

**Monsoon: A Study of Human Resiliency to Annual Flooding in
Rural Bangladesh**

by

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CONTENTS

Abstract	iv
Acknowledgement	v
Chapter 1: Introduction	1
Background	1
Objectives	3
Chapter 2: Impacts of River Flooding	6
Flood Typologies	6
Chapter 3: Flood Related Issues	10
Movement	10
Storage	10
Agriculture	12
Structural Damage	12
Local Adaptation Techniques	15
Stilts	15
Bhita	17
Social and Cultural Impacts	17
Chapter 4: Field Research	19
Sites Visited	19
Material Related Case Studies	20
Tar Barrel House – GajnarBil	20
Large raised platform Mounds – Ullapara	21
Home in Munshiganj / Mawa	22
Home with Store - Pabna	23

Chapter 5: Material Culture	24
Chapter 6: Community Development	28
Social & Cultural Sustainability	28
Social Space & Human Interaction to Water	31
Chapter 7: Site.....	32
Chapter 8: Design Development	38
Approach	38
Conceptual Collages	40
Design	45
Float Pods.....	45
Bridge	49
Work Grow	51
Platform Tower	51
Floating Garden Bed (Baira).....	53
Models	57
Chapter 9: Conclusion	63
Appendix.....	64
Annotated Bibliography of Top Publications	64
References	68

ABSTRACT

Bangladesh is one of the most flood-prone nations in the world, because a majority of the land is very flat. During the rainy season, which lasts from June to October, the combination of heavy rainfall and melt water from the Himalayas causes over 21% of the country to flood on average, and over 60% in extreme cases. The intersection of three major rivers, the Padma, the Meghna and the Jamuna, has created the largest delta in the world, where a majority of surrounding land is prone to annual flooding. The areas around the riverbank are mostly farmland, in which a majority of population live under the poverty line, which means that the effects of flooding can be devastating. It would be largely beneficial for people within local communities to develop an architectural response to cope with the flooding, based around local knowledge and materials. The goal of this thesis is to develop small-scale, flood adaptive structural systems using vernacular materials and techniques that respond to the seasonal monsoon floods in rural Bangladesh.

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CHAPTER 1: INTRODUCTION

If 'Regionalism in Architecture' has to be more than a mere slogan, then architecture, in the Third World countries in particular, must concern the overwhelming majority of the populace who live in the rural areas. (Muktadir and Hassan 1985, 86)

Background

Bangladesh is a country with a very high concentration of water bodies. It is known as the 'Land of Rivers' with a network of over 230 rivers and streams, of which 54 are fed from adjacent countries. (Dewan, Nishigaki, and Komatsu 2003, 54) Here, people have an intricate relation to water, which represents both mass devastation, and agricultural roots providing extremely fertile land. The alluvial soil left by floodwater makes the land perfect for agricultural production, which is deeply ingrained into cultural practices. In the Southern part of the country, floating agriculture was developed in order to spur agricultural production where there was less farmland. Naturally, a majority of the population in rural Bangladesh takes part in farming as their main source of income, in addition to keeping lots of vegetation on their homestead for family consumption. The traditionally introverted, courtyard homesteads hold the essence to social and cultural sustainability, by providing opportunities to extract and modify design components, and implement them externally. People have been dealing with water for a very long time in this part of the world, and it is imperative that current methods of interaction are understood in order to design sustainably.

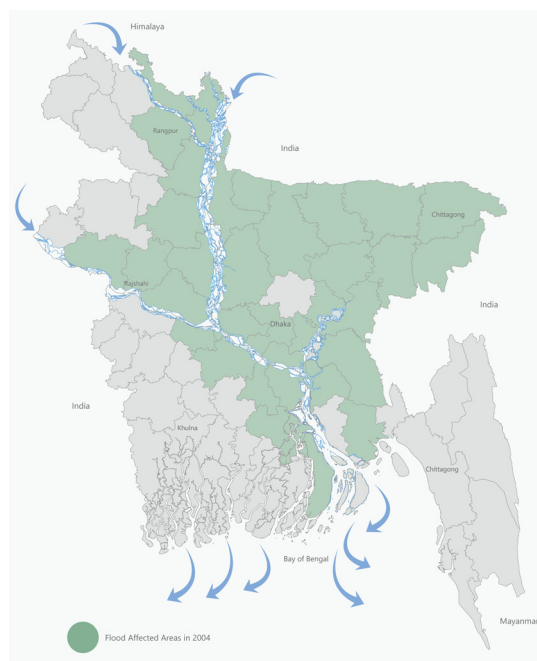


Fig 1: Map of Bangladesh; from Mapcruzin

BANGLADESH
বাংলাদেশ



Fig 2: World Map ; from Vector World Map

I was born in Bangladesh, but have been living in Canada for most of my life. I have been fortunate enough to return to Bangladesh every few years, which has given me opportunities to observe the informal development of rural communities. The need for housing and industry overshadows material culture, and is a major driving force behind my interest for rural architecture. In 1998, Bangladesh experienced the most devastating flood in its history - a flood I experienced while living in Dhaka. I can distinctly remember how the streets were flooded so high that instead of cars, boats were being used for transportation throughout the city. My primary school had flooded, and I did not attend school for two months, and a majority of the country had suffered heavy damage. It is considered a crisis situation when major cities such as Dhaka are affected flooding, which is natural phenomena occurring once every decade or so; Whilst a majority of rural areas experience a high level of annual flooding due to rising water levels during monsoon seasons. Observing the suffering of people firsthand during the flood of 1998 remains a reference point for the inadequacies of flood adaptive infrastructure in the country, and became the basis for researching a method of architectural adaptation that responds to destabilizing flood conditions in rural Bangladesh.

Objectives

Traditionally, people have devised ways to deal with flooding using local methods and materials, such as clay, bamboo, wood, and bricks. In order to keep up with population growth, the hastening pace of construction has forced vernacular methods of construction and material use to disappear. For example, treated bamboo has usually served as a structural element in informal rural typologies, but it is rarely seen being used to fit its full potential, and formal applications are scarce. Another common use of bamboo is in woven matting called “moulibera”, which can still be seen in some rural areas. (Duby 1990, 3) Alternatively, cement stabilized, earth buildings are a common type of construction developed in rural Dinajpur. (Ahmed 2005, 54) Bamboo does appear in urban settings, where informal settlements have adapted to annual flooding by raising their houses on bamboo and wooden stilts. In rural settings, residents dealing with flooding must also consider other life-essential programmatic components: for example, the protection of domestic animals, seed storage, food storage, and cooking stations. (Rahman 2014, 30) There are some areas where the solutions to these problems have already been developed,

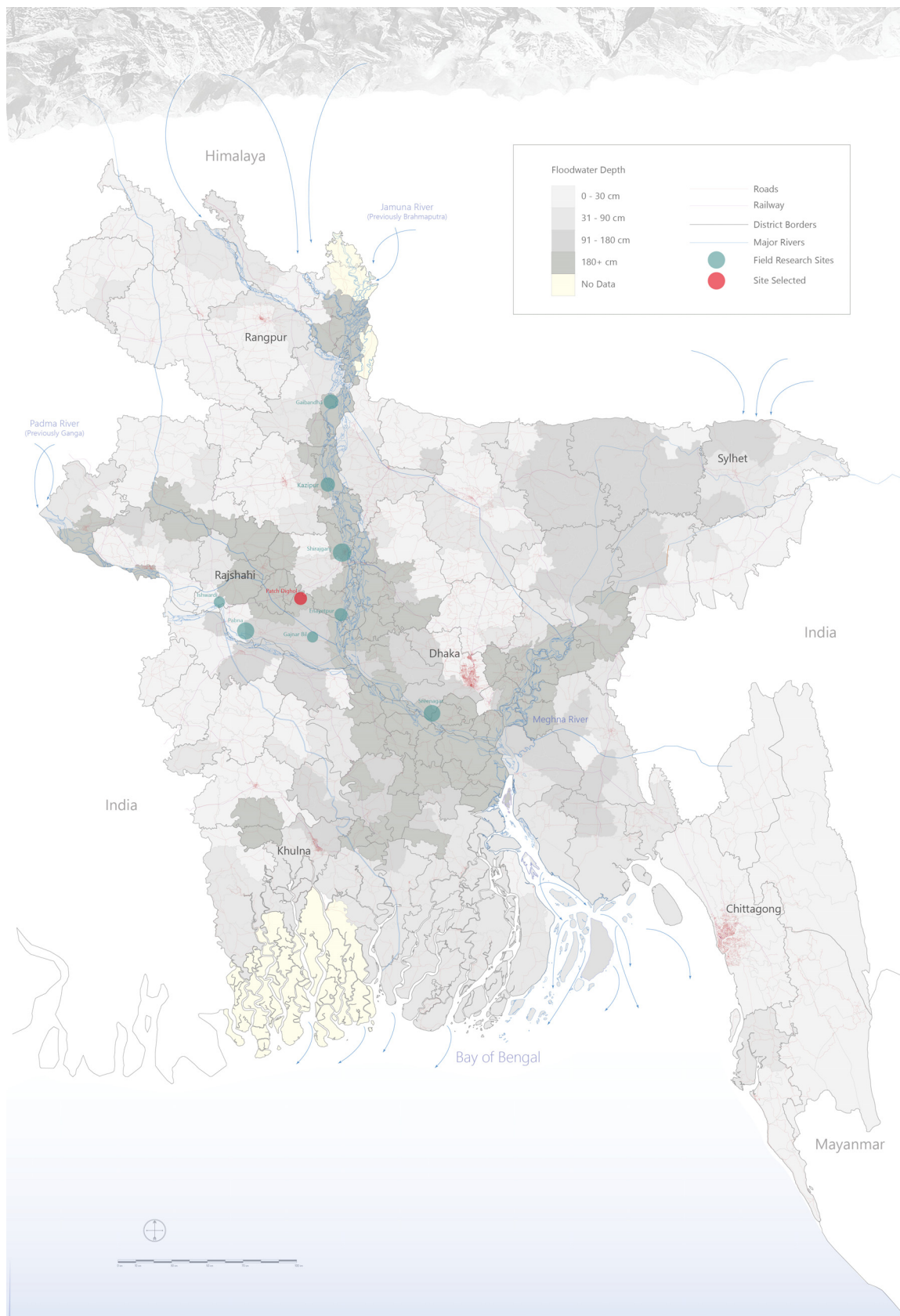


Fig 3: Detailed Map of Bangladesh; from Mapcruzin

which represents vernacular methods of adaptation. These methods must be observed to understand the intersection of local building culture and community interaction that inspire appropriate design.

During the past few decades, dams have been built upstream in adjacent countries, causing the natural pattern of Padma and Brahmaputra River flooding to change in Bangladesh. (Hofer, and Messerli, 2006, 162) The impact of these dams can be clearly seen in the major urban hubs, but in rural areas - especially for those living in poverty - seasonal flooding is still a major issue. Although increasing the use of dams could potentially help Bangladesh's seasonal flooding issues, dams still pose a threat to agricultural productivity and rural lifestyles. This is because flooding results in a build-up of alluvial soil washed down from upstream, which naturally fertilizes agriculturally productive landscapes. As well, flooding saturates the available fish stock, which is crucial to feeding the large population of human settlements. (Rahman 2014, 33) Essentially, the ecological benefits of seasonal flooding outweigh the damages suffered by a lack of built infrastructure, which creates the necessity for buildings that can deal with the inevitability of flooding.

Throughout my thesis, I will explore which methods and materials will be kept and improved upon to make it easier for people to maintain their regular lifestyle within high-depth, flood prone communities. This will provide me with the opportunity to catalogue common and uncommon vernacular building methods informing new adaptive design components that intimately respond to the hardships of seasonal flooding.

CHAPTER 2: IMPACTS OF RIVER FLOODING

Photograph below is of a dock-type elevated structure that uses compressed earth and logs to create a working platform area. This inspires anchor points fixing to land, which is a platform for facilitating temporary migration.



Fig 4: Photograph of a dock structure in Gaibandha

Flood Typologies

In Bangladesh, there are four types of flooding that take place depending on the location (Dewan, Nishigaki, and Komatsu 2003, 54):

1. Flash Floods from heavy rain.
2. Riverine Flood.
3. Flood due to high precipitation (Rain).
4. Storm surge induced flood.

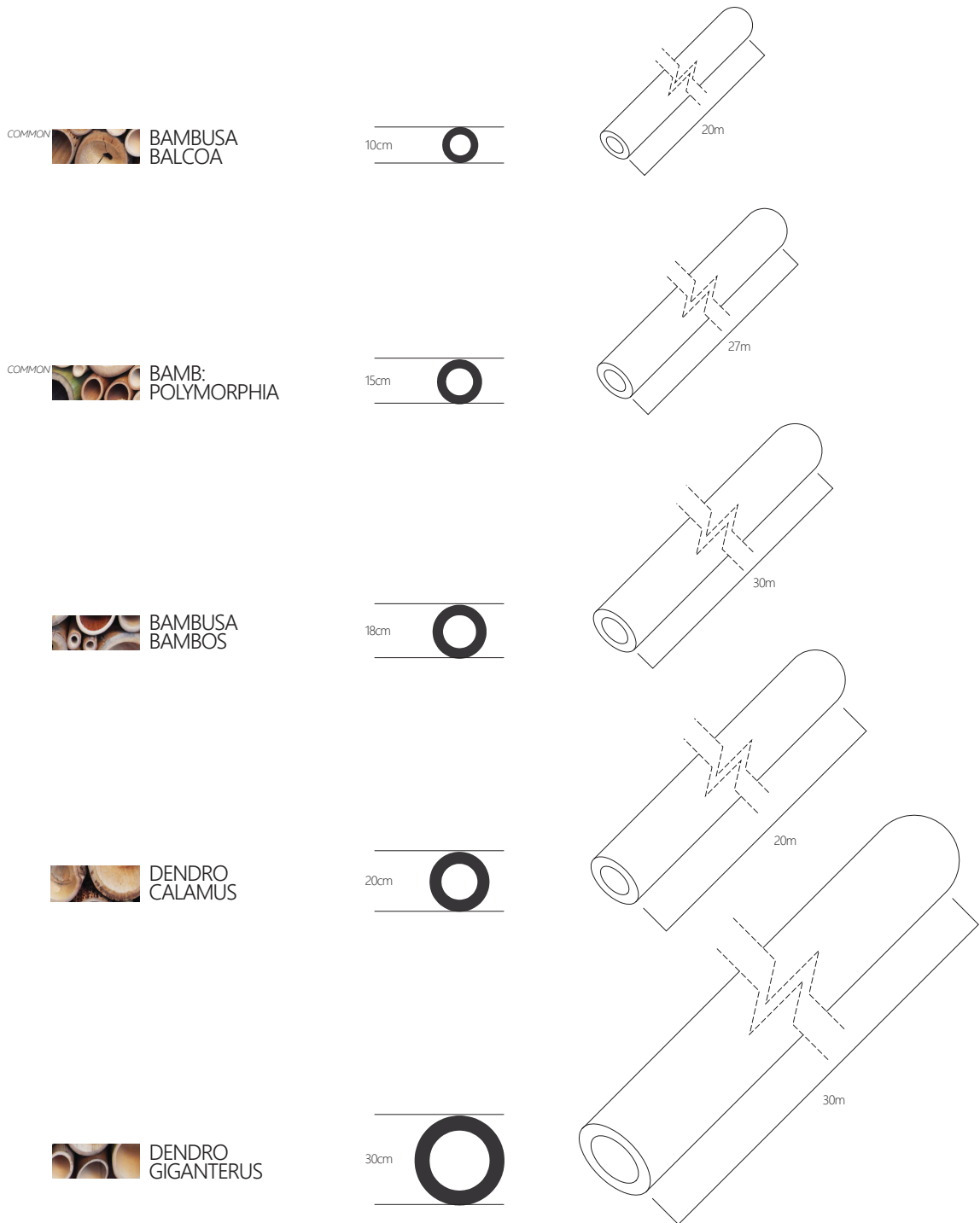


Fig 5: Bamboo species available for construction

This thesis will focus specifically on riverine floods, which rise and fall for 10 – 20 days (Dewan, Nishigaki, and Komatsu 2003, 55), and can remain for 1-5 months, depending on the area. Riverine flooding is caused by a combination of Himalayan snowmelt and monsoon rain, and is prevalent in areas around riverbanks and deltas. The country receives annual rainfall ranging between 1100 – 5000 mm moving from West to North East, (Dewan, Nishigaki, and Komatsu 2003, 55), and although the higher precipitation areas receive flash floods in the North East region, the flooding doesn't remain for long. Subsequently, rising water levels in large rivers can directly affect communities within the delta for an extended period of time; this means that there is a dire need for flood-adaptive solutions. Within the riverine flood zones, there are different typologies of flood-affected area identifiable by their altitude.

During my field research, I have had the opportunity to observe and categorize different flood types:

1. Low-Intensity Flood: Water level exists between 3-5' and remains for about 3-5 weeks.
2. The Waterlogged Areas: Similar to a Low-Intensity Flood, except water remains for a longer duration, and is noticeably more inconvenient.
3. High-Intensity Flooding: This type of flooding causes the highest amount of damage to infrastructure, because the water level can get higher than 5 ft, and can remain for 1-5 months. Depending on the affected area, High-Intensity Flooding can cause a greater array of issues

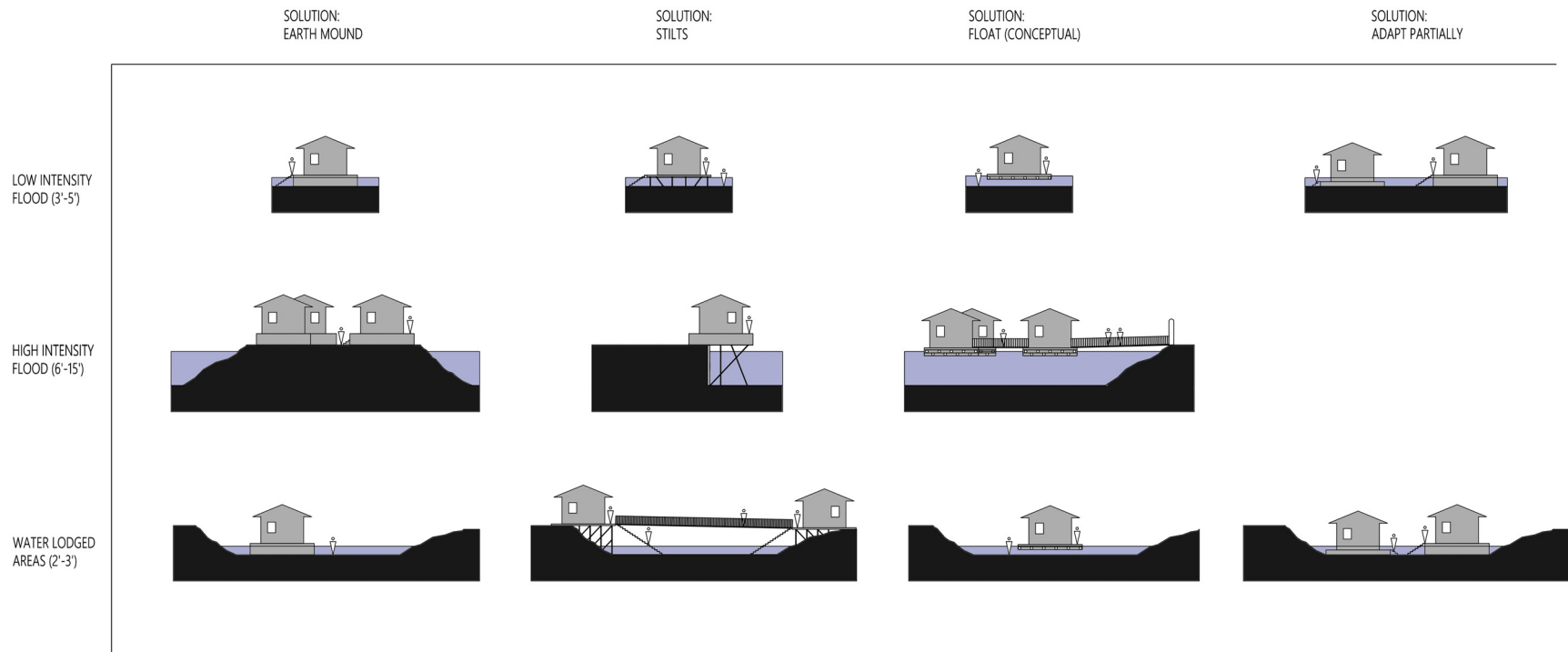


Fig 6: Diagrams for flood typologies & Coping Methods

CHAPTER 3: FLOOD RELATED ISSUES

Movement

During the seasonal, 2-3 months of monsoons, flood conditions have major effects on human and animal life in rural areas of Bangladesh. Transportation becomes a pressing issue during this time for nearly everyone, including people whose homes are not directly affected by the flooding. Shallow flooding regularly affects places where people normally walk, cycle or use any form of motorized vehicle. People may resort to using a boat if the water level is high enough. This seasonal delay creates additional time and cost to everyday travel, since boats are typically slower and require some form of payment. In cases where shallow flood water remains on pedestrian routes, water contaminated with waste and excrement causes a rise in infections from waterborne diseases, and increases local pedestrians overall discomfort with their environment.

Storage

During the monsoon season, storage issues are prevalent throughout all flood prone areas of the country. Foods typically preserved through dry storage are at-risk of getting wet and rotting. Animal feed can quickly become contaminated by diseased water, making domesticated farm animals sick. Even keeping animals safe from contaminated water becomes an issue. In areas where floodwaters rise high enough to enter the home, residents often sustain heavy damages to personal property due to a lack of dry storage space. Damages to granaries that are not lifted high enough off the ground can be devastating in the event of unexpected flood levels. Seeds damaged by flooding will have a decreased rate of germination, negatively affecting agricultural production and earnings for the following year. Due to the overall high humidity and wetness experienced the flood season, it becomes nearly impossible for residents to make necessary improvements to their private living areas. Improvements, such as flood-adaptive storage, that can be built in the dry season must become an important programmatic component for adaptive design strategies.

Issues Due to Flood

Sreenagar, Bangladesh



- Damage to Structure of home
- Damage to Exterior components
(Fence, feed area, Etc)
- Transportation issues
- Cooking area being flooded
- Storage to keep things dry
- Food Shortages: land to farm on
- Toilet – Getting Flooded
- Drinking water getting contaminated
- Damage to trees & Plants
- Domestic animals getting sick & dying
(Cows, goats, chicken, duck)
- Lack or loss of Privacy
- The cost of food increases due to loss of production

Fig 7: Photographs of a water-logged homestead in Shreenagar

Agriculture

Being essential agricultural producers, the main consequence of flooding has been the destruction of staple food crops on farms, as well as the devastation to seed crop stores; eventually culminating in a decline local food production. (Rahman 2014, 6)

Agriculture is a deeply ingrained part of Bangladeshi culture, not only in large scale farming but even at a homestead level. This is because of the rich, fertile land that exists as a result of annual flooding during monsoon season which deposits alluvial soil. Hence, agriculture has always been a major source of income in rural Bangladesh. Since most farmland is situated within areas that flood, during monsoon season there is a direct reduction in local income as the water rises. (Rahman 2014, 8) This forces the workers, often male, to migrate seasonally, seeking alternative income sources, which can cause a disposition within the family as well as social ties. (Rahman 2014, 22) There is also an issue of remote areas not being able to grow their own food, and a decline in transportation causing disruption to imported goods. This often results in people experiencing food shortages and a lack of a nutrition due to the loss of standing crops to fill the requirement. (Rahman 2011, 180)

Structural Damage

Various levels of flooding all cause a certain amount of damage to the structures of the affected area. Sometimes the damage is fairly insignificant, like damage to a few posts, while in extreme cases entire homes are uprooted. In cases of waterlogged or shallow flooding, if the home is not raised, there can be significant damage to the furniture, floors, walls, and structure in general. Focusing more on raised homes, some common issues seen throughout my research in these homesteads were:

Damage to exterior components such as the wall or stairs, as well as the stilts underneath.

- Damage to exterior components such as the wall or stairs, as well as the stilts underneath.
- Toilets (often outside) getting flooded, causing general discomfort.
- Deep tube well (Fresh water source) becoming contaminated if it is not raised high enough.

DEATHS DUE TO RISING FLOODWATER

LACK OF SWIMMING LESSONS
LEADING TO DROWNING

Drowning is the
leading killer of
children

80% Drowning
within 20m From
Home

Around 18,000
Children Drown
Annually
Ages 1 - 18



80% LAND IS
FLOODPLAINS

Fig 8: Poster for
drowning

SOCIAL ISSUES CAUSED BY FLOODING

LACK OF EDUCATION LEADING TO CHILD MARRIAGE

18% by age 15
52% by age 18

Major Drivers
Cultural and Religious Beliefs
Poverty

Natural Disasters
Lack of Safe Access



Fig 9: Poster for Child Marriage

- A lack of privacy as people must share undamaged accommodation.
- The cooking area, often separate from living space, becoming flooded, making it very difficult to build a fire, thus the stove often gets moved into the main area.

In a sample case study done by Saleh-ur Rahman, a village in Manikganj was studied after it was affected by the flooding in Padma River. Many of Rahman's findings align with what I have seen during field research, such as the majority of homes being made with a combination of bamboo, jute & earth. As well, the floor plinths are often just compressed earth, and in some cases are stabilized with cement with a corrugated metal roof. (Rahman 2014, 34) Out of the sampled twenty three homes, more than ninety percent of residents responded that their homes have some sort of structural failure, and indicated that the floodwater enters their homes every year. (Rahman 2014, 35) This is a scenario where the homes are not raised high enough, most likely due to the residents do not owning the land, or because they do not have the financial means to raise their homes. As floodwater enters the home and keeps rising daily, the furniture, the floor, walls, and nearly every aspect of the structure are negatively affected. To store valuables, often the residents must build an elevated platform, or hanging platforms. (Rahman 2014, 35) All of the components that get damaged are often fixed up by community members using local materials.

Local Adaptation Techniques

Stilts

Over generations of being affected by flooding, people naturally developed methods to tackle the issues caused by the fluctuation of water. One method is by raising buildings on stilts, which allows the fluctuating levels of water to pass through underneath.

Stilts are most often seen by the water's edge, often stretching onto the land on the bank. They are more prevalent in urban setting, where structures can function as shops of various kinds, homes, storage facilities, or even restaurants. Structures are often set on bamboo stilts in a grid, which can be surprisingly strong depending on the type of bamboo used.

Coping Strategies

Rural Bangladesh



- Stilts on River Edge
- Raised compact Earth mounds (Bhiti)
- Larger raised platforms
- Making a bridge between homes though the courtyard
- Making a portable stove
- Using the upper storage area to hold grain and other items
- Raising Furniture with bricks
- Placing the tube well higher
- Building one home higher at a time, to have a dry area in case of flood
- Planting plants on a higher ground (Should be done more often)

Fig 10: Bhita/Bhiti typology in Patch Dighol (top); Home with Bridge in Shreenagar (middle); Stairs to a raised homestead (bottom)

Bhita

Another common method to prevent the effects of flooding in rural areas are raised compacted earth platform mounds, also known as Bhitas. The size of a Bhita can range between large enough to hold two homesteads to an entire village.

A Bhita can be large enough to create its own ecology, since the way it is placed can affect the lives of many people. Usually these are built by an NGO, and because the community is laid out very tightly, it can create a loss of social areas for individual homesteads. However, usually in these cases there are designated areas for activities to take place, such as a field or a large pond. Multiple large Bhitas in the same area are usually spread throughout the river width, which allows water to pass through between them.

Small Bhitas are usually grouped together, which form the base for a village. In this case, they are usually privately owned and developed based on a person's financial credibility. These villages are often situated in a lowland part of a major river delta which gets flooded annually. This means that during the monsoon season, boats would be the only way in or out of the village. Travelling between mounds is usually done by bridges made of bamboo cane set into x bracings. These bridges are quite frail and are built to be temporary, because they can collapse easily, and are difficult to travel on. The elderly and small children cannot safely use these thin bamboo bridges.

Social and Cultural Impacts

Like the damage of physical assets, flooding has eroded social assets such as neighborhoods, brotherhood, and the strong bond of kinship...People are compelled to relocate, some permanently; hence, neighborhoods are destroyed, friendships are severed, support networks are broken, and domestic relationships come under greater stress. (Rahman 2014, 29)

Increasingly dangerous flood conditions affect much more than just monetary loss. Due to the rise in water levels, Bangladesh has one of the highest statistics of drowned children in the world, which is reported to be around 18000 deaths per year. (McVeigh 2016, 1)

In conditions of high-intensity flooding, movement by foot is not possible and boats become the sole form of transportation. In low-intensity flood conditions and waterlogged areas, trudging through knee-deep water makes people highly susceptible to various waterborne

illnesses, often restricting the travel of young children and women. Such inhibiting changes to routine and environment have demonstrated very serious social repercussions. For example, floodwater hinders the accessibility of schools for many children around the country. If the child is teenaged and female, her parents will often decide to stop her education completely. The lack of accessibility to schools greatly increases the likelihood of child marriage, which is a prevalent issue throughout rural Bangladesh. (Brides 2016, 1) Thus, maintaining personal accessibility becomes a key component to improving daily life, as well as addressing deeper issues of social welfare

Seasonal migration is an issue that takes place in two forms. One issue occurs where river islands, known as “Chor” get flooded with strong currents, uprooting people’s homesteads entirely. In such cases, people who have the financial means move their entire homes into another location, creating a disposition within their social agendas. The other, more common, occurrence is within the working class male population, who migrate to the town or cities in order to find work. This act of migrating for months at a time can create distance within their family lives, and it takes away from the potential betterment of their home area by alternative methods of earning within the local community.



Fig 11: Homes with half a floor on top for dry storage in Shreenagar

CHAPTER 4: FIELD RESEARCH

Sites Visited

My field research in rural areas has been positioned around 3 aspects: human resiliency, building material culture, and local vernacular responses to the monsoon flooding. The research was conducted in 4 different parts of Bangladesh:

1. Gaibandha, Located in the mouth of Brahmaputra river.
2. Shirajganj area, near the Padma, Jamuna Delta. Where the chosen design site is located.
3. Pabna area, located at the mouth of Padma river, Known as the Ganges in India.
4. Shreenagar, located in the Padma-Meghna Delta.

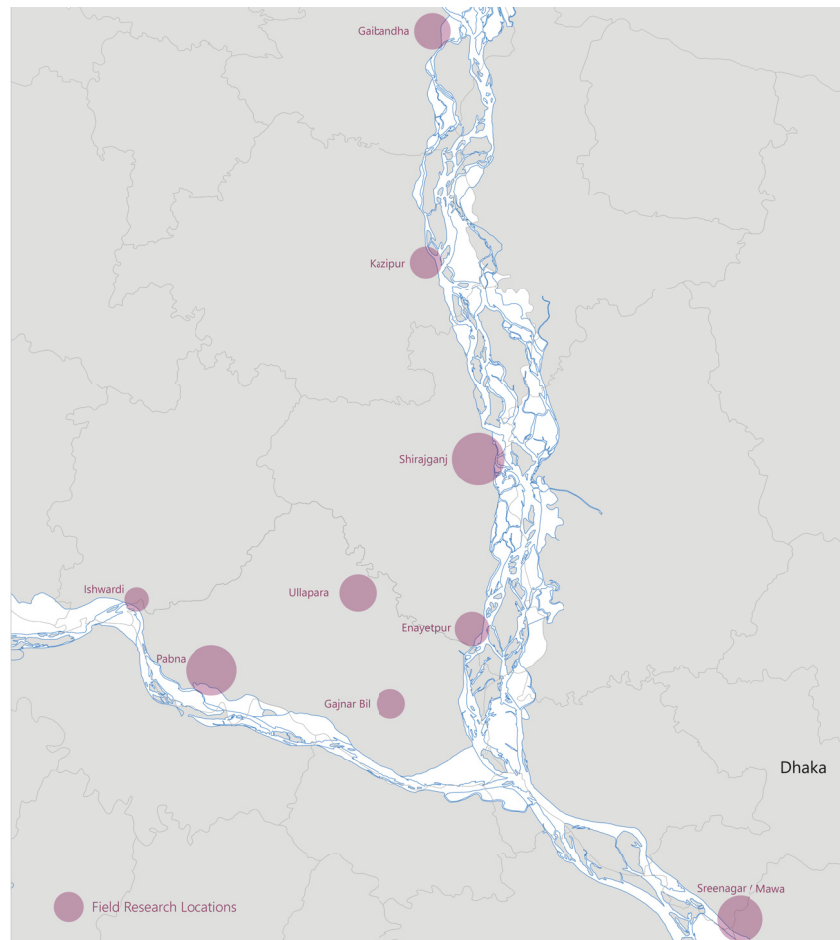


Fig 12: Map of Field Research Sites

Material Related Case Studies

Tar Barrel House – GajnarBil

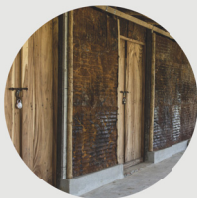


Fig 13: Photographs of Tar Barrel House near Pabna.

This house was constructed by reusing rolled flat metal barrels, concrete, bamboo posts and joists, and wood. The large array of materials and local building techniques used to construct this hybrid structure make it a perfect example of local ingenuity in dealing with recycled materials and details.

Large raised platform Mounds – Ullapara



Fig 14: Raised platform mounds (Bhita) in Patch Dighol Village

The village Patch Dighol is in Shirajganj, Central Bangladesh. It is situated about 30 km inland, and is known to get severe flooding. The site depicts a study of typology for indigenous coping strategies dealing with flooding, which is the raised compressed earth platform mound, lined with clay bricks for protection against land erosion due to the flooding. These raised platforms can range between 14-18' above ground level to build mainly housing and other program components needed on a daily basis. For example, the hay sitting on a platform on stilts is used for feed for domestic animals. The ramp is made of clay bricks, which are local to the country, and cost effective. This village is the chosen site for development.

Home in Munshiganj / Mawa



Fig 15: Photographs of a homestead with a temporary bridge through the courtyard in Shreenagar

This is a homestead in Shreenagar, which is situated in a low part of the village, which gets waterlogged for 1-2 months annually. The owner of this homestead had a bamboo bridge going through the central yard to cross between different types of raised platform houses during the flooding season. The bridge was waterlogged at the time.

Home with Store - Pabna



Fig 16: Home with a store component in Pabna

This home documented in Pabna lays within a community of workers called Sweeper colony, and is situated only about 10 km from the city centre. One particular home in the tightly packed colony had a shop built into a room in the house and run by the wife, while the husband tended to a shop outside the neighbourhood. They were making a living for themselves while providing a much-needed service to their neighbours and surrounding community members, all stuck with 3 feet deep water to walk through.

CHAPTER 5: MATERIAL CULTURE

Readily Available Building Materials in Rural Bangladesh



Fig 17: Photographs of materials gathered in Bangladesh for exhibition

These are some of the local materials observed that are low cost and durable in flooded conditions:

Bamboo, the ever-present weed that shapes the informal building culture throughout Bangladesh. The variations in bamboo cuts lay the foundation for many elements used throughout the country.

From largest to smallest:

1. Canes are often used as structural components such as columns or joists.
2. Planks are often used for flooring, and sometimes for fencing.
3. Strips are often used in making seating areas or fencing.

4. Lathes & Belts are used in making prefabricated weaved paneling systems that are used for wall to ceiling, as well as making baskets, sifters, etc.

Jute ropes are often seen being used in rural areas, but they are becoming more frequently used in urban areas.

Corrugated Metal, which is widely used throughout Bangladesh in both rural and urban single story buildings. In the Sreenagar area, traditional homes are often two story corrugated metal, a specific house typology for this part of the country.

Brick is a locally produced material, and price varies based on quality. The highest quality brick can cost up to 3 times as much as the low quality kind. Crushed Brick is often used as an aggregate.

Earth, which is used for plinths in the rural parts. It is usually compressed and sometimes cement stabilized. Rammed Earth homes with 14-18" walls used to be a common home typology throughout Bangladesh. However, because it is susceptible to damage from various sources such as water and insects, building techniques have not been progressed upon, and the typology has been mostly replaced.

Concrete is cheap and durable, but is not a local material. Thus, limiting the amount of its use should be considered.

Metal is used in small quantities, mostly as fasteners.

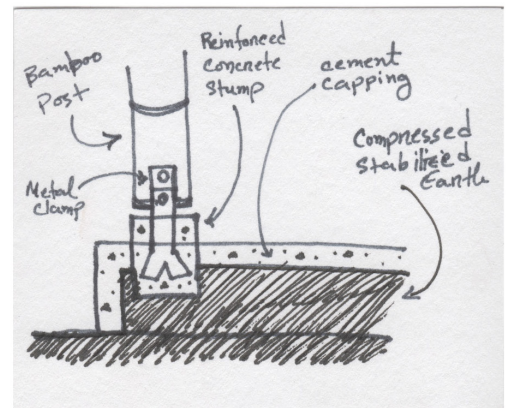
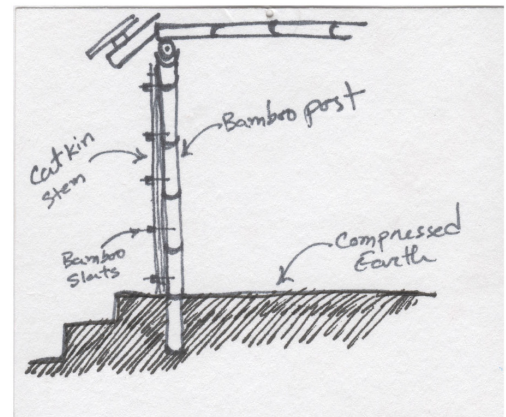
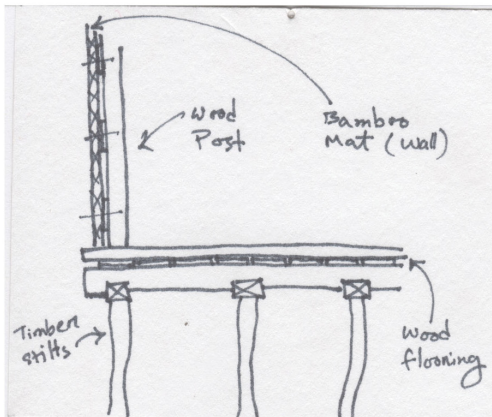
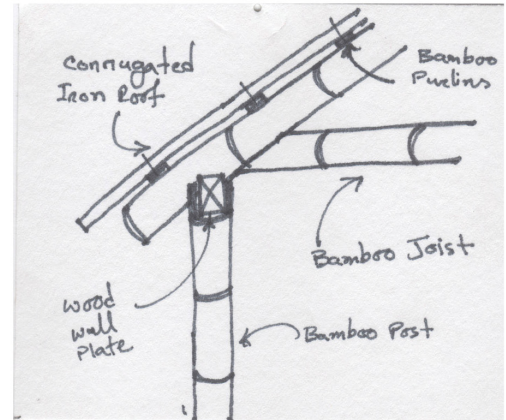
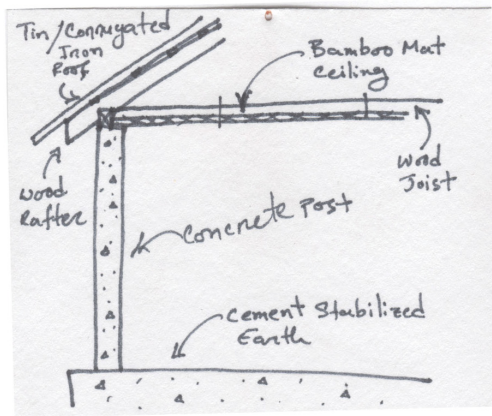


Fig 18: Some details documented during field research



Fig 19: Photo of a Boat in Shreenagar

The photograph above depicts the material culture of Bangladesh, and how these methods have been used for generations. The use of bamboo from floor to ceiling is of importance to understand the availability and range of use of one material. Bangladesh is defined by a culture with a deep connection to water, rivers and boats, which is why bamboo has become inextricably linked with their lives.

CHAPTER 6: COMMUNITY DEVELOPMENT

The socio-cultural sustainability which is not resistant to change would be allowed for developing, renewing, and maintaining most of the Bangladesh traditional houses. (Rashid 2013, 69)

Social & Cultural Sustainability

The traditional home in Bangladesh has a layout which was developed through generations of people interacting with their surroundings. (Rashid 2013, 63) The building materials used are readily available for making quick repairs, and additional elements have been added over the years. For example, many of the residents in the river islands (Chor) have recently invested in a small solar panel to run a light and a fan, because they have no electricity.



Fig 20: Pidgeon coop attached to home as an additional component



Fig 21: Solar Panel on a home in a remote river island (Chor)

Currently, the buildings that take place in rural areas are usually undertaken by the community; neighbors helping one another to build and repair their homes, and hiring local skilled labour for roofing. (Rashid 2013, 66) Community involvement is a factor that must be kept in mind while designing for the rural setting, as it is an integral part of local culture and a core of social sustainability. To facilitate this, the details of the home's layout must be familiar enough to the inhabitants, so that they could do their own repairs. For this to happen, the materials used to build and repair their homes must be culturally appropriate and readily available.



Fig 22: Locals fishing off a informal garbage dump site on a river bank



Rise & Fall of Floodwater

15 Ft

Ground

Dry Season

Fig 23: Collage representing seasonal change and water level rise

Social Space & Human Interaction to Water

The people of communities are to be involved with the flood mitigation initiatives. They should also adopt to those activities before, during and after the flood events to minimize flood losses based on the acceptance of the fact that flooding is an inevitable event. (Dewan, Nishigaki, and Komatsu 2003, 61)

Bangladesh is a riverine country, with a network of over 230 rivers flowing throughout it. As a result, many social activities take place by a body of water. By observing riverbank sites and urban sites with major water features in Bangladesh, it has become apparent that there is a high level of human activity taking place near water. Thus, for a short while during flood season, areas that are normally dry may gain a water feature as the water rises. Residents use this short period of time to create open social spaces by the water's edge for the community.

Social spaces in rural Bangladesh are usually intertwined between homesteads, roads and ponds of various sizes. These open social areas in villages are often used for various purposes, from drying grains to wedding ceremonies. During monsoon season, locations susceptible to flooding usually lose these areas, which poses great difficulty to the people in the community. It is important to understand that people in rural Bangladesh retain cultural identity through their relation to water, and how important these social spaces are to maintaining this identity.

CHAPTER 7: SITE

The site chosen for this thesis is a small village in the Shirajganj area called Patch Dighol. The village is located approximately 30km inland, is about 1.5km in length and 300m wide, with no major rivers nearby. However, it is situated in the lowlands of Padma-Jamuna river delta, meaning that the entire area floods on an annual basis. The floodwater level ranges between 8-14 ft depending on the tide, and remains for 3-5 months. The vernacular for coping with flooding in this region is compressed Earth platform mounds: they are raised about 14-16 ft, and they are occupied by 2-50 families depending on the size of the mounds.



Fig 24: Map of Patch Dighol in larger context; from Google Maps

Platform mounds are built by digging into the earth, leaving voids that become ponds. Small ponds are often used for washing and bathing, and the larger ones are mainly used for farming fish. The white spaces seen intertwined between mounds and ponds are used for social gatherings, drying crops, and play areas for children, all of which disappear during monsoon season. While road access remains during the dry season, traveling by boat becomes the only form of transportation during the monsoon season. The majority of the population are farmers, and many lose their only source of income due to floodwater. Seasonal migration causes 25-30% of the male population between the ages of 25-50 leave to find work in the city during the monsoon period.

I chose a community that has already adapted to coping with the flood, and with them, began creating systems that would improve the resident's way of life, I am proposing that, instead of trying to stop the flooding water every year or giving it to it, people must find ways to adapt to this drastic change to make the best of this inevitable act of nature.

The exact location for these concept proposals has been determined as the village square, with market or Bazaar to the west, and an open field in the center surrounded by platform mounds and ponds. One of two primary schools is situated in the North end of the field, which happens to be one of few concrete buildings in village. The school is situated on a small mound which is about 3 ft high, and the foundation is made of exposed concrete columns in order for the water to pass underneath it. The original school building remains beside the new one, but is only used during dry season. The village bazaar during dry season has a weekly event known as "Hat", where vendors from surrounding villages gather to create a larger market, which does not exist during the wet season.

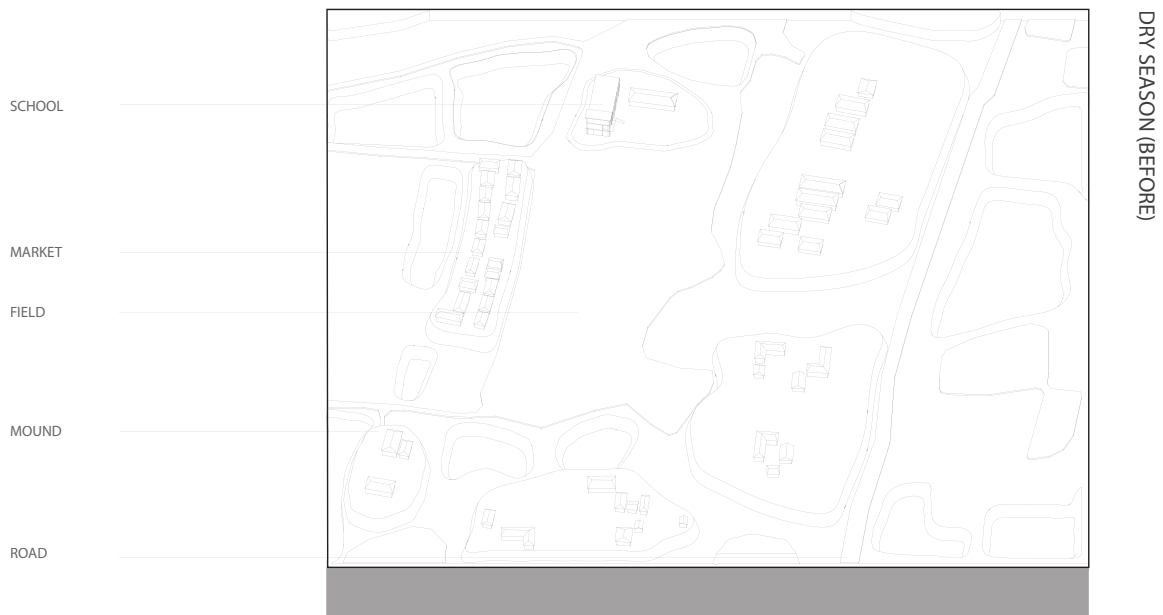


Fig 25: Patch Dighol village square in dry season



Fig 26: Patch Dighol in dry season, From Google Earth

Fig 27: Patch Dighol in wet season; from Google Earth



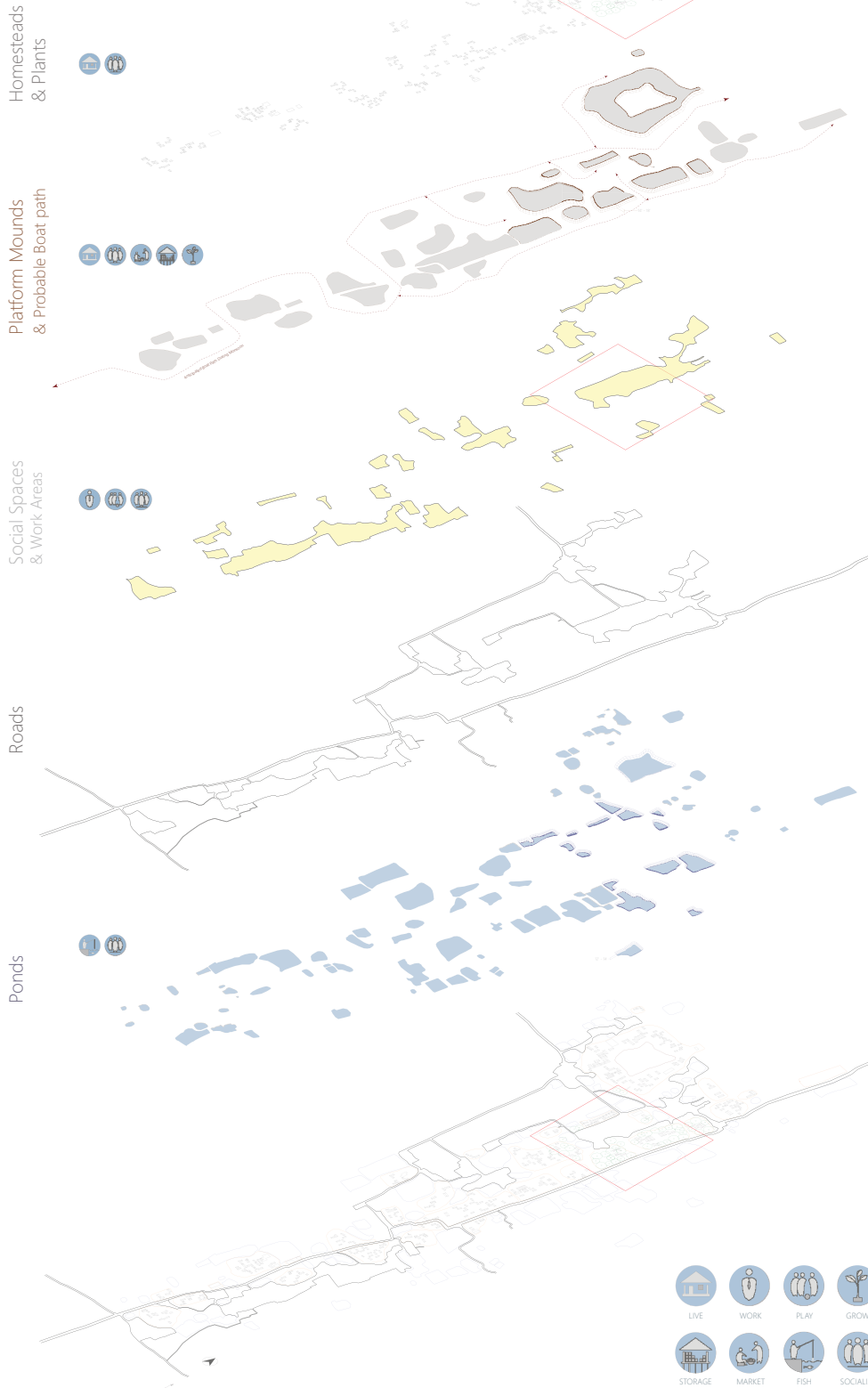
- Located approx. 30 km inland, with no major river nearby
- Approximate area of the village 1.5 km x 300 m
- Vernacular Response: Raised Earth platforms (14 ft+)
- Land modification: Digging ponds and using the Earth to raise buildings
- During monsoon, floodwater level ranges between 8 - 14 ft
- The water remains for 4 - 5 months
- Boat is only form of access in and out during monsoon
- Paved road access during dry season (7-8 months)
- Majority jobs: Agriculture & Farming Fish
- Access the platforms using stairs
- Plants are always seen in the property
- Platforms hold 2 - 20 families depending on size



WET

পাঁচ দীঘল
Patch Dighol
Ullapara, Rajshahi Division, Bangladesh

Fig 28: Patch Dighol exploded map



Regionalism will be a theme, constant throughout the design process in the village Patch Dighol in Ullapara, Rajshahi Division (Province). I am examining the existing vernacular of communities in Ullapara, where for generations, residents have developed methods of flood adaptation, mainly by using raised earth platform mounds (Bhiṭā). This design will explore developing systems to improve the way of life for the residents of Patch Dighol, which will provide the necessary programmatic components needed to address some existing issues in their own community, as well as surrounding ones.



Fig 29: Highest part of the road (above). People walking on the paved road below floodwater while a boat paddles by (below)

CHAPTER 8: DESIGN DEVELOPMENT

In the early days of civilization, architecture was very much regional in character because it evolved purely in response to these regional determinants...culture-specific architecture which still persists in the rural habitats in different parts of the world (Muktadir, and Hassan, 81)

Approach

This design will attempt to exemplify the possibilities that lay ahead for applying formal architecture in an informal setting, as well as reinforcing the socio-cultural sustainability of the diverse communities throughout Rural Bangladesh, by representing the majority populace. Not only can it improve the daily life of its citizens, it can support these communities as they become efficiently self-sustaining.

The idea is to act as a catalyst for this type of small-scale community development throughout the rural areas of Bangladesh. The proposed systems will aim to fill the gap in community support elements which disappear under floodwater during monsoon season. (Fig 26 & Fig 27) They will attempt to strengthen the interactions between neighboring mounds, while providing opportunities for social gatherings and new sources of income. The overarching theme of the design approach will be to use locally produced and/or readily available materials to design elements that compensate for the loss of social space, access route, and income source, all the while showcasing the strength and possibilities these materials hold when applied in a formal manner.

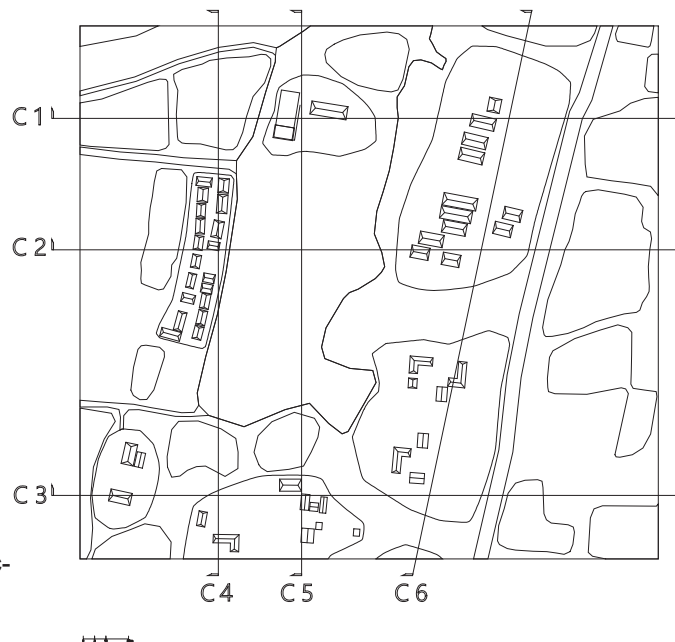


Fig 30: Site map locating section cuts for interventions

Scene 1: Mound to Ground
Scene 2: Mound to Mound
Scene 3: Ground to Pond
Scene 4: Anchor to Ground

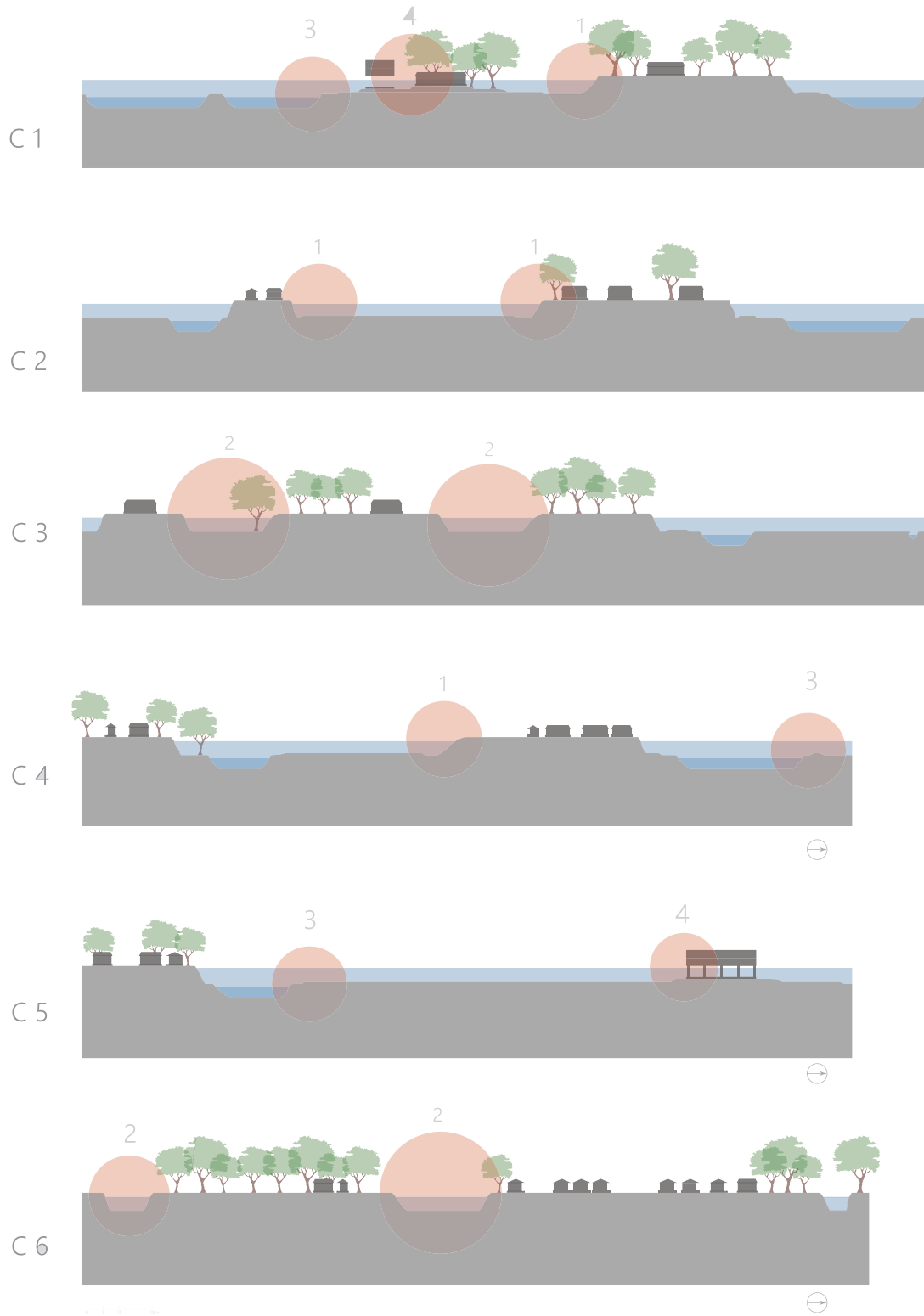
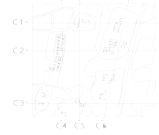


Fig 31: Sections denoting moments for architectural interventions

Conceptual Collages

3 Concepts of Small Intervention were imagined to resolve issues regarding local access and social space:

Float: The idea that is born out of the culture of boats.

Anchor: A structurally sound element to help shape spaces tying to the float element.

Bridge: A more formalized version of the temporary bamboo bridges seen all around the country.



Fig 32: Concept Float



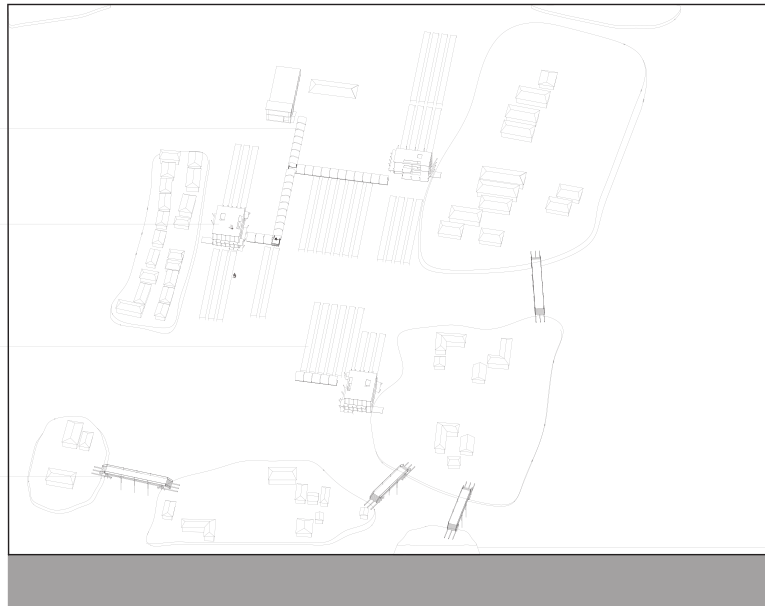
Fig 33: Concept Anchor



Fig 34: Concept Bridge

WET SEASON (AFTER)

- FLOAT POD
- ACCESS
- VENDOR
- SWIMMING
- TOWER
- WORK
- STORAGE
- GROW
- ACCESS
- SOCIALIZE
- GARDEN BED
- GROW
- WORK
- BRIDGE
- ACCESS
- SOCIALIZE
- PLAY



DRY SEASON (AFTER)

- GARDEN BED (FERTILIZER)
- GROW
- SELL
- FLOAT POD
- VENDOR
- SOCIALIZE
- SPECTATE

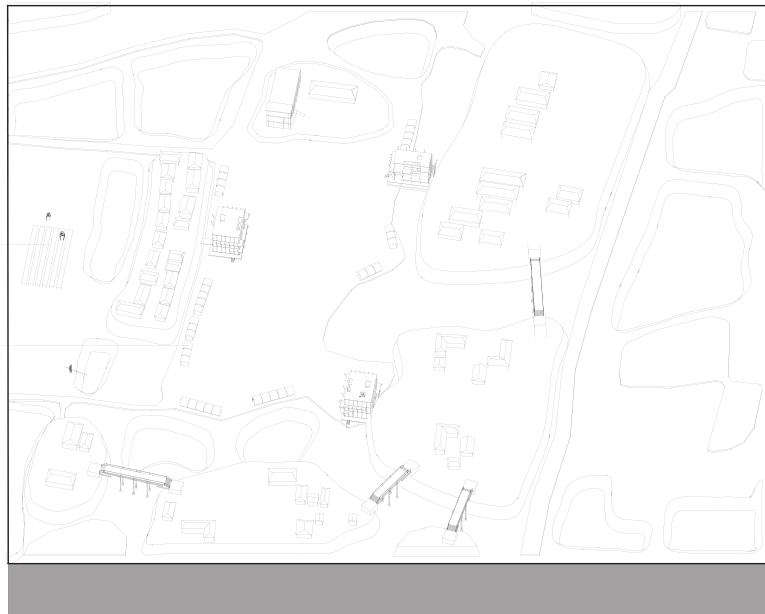


Fig 35: Patch Dighol village square with interventions in wet season (Top)
Patch Dighol village square with interventions in dry season (Bottom)

Design

Social sustainability is focused on the development of programs and processes that promote social interaction and cultural enrichment. It emphasizes protecting the vulnerable, respecting social diversity and ensuring that we all put priority on social capital. (Rashid 2013, 63)

Float Pods

Float Pods are one of three design elements dealing with the issue of lost social space, access, and agriculture. This concept is derived from traditional boats and bamboo homes. I am proposing the reusing of barrels as a float component, while the platform base structure is made up of bamboo canes and planks, and the shade uses corrugated metal arched to create a monolithic component.

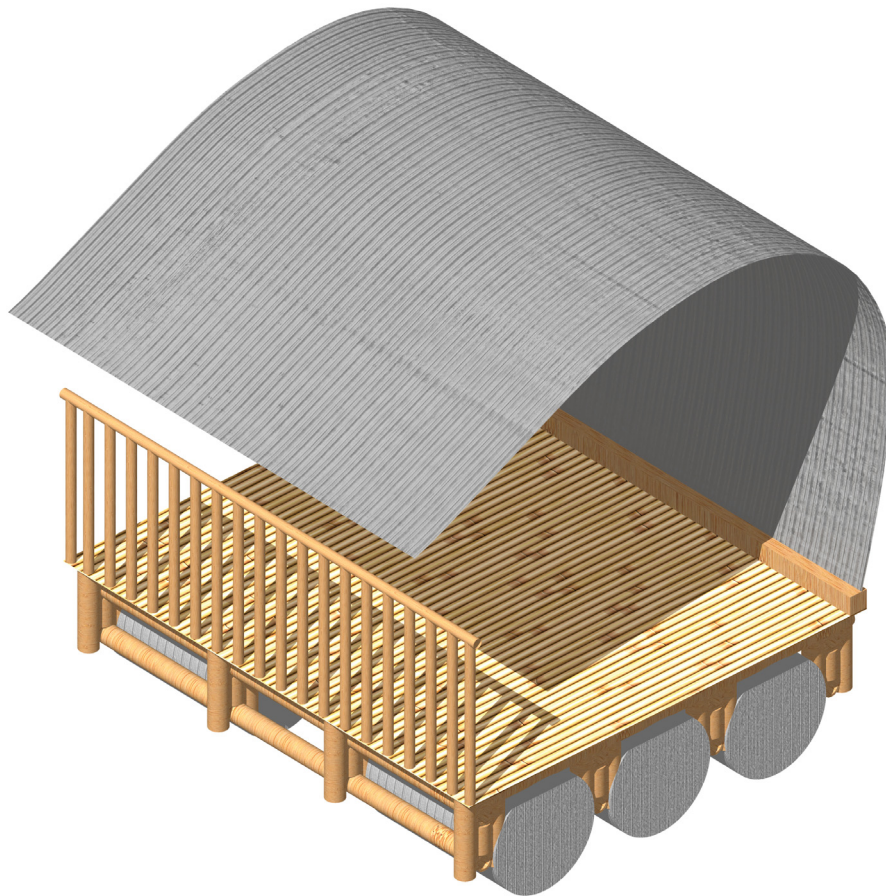


Fig 36: Float Pod material render

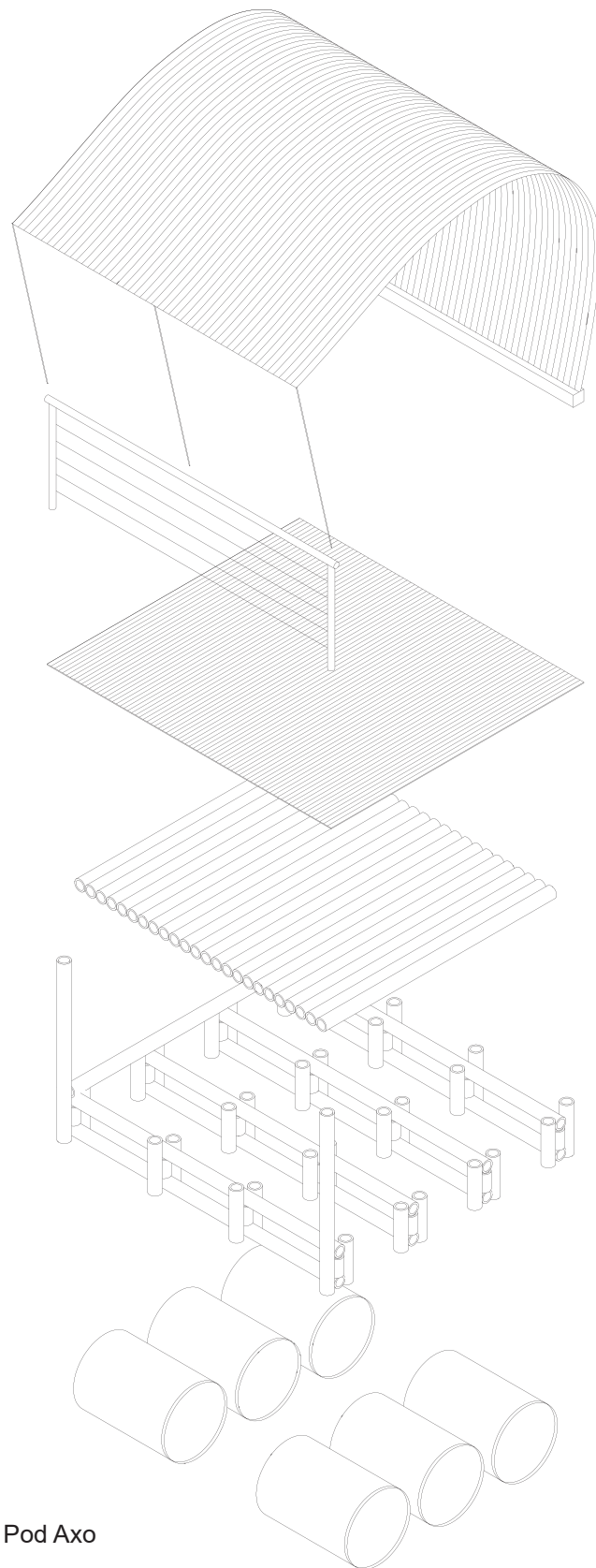


Fig 37: Float Pod Axo

During wet season, these pods are setup to latch onto one another and make a floating boardwalk for people to walk and socialize on. The individual pods in a string can be used for various uses, such as small vendor stalls, social gathering spaces, or even contained swimming areas for the children. The weekly event known as 'Hat', which normally only takes place in the dry season, can now extend to the wet season cycle, where vendors can setup in the pods to barter their goods. Lastly, the float pods are also intended to be used for anchoring element to the floating garden beds, where a bamboo can be tied to the pods to hold floating agriculture in place.

During dry season, the pods will serve as landscaping elements, where they can park in designated groves to create semi-enclosed areas serving various functions depending on location. In the iteration below, the pods are set around the field to create possibility to have spectators for sports and cultural functions. The pods can be set by the pond to create a seating arrangement in an already existing social space. (Fig 35)



Fig 38: Site model showing possible float pod layout (white shells)



Fig 39: Activity & enviromental render for float pods

Bridge

The bridge component spans between mounds that are situated a maximum of 23m apart, and they act as a permanent solution to the movement by foot issue. The structure is made completely out of bamboo with rammed Earth support on both ends of it, as well as an elevated platform for boats to pass through underneath during monsoon season.

The main function of the bridge is movement. For example, children that live nearby their schools will not have to take a boat, but rather they can keep their routine of safely walking to schools with classmates or parents. The bridge will also act as a platform for social gatherings and easier sharing of goods between residents of neighboring mounds. During the evenings, the bridge will most likely be used for social gatherings and fishing into the monsoon water. Since most of the people have plants for consumption growing in their homestead, if they wish to trade with their neighbors for a variety in their diet, that possibility becomes much easier.

In the summer, the bridge's function will shift slightly to activate the space under the bridge. This space will become a shade component along as a route for transportation . One can imagine a few pods being landed around it to have more privacy (Fig 40), or even hanging swings for children to play underneath, and simply placing a few benches under the bridge, which will create an inviting small gathering area.

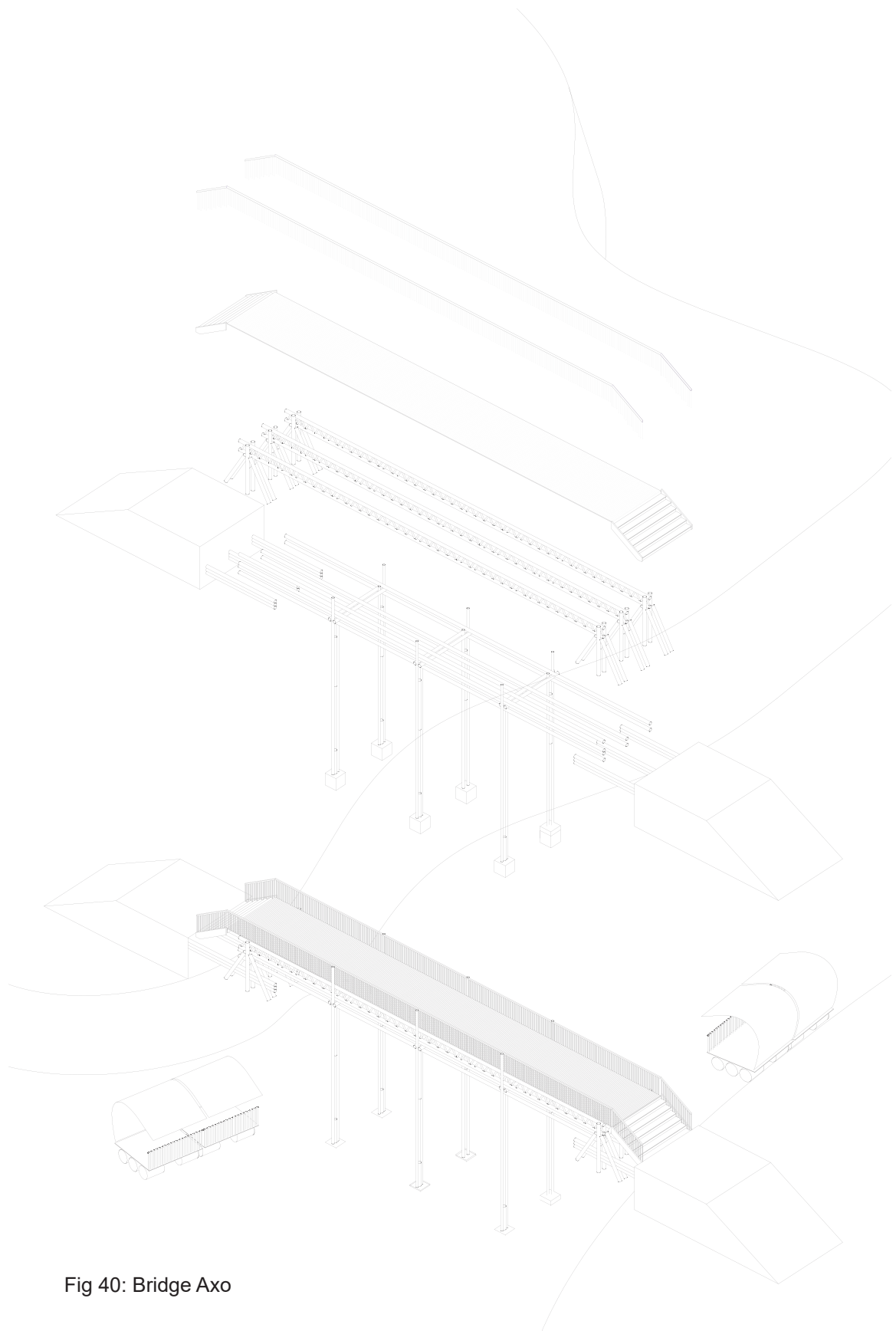


Fig 40: Bridge Axo

Work Grow

Lastly, the Work Grow Component, which is comprised of two parts, one being the platform tower for processing seedlings and storage, and the second being the floating garden beds for agriculture, which are serviced by the platform tower.

Platform Tower

The Platform Tower is a service component, which provides a space to generate the seedlings before placing them on the garden beds, as well as processing the vegetables, and a vertical access point to the mound attached by a walkway. The vision for the structure of this tower is to be constructed using bamboo, ropes and potentially some metal screws or fasteners.

The tower is 3 stories high, which means that the roof will align with the surrounding homes. While the first floor is expected to get completely drowned during the monsoon, there are two levels that can be used year-round. The tightly gridded columns and beams extend out to make railings for the platform extensions. The walls are locally made pre-fabricated bamboo panels with various degrees of openings that can be replaced easily if damages, and variations in arrangement can exist based on the time of the year. The robust structure of the tower component is intended to showcase the formal use of bamboo and the possibilities that can arise by pushing to the full extent of its strength. (Fig 41)

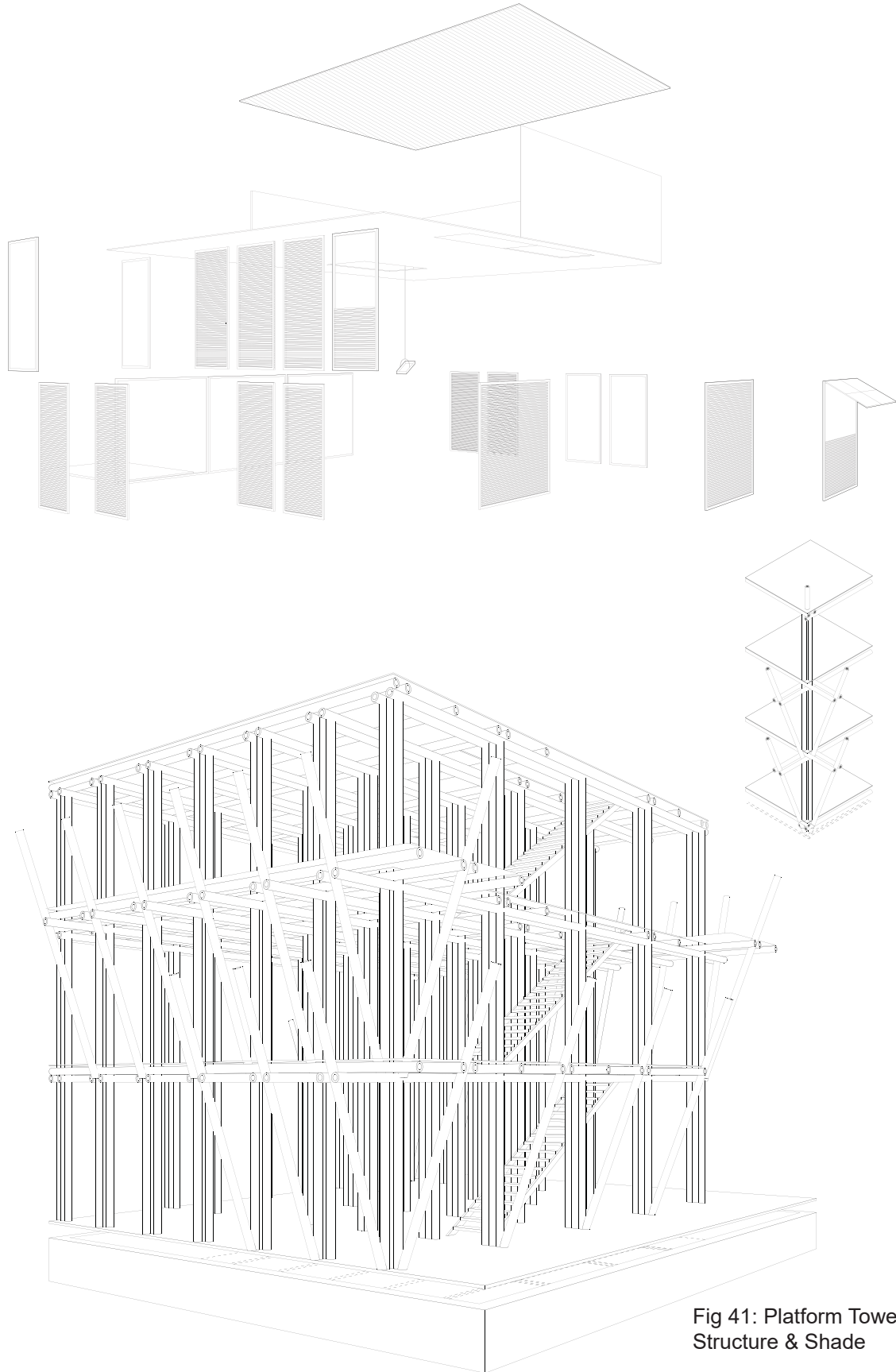


Fig 41: Platform Tower
Structure & Shade

Floating Garden Bed (Baira)

A large area of Bangladesh sits at least two meters below the sea level, and there are locations that receive long periods of flooded conditions. (Rahman 2011, 179) This condition pushed farmers, specifically in the southern part of Bangladesh, to develop a method of agriculture known as Baira, or farming garden beds. This is a locally developed technique for farming on water by using mainly Water Hyacinth, creating floating gardens. (Rahman 2011, 179) Water hyacinth is a plant that floats on water and is readily available throughout Bangladesh. Ironically, this technique has not spread throughout the country until recently, when agricultural researchers started to promote the idea.

The construction of this floating bed uses different types of aquatic vegetation, compost and bamboo for support. As the water hyacinth is layered up, the bed becomes high enough to sustain a large amount of crops without sinking. (Fig 42) The bed size can range between 6 ft wide by 4 ft high, and over 100 ft long and since they float, they can be moved by the farmer to a different location if needed. (Mohim 2002), The seed cannot be directly planted onto the Baira. Rather, a seedling is prepared in a growing medium of fermented water hyacinth and soil, known as Tema, and dropped on the floating bed with sufficient spacing. (Mohim 2002) (Fig 44) An important factor to keep in mind is that no chemicals are used in this process, thus making the produce fully organic.

The variety of crops that can be grown on the Baira is substantial. They range from green leafy vegetables to beans, radishes, eggplants, gourds, and potatoes, to garlic, turmeric, mustard, onion, etc. (Rahman 2011, 180) Since farmers in Patch Dighol Village lose their methods of income during the monsoon season, promoting this method of farming can give them the incentive to stay at home and practice their line of work, rather than migrating seasonally to the city. Essentially, by having this system of Baira in place, it becomes possible for the local farmers and other trade workers who have lost their sources of income to feed their families, while generating income in the process, which helps to keep the community and social ties strong.

SEEDLINGS ARE PREPARED CLOSER TO THE FARMERS HOME AND TRANSPLANTED AFTER THE FLOATING GARDEN BED HAS BEEN ESTABLISHED.



FERMENTED WATER HYACINTH DREDGED FROM THE WATERBED IS MIXED WITH SOIL TO ESTABLISH THE GROWING MEDIUM.

TOOLS REQUIRED



Fig 42: Preparing TEMA/ Seedlings for floating garden beds



Fig 43: Site model showing possible Baira layout (Dark wood)

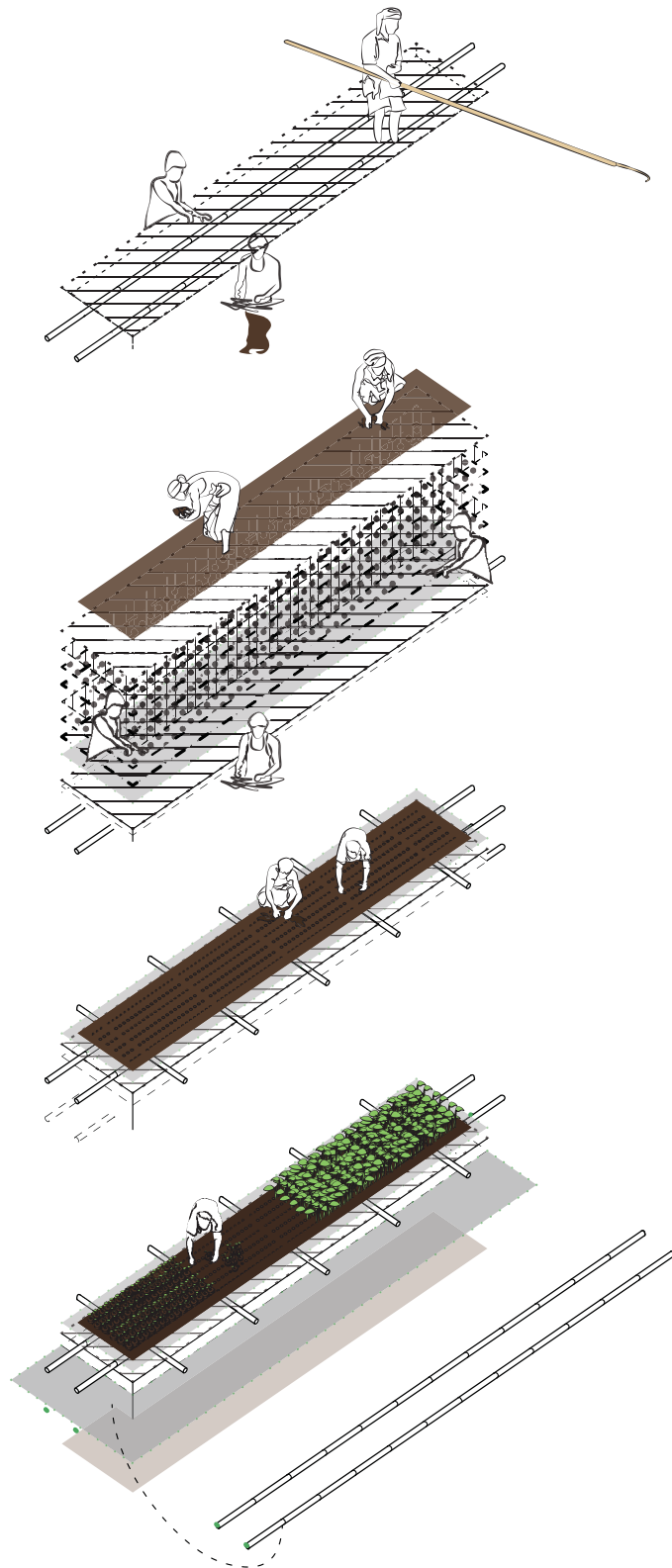


Fig 44: Creating the floating garden bed

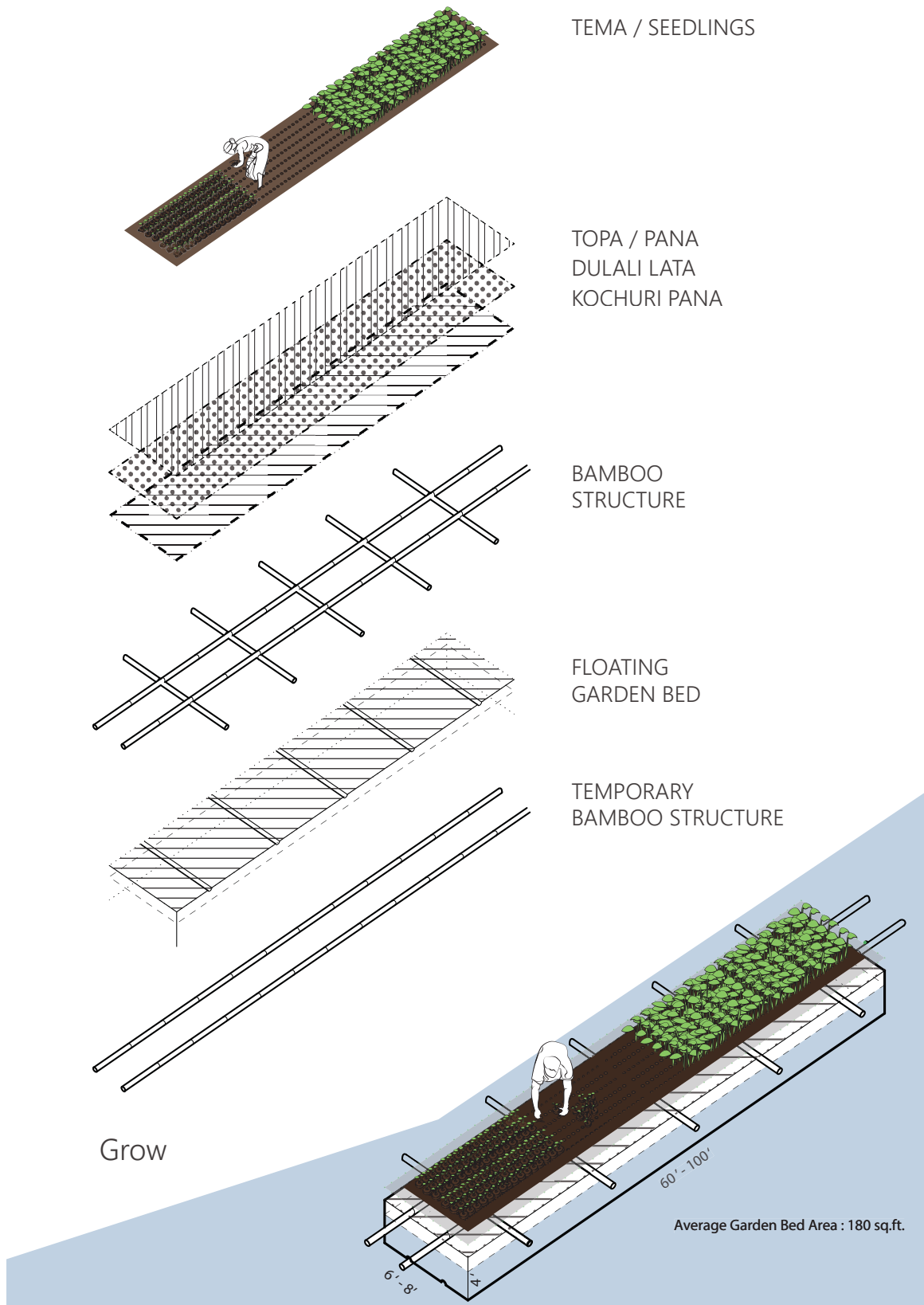


Fig 45: Floating garden bed grow setup

Models



Fig 46: Commonly occurring joint detail (1:1)



Fig 47: Float Pod (1:20)

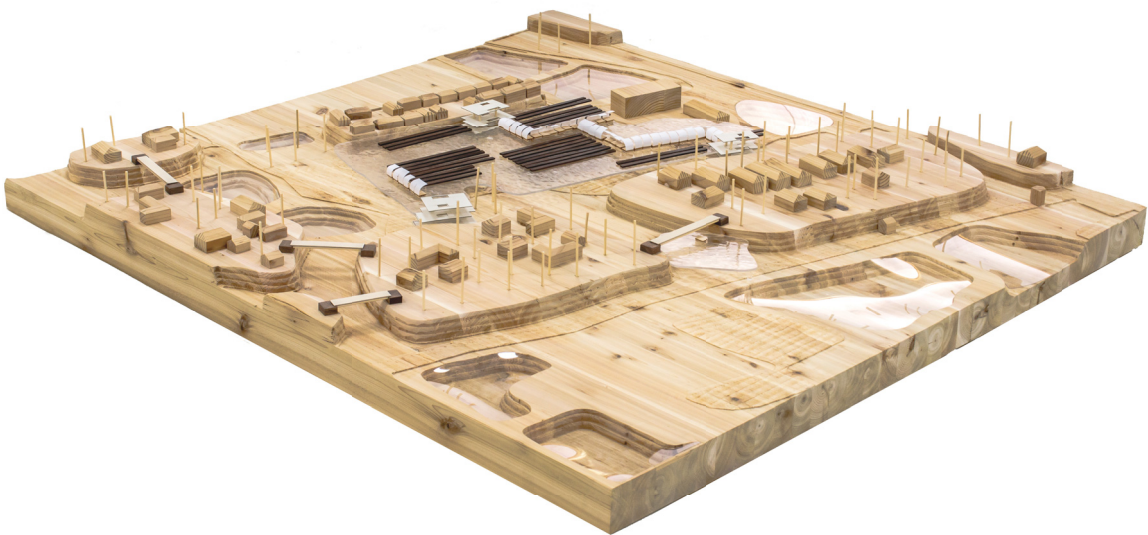
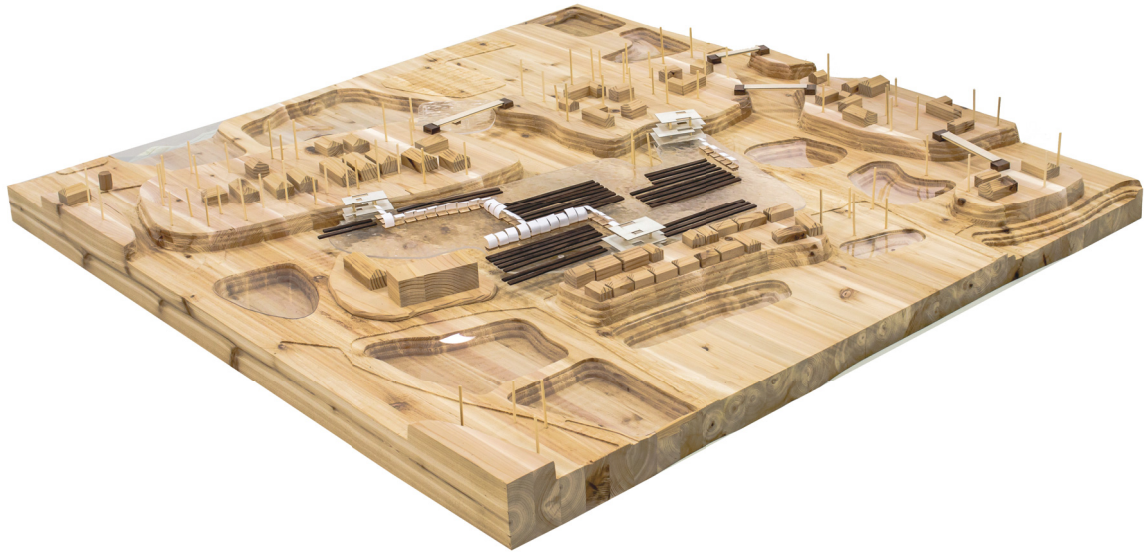


Fig 48: Site model full views (1:200)

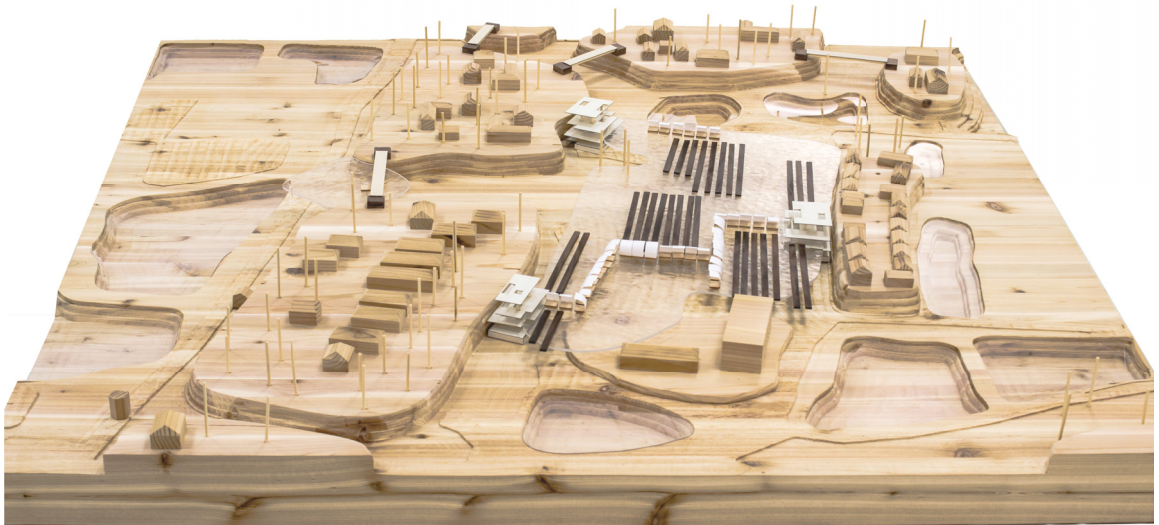


Fig 49: Site model full views (1:200)



Fig 50: Site model close-up (1:200)

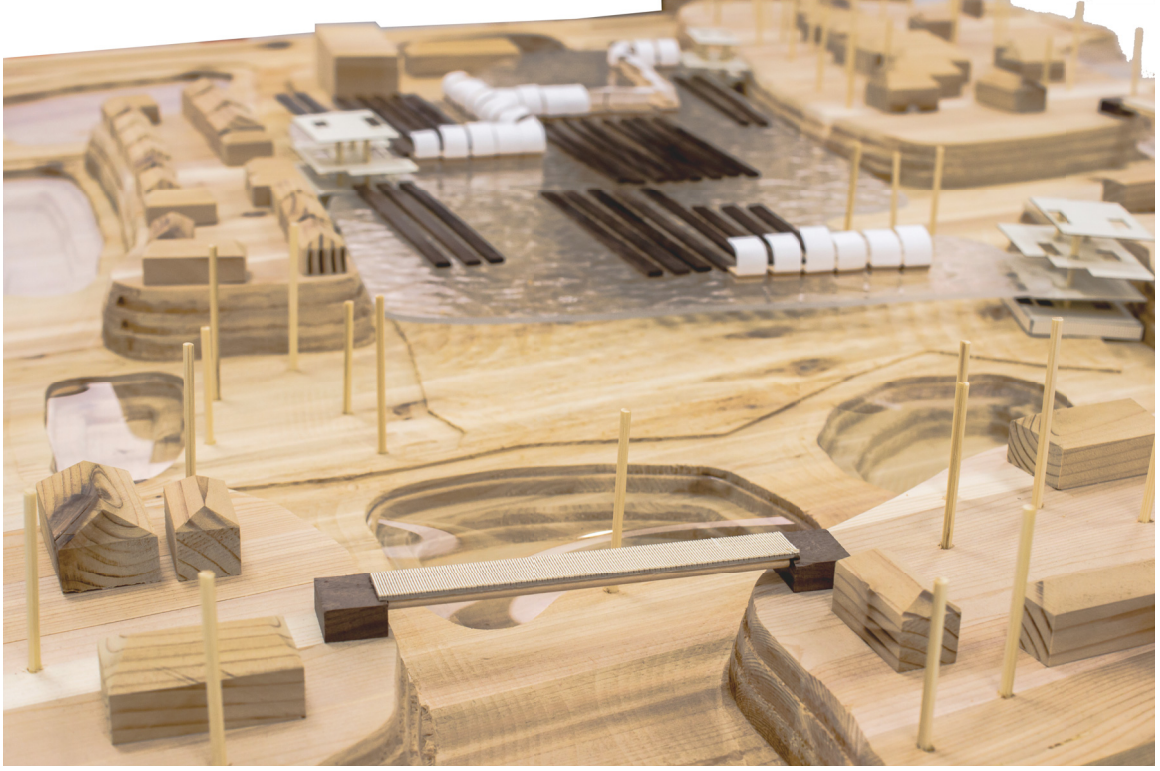
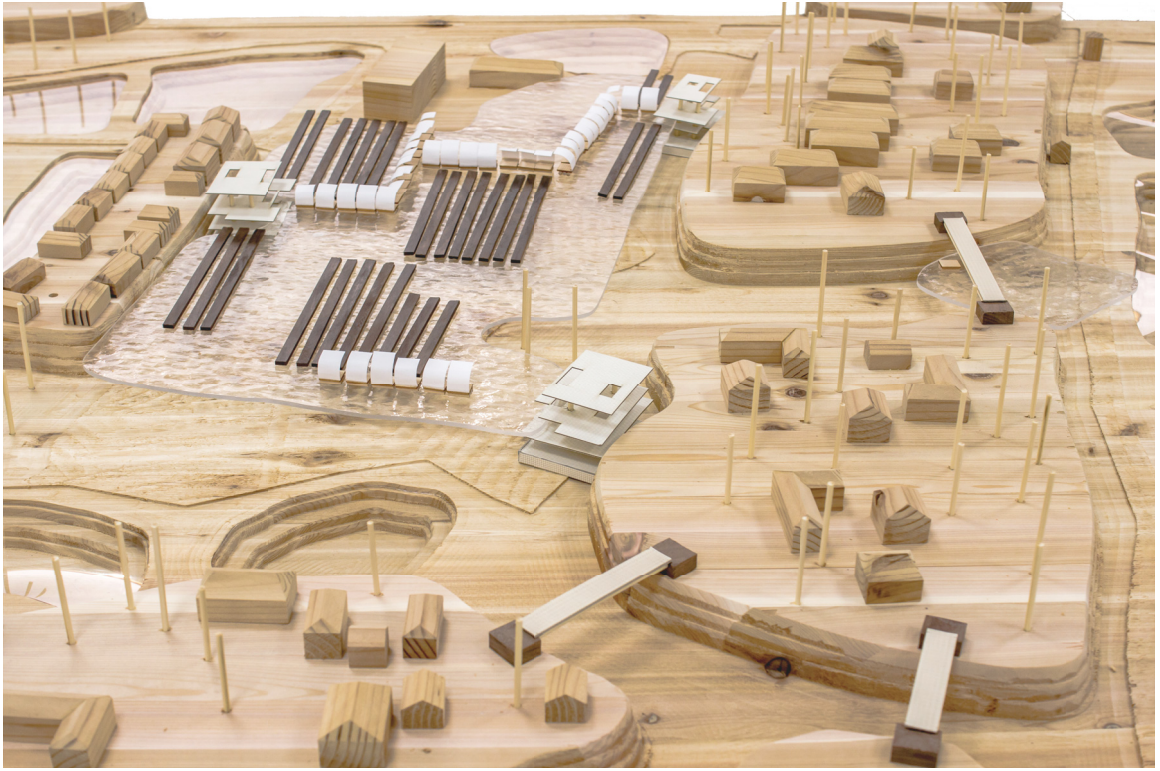


Fig 51: Site model close-up (1:200)

CHAPTER 9: CONCLUSION

Essentially, this design aims to use small scale, flood-adaptive structural systems to activate program components that get lost due to flood conditions, while addressing social issues such as the drowning crisis and access to education. To me, small interventions are far more suited to this environment than an oversized building which imposes on delicate informal surroundings. Furthermore, these interventions should act as formalization of the existing vernacular to accommodate necessary program components. The idea is to start a shift in the mindset about the use of local materials, so that the community's mindset is not to use durable local materials like bamboo and jute as cheap alternatives, but rather, to promote the use of their full potential.

APPENDIX.

Annotated Bibliography of Top Publications

Rashid, Rumana. 2013. Social Sustainability Adaptation: The case of Bangladesh Traditional House. *Global Science and Technology Journal*, 1(1), 63-70. Accessed January, 2016, from <http://www.gstjpapers.com/static/documents/July/2013/9.Rumana.pdf>

The article by Rumana Rashid is about adapting the social aspects of traditional housing into modern ways of living is a remarkable concept. Rashid argues that by dealing with traditional housing beyond the crude aesthetics, and by looking into its layout, methods of how houses interact with their surroundings will help retain core social and cultural values. Her article speaks of learning from the traditional courtyard house and applying the essence of it to present architecture. While the material use may be different, by applying techniques developed by people over a long period of trial and testing. By adapting the social and cultural methods of community interaction, one can help preservation of tradition while creating spaces that speak to the core of its culture. The article provided a direction for a way of thought into how to develop a design scheme and the importance of certain layout factors.

Ahmed, K. 2005. *Handbook on design and construction of housing for flood-prone rural areas of Bangladesh*. Dhaka: Asian Disaster Preparedness Center in partnership with Bangladesh Disaster Preparedness Center ... with support from United States Agency for International Development.

The publication by Dr. Iftekar Ahmed is possibly the most useful handbook for understanding local materials and methods of construction dealing with flood in rural areas of Bangladesh. The handbook not only has methods existing for construction, but also the ways of treating organic building material such as bamboo and wood to help prolong their effectiveness, explaining the advantages and disadvantages of these methods of preservation. The processes are shown in simplistic manner, so that they could be applied in rural setting without any high-tech equipment. Many of the material and techniques for application shown in this publication have become useful in my research, since Dr. Ahmed outlines local responses to dealing with flooding which is documented throughout different parts of the country. Essentially, this book has helped me identify many different material uses for construction, which can be used as the basis for the architectural response in my thesis.

Alam, M., & Ali, M. 2002. "Concept of Flood Shelter to Cope with Flood". *Engineering concerns of flood, 1998 perspective*. 175-186. Edited by M. Ali. Dhaka: Bangladesh University of Engineering and Technology.

The paper, "Concept of Flood Shelter to Cope with Flood" by M.J.B Alam and Md. Hossain Ali investigates the advantages and disadvantages of the concept of flood shelter and proposes measures to improve their effectiveness. They based their studies on observing two flood shelters in Kurigram, an area that sustained severe damage during major floods and overall very prone to flooding annually. Their studies define the criteria being used for building flood shelters and the programmatic components that go with it. Since Kurigram is a location I am planning on visiting during the research trip, this paper helped me discern which areas I should visit, as well as the statistic towards the rise in water level in different areas throughout the Brahmaputra river bank. I was not familiar with flood shelters since it is a fairly new phenomenon, and this article was helpful towards building an understanding on the concept itself.

Dewan, A.M., Nishigaki, Makoto., & Komatsu, Mitsuru. 2003. Floods in Bangladesh: A Comparative Hydrological Investigation on Two Catastrophic Events. *Journal of the Faculty of Enviromental Science and Technology*, 8(1), 53-62. Accessed December 1, 2015, from ousar.lib.okayama-u.ac.jp/file/11503/008_053_062.pdf

The article by Dewan, Makoto and Mitsuru does an investigation on two of the worst floods in the history of Bangladesh, one in 1988 and the other in 1998, of which the 1998 event is widely believed to be the worst. They do a comparative study of the two events, providing information on the worst-case scenario on a national scale. The data shown in this article provides information on the rise in water level, the areas affected and the duration of flooding in different parts of the country. The information is useful since these are facts, which can be used to better understand the architectural response necessary in such cases. Also, since I was there in 1998, and have felt the effect of such catastrophe, I have gained a deeper understanding on the areas that were severely affected in comparison to my location at the time.

Duby, P. 1990. "Flood Adaptive Housing in Bangladesh", edited by H. Khan. *Mimar 37: Architecture in Development*: 78-80.

The article, "Flood Adaptive Housing in Bangladesh" by Peter Duby explains three approaches towards dealing with flood adaptive houses. Peter Duby is an architect who

volunteered for the Red Cross from 1988-1989, which was during one of the worst floods in the nation's history. By working with local engineers and architects, he worked on developing a simple housing solution to deal with floods. The article mentions different local materials used for construction purposes, some of which I was unaware of. Duby's research is important towards understanding what materials could work and the appropriate uses of local materials, and simple solutions to some serious issues that take place during a major flooding event. The economical approach taken by Duby in his work is an aspect that I will have to take into consideration, since in the areas of study for research have a large population in poverty.

Kotnik, Toni, and Weinstock, Michael. n.d. 2012. "Material Form and Force". *Material Computation: Higher Integration in Morphogenetic design*, Vol. 82, Ser. 2, 105-111. City: London. Edited by A. Menges. Architectural Design.

Material led design was a foreign concept in my mind prior to reading this paper. The authors Kotnik and Weinstock examine two structures designed to take full advantage of the properties of material used. This has allowed for a unique relation between the material, form and forces working hand in hand. The idea of design led by materials, rather than form was a concept I was not familiar with, and this article allowed me to have a peek into what it is about in the modern world. Although, doing tests to figure out material properties can be a painstaking process requiring a lot of equipment, just the idea of thinking materials coinciding with form can be a step towards the right direction. Materials don't necessarily have to dictate form, but facilitating the process of form finding will be a key component towards design in my project. This article helped me understand the important relation between materials and form, and the potentials that lie in the combined investigation of both.

Rahman, Saleh Ur. 2014. "Impacts of Flood on the Lives and Livelihoods of People in Bangladesh: A Case Study of a Village In Manikganj District." 1-45. Master diss., BRAC University. <http://dspace.bracu.ac.bd/bitstream/handle/10361/3802/13168004.pdf?sequence=1>

The dissertation by Saleh Ur Rahman does a study on how flooding has affected the lives of people in Manikganj, which is situated on the bank of Padma River where it meets Brahmaputra River. This publication is especially helpful since I was planning on traveling to Manikganj during my research trip, and Rahman did an in-depth study of the area,

the people and their needs and issues during the monsoon flood. He has also proposed ideas for what approaches should be taken to try dealing with the issues, some of which are strongly in line with my thesis ideas, such as thoughtful innovative development and thinking long-term stability rather than having to perform seasonal migration. The author has also posted his data collection questionnaire, which has been very useful in helping to shape my approach to understanding major social and cultural factors of that specific area.

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