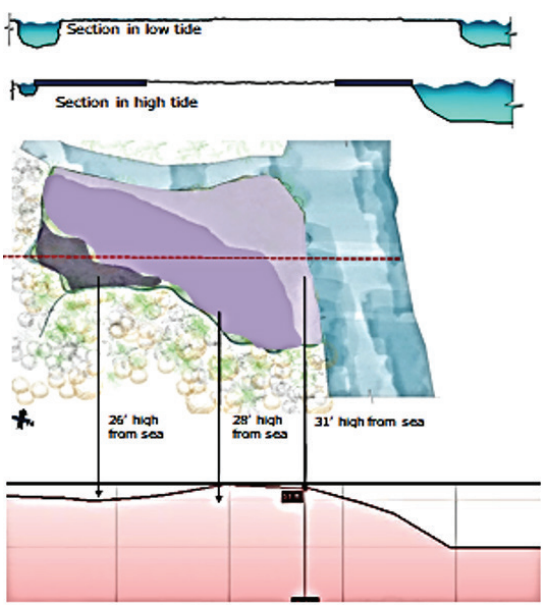
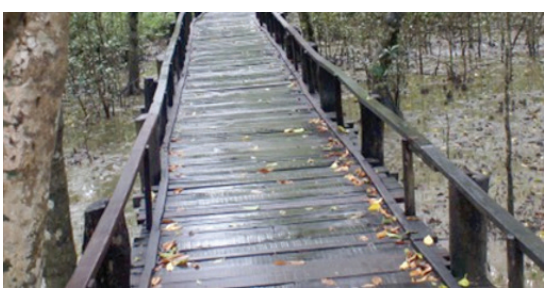
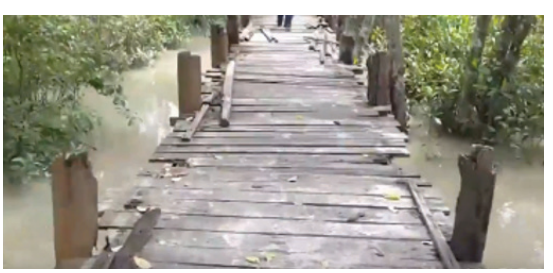


Figure 11:
Site topography
(Source: Author)



During low tide



During high tide

Soil Condition

Soils of the SRF are derived from a mixture of deltaic floodplain deposits and tidal marine deposits. In general, the soil fertility decreases from east to the west and from north to south. The soil condition of Karamjal is slightly saline, silty clay loam and the sub-soil consists of alternate layers of clay and sand (Kamal, 2013). Silt appears to be the most common textural class and grain size is larger (Kamal, 2013). Breathing Roots are found in most of the place.

Salinity Zoning

Three types of Salinity can be found in Sundarban. Those are strong saline (more than 4 ppt), moderate saline (2-4 ppt) and fresh saline (less than 2 ppt) (Rahman, 2010-2011). Karamjal is situated in the freshwater zone (Figure 12) (SRF-IRMP, Vol. 01).

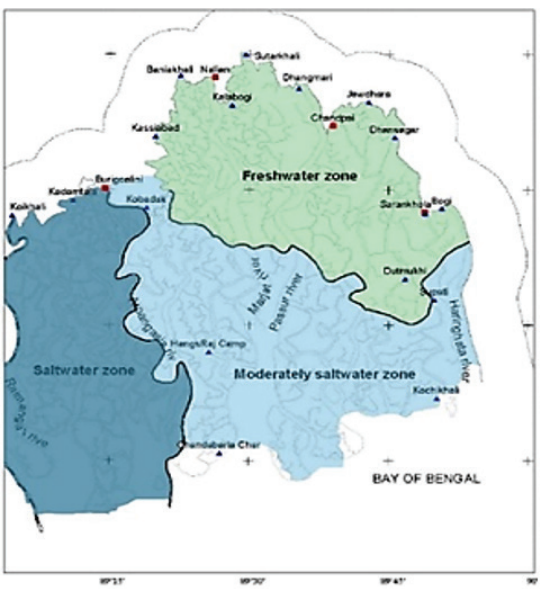


Figure 12:
Salinity zones in the Sundarbans
(Source: SRF-IRMP, Vol. 1)

Ecological Condition (flora & fauna)

In Karamjal, Sundari, Gewa, Bean, Goran, Passur, Hetal, Golpata, Nolkhagra and many other varieties of flora are found. A large percentage of trees produces pneumatophores, or breathing roots which overhang from the ground like spikes. Pneumatophores help in taking oxygen from the air to the roots of trees. The breathing roots may grow up to 4 inch to maximum 1 feet 6 inch. Spotted deer, crocodile, monkey, crab, turtle and a huge amount of birds are the main attraction of Karamjal (Figure 13). Sometimes Royal Bengal Tigers and Deer are seen beside the canal.

Local Architecture

Traditional house pattern was seen in the village areas, but on the coastal side beside the river, houses are seen uplifted from the ground. Wood and Bamboo for structural support, Bamboo Mat

Figure 13:
Flora and fauna of Karamjal
(Source: Author)

Figure 14:
Local house beside Karamjal
(Source: Author)

and Mud for façade, Golpata and Corrugated sheet for roof, Mud and Wood for floor are used as main construction building material in the locality (Figure 14). But now-a-days Brick and Concrete post seems to be used more frequently.

PROBLEM IDENTIFICATION OF EXISTING CONSERVATION CENTRE

- Site is being eroded by tidal water and natural disaster as no protection is considered.
- Half of the pathway, Deer ground, Crocodile pond and also the buildings are constructed by destroying the top soil of the site.
- Master plan is not well organized and there is no continuous looping to visit the whole compound. Conservations points such as Deer ground, Crocodile pond are not integrated with the main circulation path.
- Indigenous and local materials are not used. Built forms are constructed with brick, plaster and tin shed roof.
- Power is being generated by diesel generator which created heavy noise and pollutes the environment.
- Many trees are cut down for placing the built form and trail. But those trees were not replanted in the site.
- There are not enough recreational facilities for tourist attraction.
- Existing wooden trails and watch tower are broken down by natural disaster as the materials were not weather treated.
- Seating arrangement, bio-degradable toilet and trash management for tourist were NOT found in the site.

DESIGN PROPOSAL

Addressing the problems found in the existing centre, a design proposal “Wildlife Conservation and Mangrove Interpretation Centre” is proposed which produce a new assessment of site-specific design process with integrated ecological condition of mangrove forest. Without hampering the natural setting, the visitors could experience and feel the real ambience of Sundarban. Nature integrated master plan, prevention of site erosion, eco-friendly sustainable material, exciting built form, bio-degradable utility facilities, solar energy generation, rain water harvesting and top soil free stilted built form are considered to develop the project. These considerations may help to prevent environmental deterioration and give an opportunity to improve nature based tourism.

CASE STUDY: WILDLIFE CONSERVATION AND MANGROVE INTERPRETATION CENTRE

Project’s Aim and Objective

The project aims to achieve the development of a sustainable eco-friendly design and biodiversity conservation system for all resources in the

project area. The Centre will disseminate updated information on the SRF ecosystem, conservation concerns, local culture and appropriate conduct for visitors. Creating new possibilities and alternatives for leisure and nature enjoyment while raising public education and environmental awareness of the visitors of the Sundarbans is one of the major concerns of this project.

Concept of the Project

'Going Green' is the key concept in this project and achieved here with adhering to the context of the surroundings. Serenity of the backdrops, association with nature, sublime structures, rigor of arranging scientific research facilities and dissemination of activities through site visit, is amalgamated in a single complex. The interface is local, activity is world-class, shapes are organic and structures are low carbon. Ultimately, design blended with nature for a sustainable research facility.

Site Protection

The site is situated beside the Passur River and Karamjal Khal, and the soil is washed away two times a day by tide. So, for the protection of the soil, sustainable permeable retaining structures are used and trees are planted (Figure 15). Permeable Structure is constructed by the local materials such as wooden log, wire etc. (Figure 16). Tide water can pass through the permeable structure but the soil cannot thus create a natural barrier for washing away the soil due to tidal surge. For the protection

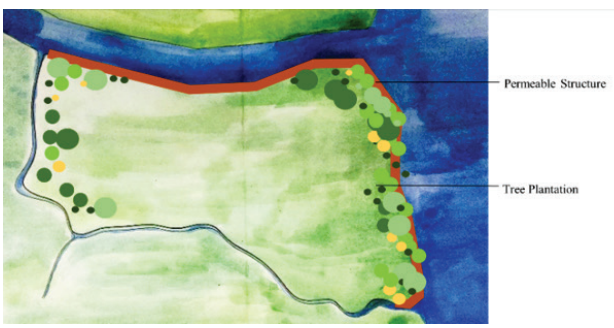


Figure 15:
Site protection
(Source: Author)

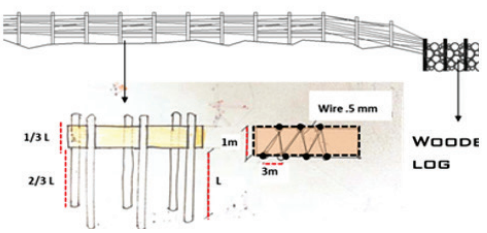
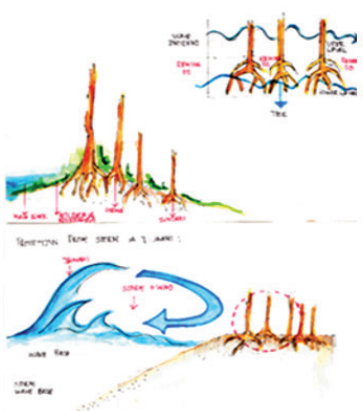


Figure 16:
Permeable structure



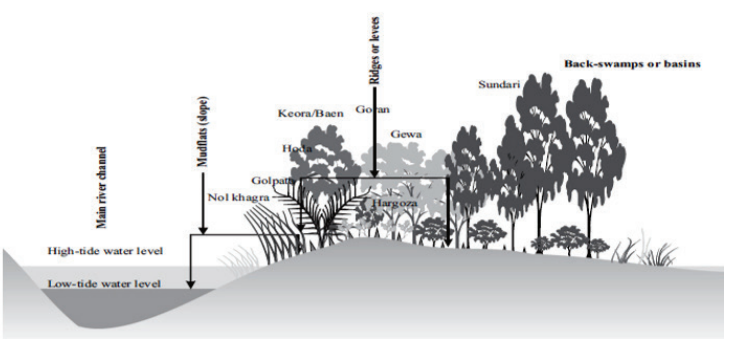


Figure 17:
Tree plantation
(Source: Dipu, 2013)

from cyclone and storm, a natural barrier is created by planting huge number of trees in three layers; Nolkhagra, Golpata at the Mudflats (slope) area near the river, Keora, Goran, Gewa, Hargoza at the ridges and Sundari at the basin areas (Figure 17).

Built Form Derivation

The form of the structures is inspired from the idea of the boat which is one and only mode of transportation in Sundarban. The form is biomorphic in shape and run through the trail. These organic shapes attract the tourist as well as merge with the natural setting (Figure 18).

Figure 18: Build form derivation
(Source: Author)

Width of the built form is maintained in such a way so that natural light and ventilation can easily circulate throughout. Vaulted shaped form is selected as the façade and roof are connected with each other and tied to the ground thoroughly so it can be more resistance to the heavy wind flow and cyclone (Figure 19).
Structural System is designed with aligning the water and wind flow so that it permits the natural flow (Figure 20). Built forms and trails are uplifted 5 feet from ground for the protection form cyclone

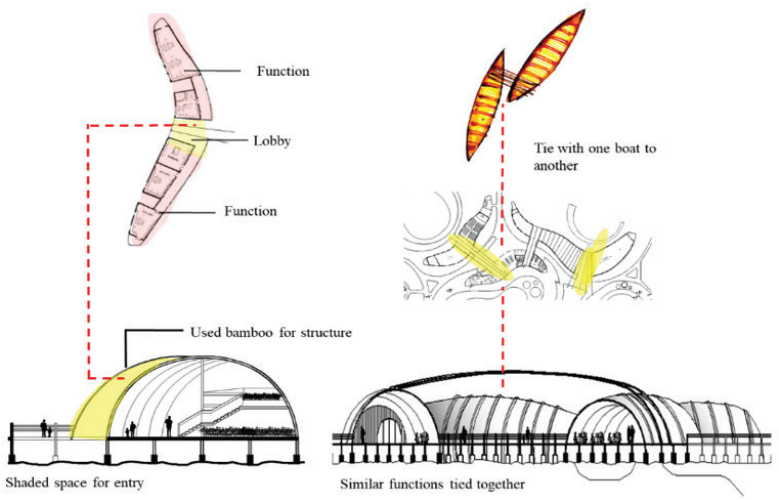


Figure 18:
Build form derivation
(Source: Author)

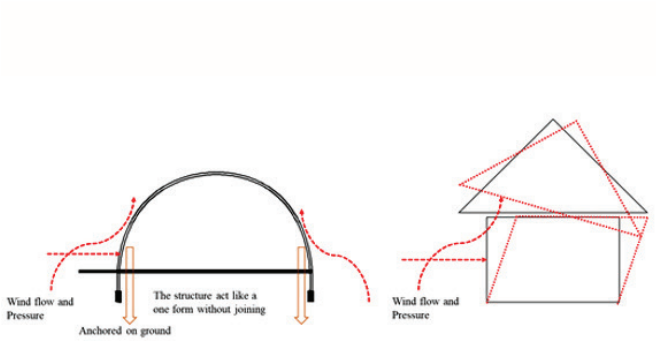


Figure 19:
Vaulted shape
(Source: Author)

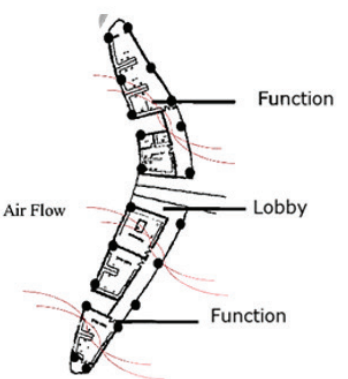


Figure 20:
Structural system
(Source: Author)

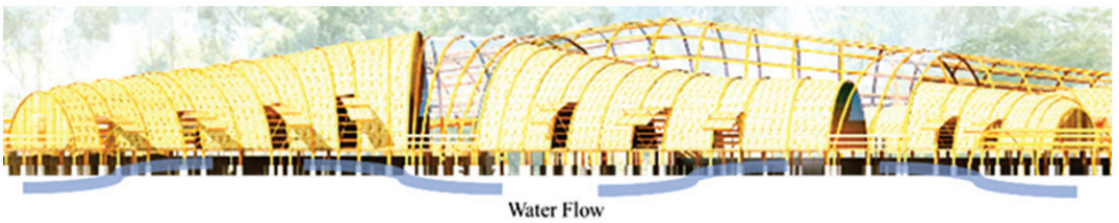


Figure 21:
Built form
(Source: Author)

and tide water. It has also created an enormous opportunity for the animals to move without obstacle, helps the trees to breath and the breathing roots to grow easily (Figure 21). The circulation path hence the trail is conceptualized to denote the river of the Sundarbans.

Design Development (Master plan organization)

As the site is flooded 2 feet to 2 feet 5 inch in average during high tide, so first consideration is to select the four highest points to accommodate the conservation facilities of Crocodile conservation pond, Deer ground, Turtle pond and an experimental pond (Figure 22). Then the entry point is selected in the middle so that all facilities can be distributed easily. All the functions are distributed in distance and connected with stilted trail so that strong wind can easily pass through the built form. The circulation is designed with respect to the four points which is assigned for the preservation services. Trees cut down for placing the built form and trail are replanted later on for conserving the existing ecological condition (Figure 23). 70% of total site area is kept green and open while developing the master plan.

The journey through the site is designed to stimulate the experience of the visitors. There are two loops: one for the visitors and other for the staff. When visitors come, they first drop off on entry deck from the boat. Close to the entry gate there are rest rooms and a café. If turned left, one will find a library, an animal museum and a plant museum. Those three functions are accommodated under a single structure with different entry and exit. Moving forward, visitors can watch deer ground and can experience animal and plant lab. Visitors can also visit plant herbarium nearby and get back to the trail again. On the way visitors can experience crocodile pond and can move further to the dense forest following the walking trail. While visiting the forest, they will find observation deck and seating arrangement beside the trail. At the end of forest journey, there is a turtle pond inside

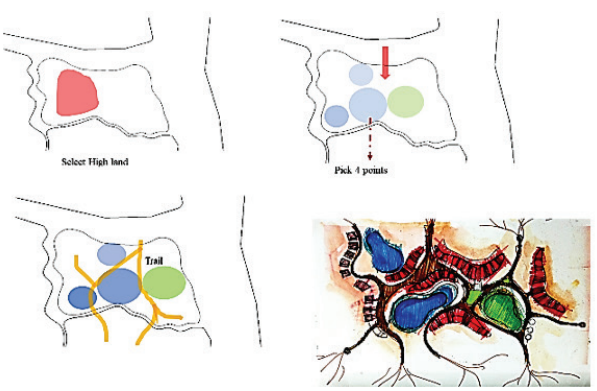


Figure 22:
Master plan development
(Source: Author)

Figure 23:
Built form and tree plantation
(Source: Author)

a compound. The journey takes its final shape at the seminar room where visitors can participate in a seminar on the related issue. By now visitors have reached to the starting point from where they started their journey and completed the loop. Other supporting facilities like staff cottages and researcher cottages are located at the right of the entry point. With every cottage there is a deck for experiencing the scenery of the forest (Figure 24).

Special features for visitors

Sitting arrangement alongside the trails, window pockets for capturing the scenic beauty (Figure 25) and four observation deck (Figure 26) are designed for visitor's attraction.

Figure 24:
3D visualization of master plan
(Source: Author)

Figure 25:
View from watch tower
(Source: Author)

Figure 26:
Observation deck
(Source: Author)

Materials Selection

The main curved structure is made with processed bamboo as it is the locally available and vernacular material. Curve structures are made by heat treatment process. Though Golpata is locally found and very popular material for roof and façade but it is not durable enough to withstand the heavy rain and wind. So, the curved façade is covered by corrugated bamboo roofing sheet (CBRS) which is more durable and stronger than Golpata. The process of producing CBRS involves 6 steps: 1. Bamboos are split into thin slivers, 2. Slivers are woven into mats, 3. Mats are soaked in adhesive resin, 4. Mats are allowed to drain and dry, 5. Mats are glued together under higher temperature and pressure, 6. Sheets are trimmed to shape. Corrugated bamboo roofing sheets are environmentally friendly, safe alternative to plastic, zinc or corrugated asbestos roofing panels, durable and strong with excellent internal bond strengths and a high resistance to weathering, fire or insect attacks (Schröder, 2014). In every entry point there are semi shaded spaces which is made with bamboo structure. The footing of the structure is made of treated concrete so that footing can be protected from erosion of salinity. The floor and trail are made by processed wood which are collected from the trees cut down earlier in the site (Figure 27). Partition walls are made by bamboo.

Conservation Feature

Conservation facilities is design for Crocodile and Deer breeding. There is also a provision for Turtle conservation. Crocodile Pond is uplifted 3 feet from the existing ground level by earth filling. Mother-crocodiles are kept in the natural setting and Baby-crocodiles are moved to the smaller round concrete made pond after breeding. Turtle pond is also uplifted 3 feet from the existing ground level by sand filling and concrete retaining wall is designed for the preservation of the water. All the animals are given back to its natural setting after proper breeding process (Figure 28).

Eco-friendly Building Services

Eco-friendly building services are designed for reducing carbon emission and preservation of nature. Power generation through solar photovoltaic system, eco-friendly composting toilet, rainwater harvesting is the crucial consideration for sustainability (Figure 29).

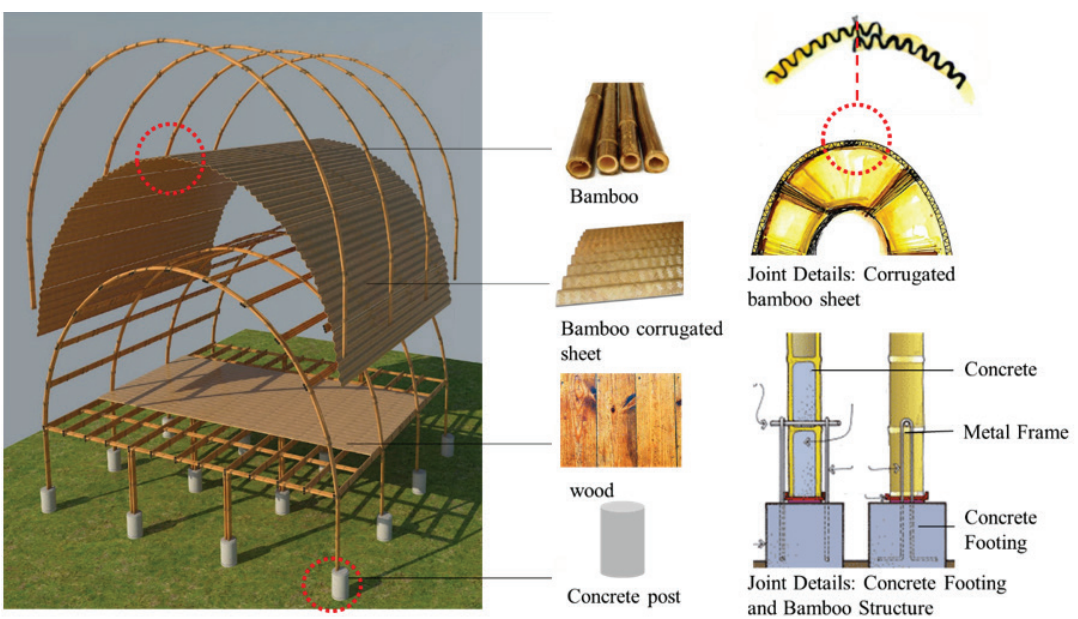


Figure 27:
Materials and structural system
(Source: Author)

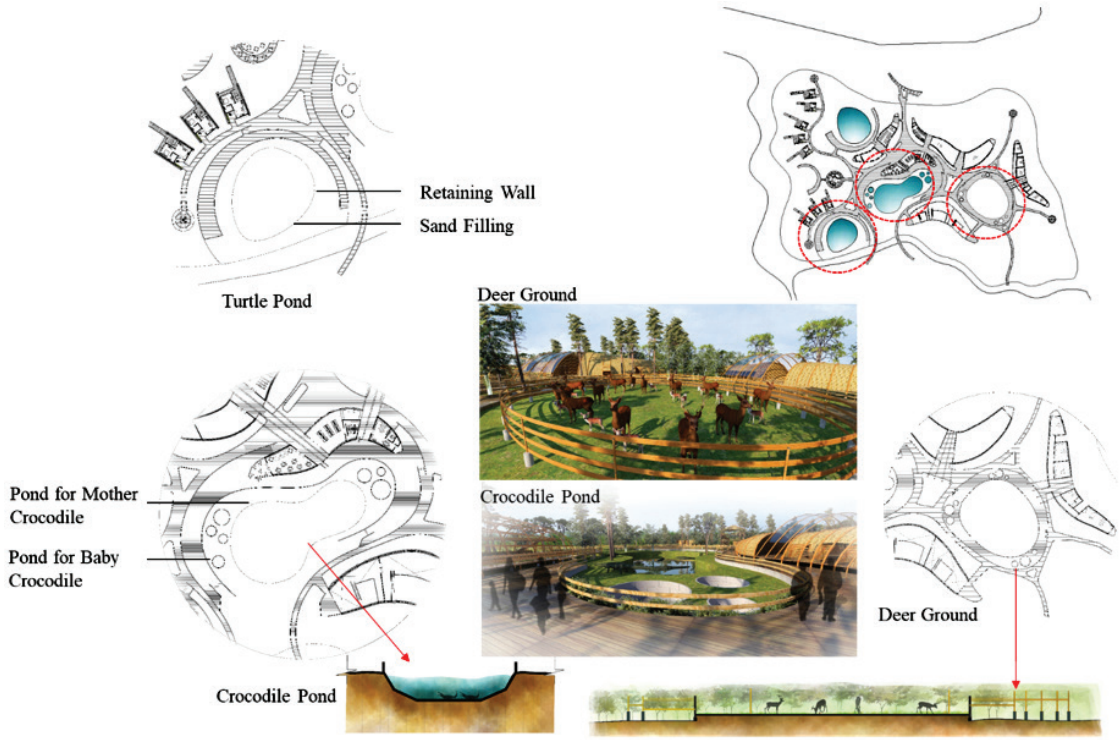


Figure 28:
Conservation feature
(Source: Author)

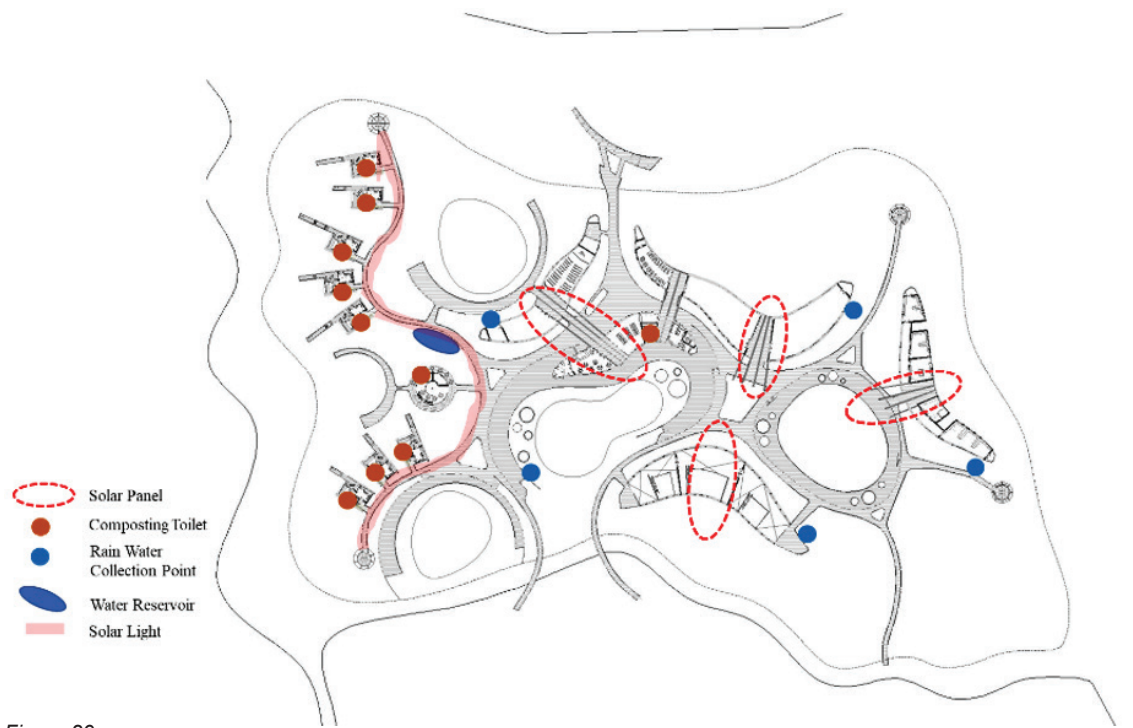
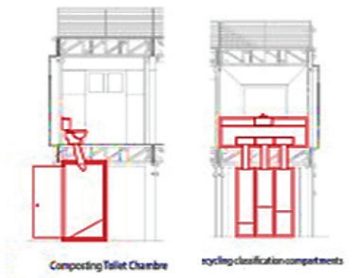


Figure 29:
Service plan
(Source: Author)

Solar panel
(Source: Author)



Composting toilet
(Source: Author)

Rainwater harvesting
(Source: Author)

CONCLUSION

Sundarban is an ideal tourism and research place for its diversified ecosystem and uniqueness. Designing a building in a resourceful landscape like Mangrove Forest needs to emphasize more on the ecological factors as well as the architectural factors. Modification of the physical-biotic aspects especially vegetation, water and soil should be minimal and must not hamper the existing ecosystem of the plant and animal communities. Built form should be placed in such a way so that this should not hinder the natural tidal flow and allow the plant roots and aquatic microorganisms to attain enough nutrients and air.

But the existing tourist facility in Karamjal, Sundarban was neither designed in consideration of the ecological issues, nor the local vernacular architecture. The introduction of buildings in the estuarine sensitive ecosystem should be approached by addressing the existing factors of the site. Physical and climatic characteristics of mangrove forest should be integrated through the zoning process of the built form. This site specific design proposal, addressing all the issues, were made by making design decisions in an eco-sensitive manners, and enable the experience of harmony of building design considering the ecology. This may raise a greater awareness among the designers about environmental issue causes by unplanned built form. This project can also bring social-economic gains to local community residing in the forest as local people can earn their livelihood by providing necessary materials and construction services.

From this paper, one can have a chance to know the overall site specific design process and also gain information about local architecture, vernacular materials and bio degradable systems. At the same time, it brings up an opportunity to develop a designer guideline to the ecological building process along with the architectural design process. By promoting ecotourism through this type of project, earning of local and foreign income will be a greater benefit for developing country like Bangladesh. Moreover, it is necessary for the Government to take required initiative regarding construction of building in such kind of sensitive site otherwise the ecologically rich sites will lose its attractiveness.

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