DESIGNING FOR RESILIENCE:

HOUSING FOR FISHERMEN COMMUNITY AT MANDARMANI, WEST BENGAL

Thesis submitted in partial fulfilment of the requirements for

The award of the degree of

BACHELOR OF ARCHITECTURE

By

DEBESHI GHOSH

2015BARC026.

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DEPARTMENT OF ARCHITECTURE

SCHOOL OF PLANNING AND ARCHITECTURE,

BHOPAL.

1 DECLARATION

I **Debeshi Ghosh**, Scholar No. **2015BARC026** hereby declare that, the thesis titled **Designing for Resilience: Housing for Fishermen Community at Mandarmani, West Bengal,** submitted by me in partial fulfilment for the award of degree of Bachelor of Architecture at School of Planning and Architecture, Bhopal, India, is a record of bona fide work carried out by me. The design work presented and submitted herewith is my original work and I take sole responsibility for its authenticity. The matter/result embodied in this thesis has not been submitted to any other University or Institute for the award of any degree or diploma.

Debeshi Ghosh
(2015BARC026)

Date: 20.07.2020

2 CERTIFICATE

This is to certify that the student Ms Debeshi Ghosh Scholar No. **2015BARC026** has worked under my guidance in preparing this thesis titled **Designing for Resilience: Housing for Fishermen Community at Mandarmani, West Bengal.**

RECOMMENDED

Anand Wadwekar

Digitally signed by Anand Wadwekar
DN: cn=Anand Wadwekar, o=School of Planning and Architecture Bhopal, ou, email=wadwekar@spabhopal.ac.in, c=IN
Date: 2020.12.09 16:35:55 +05'30'

Dr. Anand Wadwekar

ACCEPTED

Prof. Piyush Hajela
Head, Department of Architecture

July 2020, Bhopal

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4 ABSTRACT

Climate change – the rise in global temperatures has caused climate volatility and an increase in water levels, directly impacting the coastal communities because of their geographical exposure. According the United Nations, the most vulnerable are the communities belonging to the lower strata of the society, in the coastal regions of the developing nations, due to the lack of proper housing, infrastructure, access to climate related information and their dependency on climate sensitive livelihoods like fishing and tourism. This necessitates external intervention for building resilience to natural disasters in the community.

The fishermen community at Mandarmani is one such community. Mandarmani, is a coastal village in South Bengal, in the East Midnapore district. Lying within the Very High-Risk Zone for cyclones along the coast of Bay of Bengal, the community faces a repetitive cycle of destruction frequently. At the same time, a fall in marine productivity and uncertainty has disrupted their economy. The project focusses on building disaster preparedness within the existing community fabric in the fishermen village, with focus on economic diversification, resilient housing, infrastructure, and community spaces.

On May 20, 2020, the super cyclone Amphan, struck the coast of South Bengal, making landfall at 75km from Mandarmani. The village, consisting majorly of kuccha structures, faced a major blow as most of the structures decimated, rendering the villagers homeless. Occurring at a time when coronavirus had brought lives to a standstill, the fishing economy was already in a stressful condition. Moreover, the social distancing protocols in the cyclone shelters allowed them to be occupied at fifty percent capacity, causing the others to seek shelter in other temporary structures. Hence, disaster recovery and social distancing were added to the layers of preparedness in the design to enhance resilience of the community.

The concepts of vulnerability and resilience with respect to communities and disaster risk reduction were studied. The vulnerabilities on the proposed site were understood. As one of the oldest communities in India, the fishermen community exhibits an advanced understanding of the natural forces and has adapted to their natural environment through thousands of years of experience. However, due to the increased frequency and intensity of the cyclones, the buffer time required for the individuals to recover from the damage and return to functioning had decreased. The fall in economic capacities had added to the ineffectiveness of their recovery. Hence, traditional knowledge system embedded in the community must be respected while planning for interventions.

Continuity – the link between the past and the present plays a significant role in coping with post disaster trauma. Thus, keeping traditions and familiarity alive was of utmost importance while conceptualizing the design. To improve the standard of life and cater to the aspirations of the people, infrastructure and shared spaces were incorporated. Economic diversification was planned for to act as a buffer to counteract the fall in economic conditions.

The use of local materials available on the site while incorporating technological upgradations was done to allow a flow of revenue, at the same time, live up to the yearning for a pucca house – a symbol of pride and upliftment within rural communities of Bengal. Yet, the spirit of the place needed to be kept intact for the community to acclimatize with the built environments. Minimal intervention in settlement pattern ensured similarity with existing practices in the community and kept the socio-economic networks in the community alive – "a living society in all its complexity" (Fathy, 1973)

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8 INTRODUCTION

8.1 PROJECT BACKGROUND

Climate change has called for worldwide attention. With radiative forcing overshadowing the effects of estimated forcing, climatic shifts are taking pace at an unnatural pace. The drastic reduction of carbon sinks due to human induced factors have led to a rise in global temperatures, causing climatic shifts. The present statistics suggests a 1.62-degree Fahrenheit annual **rise in global temperatures**. An **increased frequency and magnitude of natural disasters** has been observed, with **hydro-hazards** featuring as the most frequent. **World Conference on Disaster Risk Reduction (2005)** stated that water-related disasters have almost doubled from 1960. Between 1990 and 2006, 1047 water-related disasters, have claimed 272,000 lives and have affected 429 million individuals – accounting for 90% of fatalities due to natural disasters.

With various **international organizations** working to counteract the causes and effects of climate change, the measures taken can be broadly categorized into **mitigation and adaptation**. Mitigation aims at reducing the intensity of the factors that cause climate change. Adaptation, on the other hand, refers to coping strategies implemented to tackle the negative effects of climate change.

Climate change affects societies at various levels, ranging from health hazards, agriculture and food, water supply, transportation, energy availability to the ecosystem in its entirety. However, the distribution of **vulnerability to hazards is geographically disproportionate**. With coastal regions acting as a buffer between inland societies and hazard exposure, the coastal societies are directly impacted by the rise of sea levels, increasing marine temperatures, volatile climatic cycles and acidification of oceans. The risk of erosion, storm surge damage and flooding pose a threat to the daily subsistence of, livelihood, health, food security and on the sustenance of community living as a whole.

India, having a coastal stretch of 7517 km, and home to myriad coastal communities, is susceptible to volatilities of climate change. **The fishermen community at Mandarmani**, is one such coastal community along the coast of **West Bengal, in the Purba Medinipur district**. The community, evolved in harmony with its natural surroundings and has developed an inherent system of living, where the cyclical characteristics and uncertainty of climate is resonated in the **flexibility and permeability** of their living and working environments. However, with recent shift in climatic patterns, **climatic cycles are becoming increasingly volatile and unpredictable**. The shifts are taking place at an unforeseen pace, making it difficult for communities, that have evolved through centuries of experience and trial, to cope.

8.1.1 ABOUT THE SITE

Mandarmani is a popular tourist destination, deemed as a weekend getaway, lying within an approximate 170 km distance from Kolkata, the capital city of West Bengal. The first account of documentation of Mandarmani was found in the topographical survey map of 1956, as a fishing village. The village persists.

Due to an active fishing culture in Mandarmani, it has been established as an economic hub for fishing activities. Villagers and fishermen migrate form inland areas and temporarily settle in the village, near the coastline during the fishing months. Such t**ransient fishing villages** are entities unique to West Bengal (Nayak, 2001). Approximately 3000 fishermen migrate from inland areas during this time. They are functional from the months of November to March. Fishing takes place in traditional sustainable methods. The sustainability lies in the design of net and fishing technique. The *behundi* or fishing net is designed such that its holes is larger at the mouth and tapers towards the end. The fish lings can swim through while only the mature fishes get caught in the net. (Saha, 2015)

A **fishermen village** abutting the transient village also benefits from the economic hub that comes up. It is the highest paying job in the area with monthly salary ranging from Rs. 8000 to Rs. 12000. Working as an integrated system, the two settlements have a symbiotic relationship with each other. While the transient fishing activities provide a stable source of income to the fishermen in the village, the village helps the transient village by provision of basic necessities during the festive months through fund raising and sharing village infrastructure like school and medical facilities. Here, a cultural dimension comes into play, where along with the intertwining of livelihood activities with the living quarters of these fishermen, festivals and cultural activities involving both the communities have originated.

The **landing centers and processing units** where the fish hauling, and processing activities take place lie in proximity – within half a kilometer to the settlement areas and forms and intricate part of their daily lives. A work-based community by nature, the morphology of their houses is strongly influenced by fishing activities.

8.2 PROJECT BRIEF

Benfish is **West Bengal State Fishermen's Co-operative Federation Ltd.** (An organization under Department of Fisheries, Govt. of West Bengal). It is an apex body of all the primary fishermen's cooperative societies in the state, established in 1978, (Benfish, n.d.) the administrative body for the management of the landing centers or *khoti*. The present working capital of the organization is 481 crores. The department has called for the upgradation of the landing centers and to improve the standard of living of the fishermen involved in the khoti organization at Mandarmani. That includes expansion of the landing center and upgradation of the housing settlement in the fishermen community.

The department of Animal Husbandry and Dairying, under the **Ministry of Fisheries, Animal Husbandry and Dairying, Government of India**, (Tamlin L. Watson, 2020) under a "centrally sponsored national scheme of welfare of fishermen" has proposed for financial assistance to fishermen for construction of houses, community hall for recreation and common working space and installation of water supply. Under the scheme, a component includes the development of a model fishermen village where eligible fishermen in inland and marine sectors would be provided with the basic amenities mentioned above. (Department of Animal husbandry and Dairying, n.d.)The responsibility for selection of beneficiaries and provision of land would be on the State or Union Territory governments. The cost of development would be distributed equally between the State and Central Government. The clauses for selection of beneficiary includes:

- The beneficiary should be an active fisherman identified by the State Government

- Landless fishermen or fishermen below poverty line would be given due preference
- Fishermen owning land or kutcha structures would also be considered for the allotment of houses under the scheme (Department of Animal husbandry and Dairying, n.d.)

The major components for the model fishermen village include:

Housing: The minimum number of houses to be constructed in a village are 10. The plinth area of the housing should not exceed 35 sq. mt. (Department of Animal husbandry and Dairying, n.d.)

Drinking Water: A fisherman village would be provided with one tube well for every 20 houses. The cost of installation of the tube well should not exceed INR 30,000/- The actual number of tube wells may be rationalized based on the actual water requirement of the inhabitant families and the capacity of tube wells. (Department of Animal husbandry and Dairying, n.d.)

Community Hals/ Work Shed: As a recreation and common working place, a fishermen village with at least 75 houses will be eligible to seek assistance for construction of a community hall if found necessary. The hall will be constructed on an area not exceeding 200 sq. mts. Two toilets and a tube well will also be provided with a community hall. (Department of Animal husbandry and Dairying, n.d.)

8.3 RATIONAL/ PROBLEM STATEMENT

8.3.1 WHY THE PROJECT WAS REQUIRED

The community has been suffering from the effects of climate change in the recent past. With global warming, the cyclonic disturbances have intensified over the Bay of Bengal, drastically impacting the village communities along the coasts of Bengal, Orissa and Andhra Pradesh. Mandarmani has seen an increase in the **frequency and intensity of cyclones** experienced, making their natural resilience insufficient. The society has seen repeated collapse of built environments, leading to widespread disruption of social and economic networks embedded within the community. Also, **with coastal regulations under CRZ norms**, building pucca houses within 500 m of the sea has been prohibited. This has affected the durability of the existing fishermen houses which are made up of materials like dried leaves, bamboo and mud. With increased cyclones in the area, the frequency of requirement of rebuilding and maintenance has increased, making these communities economically vulnerable. The houses that are rebuilt often compromise on quality and spaces. Thus, robust housing solutions are sought.

Due to global warming, there has been an increase of temperatures of the sea waters. This has led to creation of ***dead zones***, where the fish productivity has reduced to negligible conditions. **Commercialization of fishing territories** by selling fishing rights to international companies of Hong Kong, China and Japan have also disrupted the productivity of waters. The trawlers of these companies catch fishes from the seabed – the breeding ground of fishes. Due to unsustainable practices, the destroy

the ecosystem and kill fishes that have not matured. Thus, there is a drastic fall in the abundance of fishes.

These are directly affecting **productivity and economy**. Thus, there is a need for diversification of livelihoods as it is becoming increasingly difficult to sustain life with decreasing economic capacities. There are various proposals for the involvement of women within the income diversification system. Education and empowerment of youth and women are infallible requirements for the sustenance and progress of the community.

8.3.2 Cyclone Amphan in times of COVID-19


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News / India / Cyclone Amphan Worst storm since 1737, will wreak havoc till midnight, says Mamata Banerjee

Cyclone Amphan Worst storm since 1737, will wreak havoc till midnight, says Mamata Banerjee

Kolkata/Bhubaneshwar/New Delhi | May 21, 2020 00:35 IST

Cyclone Amphan Weather Live Updates: Extremely severe cyclone Amphan, packing winds of up to 190 kmph roared into West Bengal on Wednesday, dumping heavy rain and leaving a trail of destruction that left at least two people dead. After making landfall at 2.30 pm between Digha in West Bengal and and Hatiya island in Bangladesh, Cyclone Amphan cut a swathe through the coastal areas, flattening fragile dwellings, uprooting trees and electric poles. At least 6.58 lakh people were evacuated in West Bengal and Odisha before the cyclone struck. NDRF said that 20 teams of the federal disaster response force had already begun road clearing operations in Odisha, while the 19 units deployed in West Bengal were shifting people to safety. IndiaToday.in is tracking and running live news updates on Cyclone Amphan, stay with us.

Figure 1 Newspaper clipping reporting Cyclone Amphan (Source: India Today News)

The outbreak of the coronavirus pandemic on November 17, 2020 gradually spread to all corners of the world. It shook the world to its very foundations and brought life to a complete standstill. **Coronavirus disease**, also termed as COVD-19 is a contagious disease caused by the coronavirus. The transmission of the disease takes place through droplets of saliva or nasal discharge. The way to slow down the transmission is by reducing contact between individuals in the society. For this, **social distancing** has proven to be an effective measure and has been adopted as a standard protocol all over the world. **A lockdown** was placed in India on March 24, 2020, as a preventive measure against the pandemic, barring movement of 1.3 billion individuals across the country.

In this situation, **Cyclone Amphan** struck. It was a category 5 cyclone which reached a peak velocity of 240 kmph that sustained for 3 minutes on the Bay of Bengal, and moved north east, parallel to the eastern coast of India, as reported by Indian Meteorological department, on May 18, 2020. On May 20, it made landfall in the state of West Bengal, at Sagar Islands, near the India-Bangladesh border, devastating coastal areas of Est Midnapore, South 24 Parganas, Kolkata. Hooghly and Howrah in the state.

The cyclone shelters were established along the eastern coast of India to reduce loss of lives in rural settlements were deemed insufficient as the social distancing protocols allowed the cyclone shelters to be occupied half the original capacity. Termed as a double disaster, it disintegrated the already worsening

economic conditions of the people of rural coastal Bengal. Mandarmani was one of the communities that suffered severe destruction. Through telephonic interviews and secondary sources of data, it was concluded that majority of the built structures had been decimated by the severe cyclonic storm. The social and economic dimension of the community had crumbled.

8.3.3 APPROACH OF THE STUDY

The study undertaken, aims to develop a proposal for the revival of the fishermen community at Mandarmani, West Bengal. The revival was conceptualized to provide a possible solution to the community to bring them out of the vicious cycle of repetitive destruction and prevent them from spiraling down under the socio-economic burden brought about by the effects of climate change and commercialization. Through secondary sources literature, the concepts of vulnerability, resilience and disaster management were understood, followed by an analysis of the same at the site. For better understanding, different case studies were conducted with the aim of understanding the effect of a third-party intervention within the community structure.

Visit to Mandarmani prior to the cyclone was done to familiarize with the social, cultural, and economic layers of the society, to understand the community and their lifestyles. Later, as string of events unfurled, a paradigm shift in the approach of the study was necessitated by the occurrence of the pandemic – COVID-19 and the cyclone Amphan. Through unstructured telephonic interviews, the impact analysis was done. Through the documentations, sensitive choices and nuances were incorporated into the design developed for the revival of the community. A socio-cultural approach was sought so that the wounds incurred by the community through due to the unfortunate turn of events would not be aggravated by the imposition of a global design that would further increase the gap between the past and the present, driving the community towards a total collapse.

8.4 RESEARCH QUESTIONS

The research questions pivotal to the study are –

1. What are the vulnerabilities of communities dependent on climate sensitive livelihoods?
2. What are the needs and aspirations of the fishermen community at Mandarmani?
3. What are the issues faced on the site?
4. How can the revival of built environments be designed to increase the resilience of the community?

8.5 AIM

To design a cyclone resilient housing settlement for the fishermen village at Mandarmani, West Bengal, to enhance disaster recovery and disaster preparedness.

8.6 STUDY OBJECTIVES

1. Understanding the role of housing to make communities resilient to climate change
2. Understanding how spatial design can provide opportunities for livelihood
3. Understanding sensitive design approach to livelihood-based communities
4. Understanding the relation between ecology and spatial design
5. Designing for resilience to improve standard of living and the future of the community

8.7 SCOPE

The study focusses on increasing resilience within the **existing community** through emphasis on disaster **recovery and preparedness**. Interventions were focused on the **built environment** with limited exploration of policies. The built environment included are **housing and social spaces**. The economy of the region has been left undisturbed. Minimal interventions in the culture and community fabric has been introduced to help the community maintain identity and function.

8.8 LIMITATIONS

The circumstantial shift in the design thought process was due to the incidence of **coronavirus disease** and landfall of **cyclone Amphan** on the coast of Bengal in June 2020. The responses to these incidents were considered as **layers to the existing design proposal**, limiting time for an in-depth exploration of the same. The development of design considers **a part of the village of Mandarmani**, in proximity to the landing center and social spaces, involving 80 households.

8.9 DESIGN INTENT

To develop a design solution for the existing fishermen community that caters to the **future aspirations** of the community, while providing **infrastructure and economic opportunities** to increase the **adaptive capacity** of the individuals. A **continuity** in the community fabric was maintained to secure the sense of identity, while aiming for progress.

8.10 METHODOLOGY

The methodology followed for the study was –

- **Stage 1:** To establish aims, objectives, and research questions
- **Stage 2**: To conduct literature study to understand the various concepts, their components and their applications
- **Stage 3:** To define design parameters based on the literature studied
- **Stage 4:** To conduct a survey through observation, photographic documentation, unstructured interviews, and documentary analysis to understand the applications of the concepts
- **Stage 5:** To conduct a site study to understand the users and their relationship to their environment
- **Stage 6:** To develop a design solution for disaster resilience

The design process first enquired into the basic aspects of climate change, to understand the concepts, causes and effects. The vulnerable groups were identified based on their social systems, ecological systems and economic systems which determined their adaptive capacities and exposure. One such community was selected for the development of design proposal – the fishermen community in South Bengal, directly exposed to the hazards of the volatile Bay of Bengal. Vulnerabilities were identified based on a detailed site analysis and user study. The concept of resilience was enquired into. The understanding of the concepts of resilience provided the basis for the identification of gap between vulnerability and resilience of the community. Needs and aspirations of the community were understood to develop the design program. Situational modification was done, by adding layers of COVID-19 and Cyclone Amphan to arrive at the final design concept, and a subsequent design proposal.

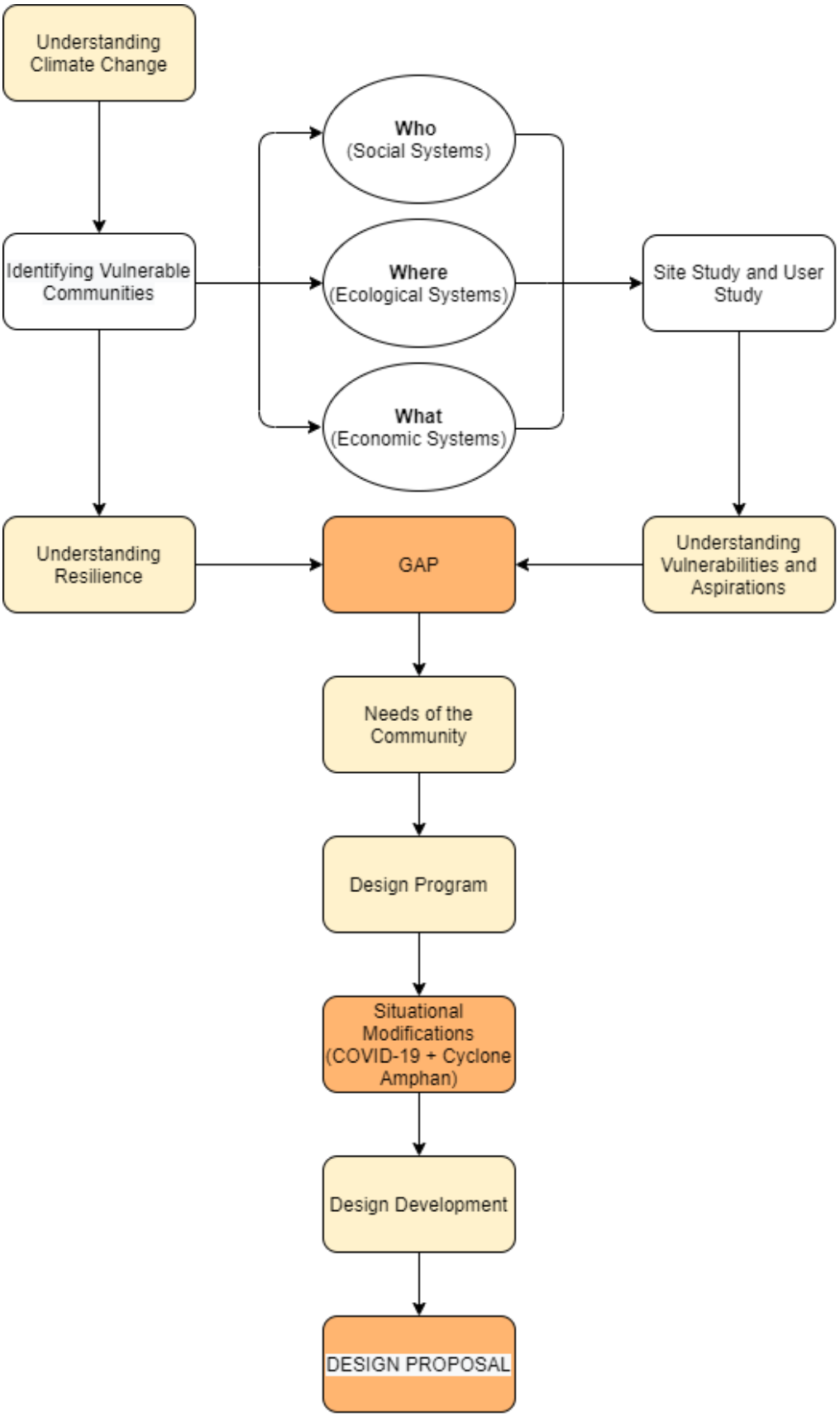


Figure 2 Methodology Flowchart (Source: Author)

9 LITERATURE STUDY

9.1 DISASTER VULNERABILITY

The varied climate change events around the world, render a disproportionate distribution of impacts even within populations in relatively small geographic areas. The differential human vulnerability to the disaster events can be understood from two contrasting paradigms.

9.1.1 CLASSICAL PARADIGM

The first is the **systems-oriented perspective or the Classical Paradigm**. This approach considers **disasters to originate in the environment and affect social systems, forcing them to adapt**. Societies and communities are considered to be social systems organized around essential functions.

"An event, concentrated in time and space, in which a society, or a relatively self-sufficient subdivision of a society, undergoes severe danger and incurs such losses to its members and physical appurtenances that the social structure is disrupted and the fulfillment of all or some of the essential functions of the society is prevented."

- *Charles Fritz (1961):*

Disasters are events measured in terms of the extent to which social systems are disrupted. There are, however, various shortcomings of this approach. Disasters are treated as **'event-focused' rather than 'process-focused'**, that considers disasters to begin at the time of the impact, neglecting the fact that the primary causes of disasters often lie within the social systems. It also ignores the diversity of communities within societies, **undermining the chances of differential social impacts**. (Jennifer & JoAnn, 2005)

9.1.2 VULNERABILITY PARADIGM

The shortcomings of the systems approach are addressed by the **Vulnerability Paradigm**. This paradigm of understanding disasters considers the comparative levels of damage due to disasters and hazards are caused by social rather than physical factors. Disasters are experienced differentially by different social units within communities and emphasizes on the **need to focus on groups that are vulnerable**. Society is not seen as an integrated system working together but is rather characterized by inequality. Vulnerability is linked to the interaction between the societal factors and the hazard or disaster events. It is a function of **exposure, sensitivity and adaptive capacity**. The dynamic relationship

between these three factors determines the impact of disasters on individual social groups within societies. (Jennifer & JoAnn, 2005)

9.1.3 THEMES OF VULNERABILITY

The societal factors and dynamics that determine the adaptive capacity of individual social groups can be broadly grouped into four themes. The first is **access to resources,** exploring how access is varied in societies and how inequalities in this regard is a driver of differential sensitivity to the impacts of environmental hazards. The second is **governance** where representation and empowerment are fundamental factors. Power differentials determine the end users of benefits of government policies and aids. The third is **culture** that determines how individuals perceive and react to hazards. It is a context-specific embedded knowledge that decides the robustness of societies in their perception of the environmental changes, risk and exposure. The fourth is the superimposition of **knowledge and information** and the need to move from a knowledge-deficit model that advocates scientific information to a more comprehensive understanding of climate risk. (Kimberley, et al., 2018)

9.1.3.1 Access to Resources

Access to resources is the **ability to derive benefits from natural and human resources** (Jesse & Peluso, 2003) that influences the exposure, sensitivity and adaptive capacity. The resources are tangible and intangible, private and public goods. (Winthrop, 2018) They include private capital, liquid assets, disaster warning systems, emergency response, alternative housing, insurance, food stores, migration support, durable infrastructure, transportation (Winthrop, 2018), and networks of communication and information (Cinner, et al., 2018). However, availability is not always synonymous with accessibility.

Factors affecting accessibility can be enlisted as follows –

- Race, Caste and Gender - The accessibility is often dictated by various factors like **racial discrimination, caste system, gender disparities**. Lack of control over and entitlement to basic resources undermine the ability to cope with disasters.
-
- Poverty – Poverty is another important driver that determines the **economic capacity, institutional capacity and political capacity** of different groups (Bohle, Downing, & Watts, 1994). If the limitations access is posed by income or wealth, it is due to lack of economic capacity. If there is non-existence of resources in an area inhabited by a certain group of people, the vulnerability arises from lack of institutional capacity. Ultimately, if access to resources is subjected to exploitation and appropriation of surplus, the vulnerability stems from lack of political capacity. Also, with relationship to the built environment, the location of residence of poor strata of society are physically more exposed to the impacts of weather and climate.

9.1.3.2 POWER DIFFERENTIALS

Power differentials or **social power** – the ability to influence different social groups, constituting social hierarchies that causes inequality in distribution of resources and sometimes, deflection of risk from target

groups without sensitively analyzing impact areas induces differential vulnerability within communities. Vulnerability occurs not only because of marginalization of different communities but also because of the persistence of factors that cause and expand marginalization. (Kimberley, et al., 2018)

9.1.3.3 GOVERNANCE

Governance refers to the process in which societal problems are addressed by government and other institutions. The concept surpasses government institutions to comprise "the relationships between **government and society** including the means through which private actors, markets and interest-based networks influence policy decisions" (Chaffin, et al., 2016). Posing a threat to effective governance, climate change demands response to acute and chronic challenges for **"pulse events"** such as cyclones and tsunamis, and **"press events"** such as sea level rise. (Collins, et al., 2011)

The primary issue is **representation**. It refers to the capacity of various social groups to participate in political processes that ensure human security by introducing procedures and influencing outcomes. Non-governmental Organizations (NGOs) also help in reducing vulnerability of communities by challenging governmental policies that render ineffective or biased. The coordination between governmental institutions and NGOs, generally, result in effective adaptation and mitigation strategies. The most socially efficient approaches are those that are participatory in nature and involve the target community groups at every stage pf planning and execution. (Kimberley, et al., 2018)

9.1.3.4 CULTURE

Culture refers to the patterns of thoughts, cognition, action and values that are transmitted in social groups through interaction. It influences the experience of nature and environmental changes to human beings. to understanding climate change vulnerability. "Nature is seen by humans through a screen of beliefs, knowledge, and purposes, and it is in terms of their images of nature, rather than of the actual structure of nature, that they act" (Rappaport, 1979). In climate change approach, culture mediates the risk perception, and the implementation and planning of responses.

- Vulnerability assessments emphasize on **tangible factors** that include roads, housing, food supply, sanitation, availability of fresh water and **intangible factors** like social systems, traditional knowledge and daily practices. Cultural knowledge is often transmitted through tangible elements like natural and built environments. (Kimberley, et al., 2018)
- **Cultural heritage** imparts the phenomenon of place or placeness. Losses due to disasters suffered to intangible and tangible heritage is often irreplaceable. There may be no equivalents to lost places with mythic associations, places providing spiritual and emotional wellbeing or generational livelihood aspects that lead to psychological devastation of communities. Thus, the United Nations, in their United Nation Framework Convention on Climate change, has enlisted cultural heritage as a component of non-economic loss (UNFCCC, 2013).

9.1.3.5 KNOWLEDGE AND INFORMATION

Knowledge transmission is an important factor that directly or indirectly helps communities increase their adaptive capacities, influencing exposure and sensitivity. There are various aspects of knowledge.

- **Environmental knowledge** refers to scientific warning systems and communication of predictions and forecasts, issued by public or private agencies. Intra community interactions is a powerful medium for the transmission of this knowledge. **Social memory** is another important component of knowledge. It constitutes the knowledge that humans possess of the environment through inter and intra generational interactions within social groups. It depends both on environmental cycles and the ability of communities of retaining memory the risk and responses to the change in such cycles. It helps communities identify risks and make informed decisions.

- Traditional knowledge system or **Traditional environmental knowledge (TEK)** is information collected and accumulated through generations. Generally possessed by indigenous communities, these hep in countering the effects of marginalization when disasters strike. They lend critical insights into the prediction and perception of risks with embedded responses that increase the adaptive capacities vulnerable communities.

- **Deep time knowledge** is a form of knowledge that is retrieved from paleontological data that reveals information on human behavioral trends in responses to larger environmental events through the centuries. The overlap of the various layers of knowledge leads to **co-production of knowledge** to come up with adaptation and mitigation strategies that are rooted in their contexts and are more comprehensive in their approach. (Kimberley, et al., 2018)

9.1.3.6 DISASTER RESILIENCE

From the above discussion, it can be concluded that given the increased rate of hydro-hazards in the recent years, vulnerability having a skewed impact group, and coastal areas and island regions being the geographically peripheral areas that act as buffers between the water and inland, the **coastal communities of developing countries are rendered as the most vulnerable to climate change disasters**. Ethnic social groups of these areas possess traditional knowledge that have helped them mitigation and adapt to disasters effectively. However, due to physical socio-economic factors, interventions for increasing adaptive capacity of these communities become important. Co-production of knowledge render effective adaptation measures to increase the resilience of these communities.

- Measures for Disaster Resilience by United Nations - Disaster Resilience is defined as “the ability of a system, community or society exposed to hazards to resist, absorb, accommodate and recover from the effects of a hazard in a timely and efficient manner, including through preservation and restoration of its essential basic structures and functions” (UNIDSR, 2009).

9.2 UNDERSTANDING ETHNIC COASTAL COMMUNITIES – BAJAU

9.2.1 ENVIRONMENTAL CLIMATIC ADAPTATION IN BAJAU COMMUNITY

The Bajaus are sea nomads who migrated from Southern China 4000 years ago, sailing northward from Malay Peninsula towards South-East Asia. They **have lived on and around island nations** and have **close, dependent relations with the sea**, sharing an intimate knowledge system. Changes climate are **anticipated, perceived and interpreted** by them. Their **deep-rooted knowledge system** derives from sensitivity to location of villages, navigation and fishing methods with spiritual and physical interpretation of changes in fish resources. They have, for **thousands pf years, adapting to the different climatic events** that make them resilient and live **with minimum footprints for centuries**.

Traditionally, they protect and preserve sardine and small fishes in the waters of Sulu. Adapted **to fishing pattern** characterized by **alternating harvesting and replenishment periods**, they have a sensitive approach towards marine ecosystem through indigenous methods that do not disrupt natural balance. The **sea-nomads** are affected by the recent climate change in a number of ways. Lately, an abnormal behavior of fish species has been observed. There has been influx of species into previously uninhabited areas, such as shallow waters. This have rendered the **species vulnerable to commercial fishing**. Spells of low tide have prolonged periods **of low productivity, constituting a threat to food security**.

9.2.2 BAJAU CULTURE

As a community, they **were free wanderers** who would take **the shelter of their boats and make a living by free diving into the ocean waters for fishing** and trade rice from inland communities. In the early 1990s, when the trade economy gained momentum, some of the social groups gave up their wandering lifestyle and **moved at the margins of the mainland, constructing their houses on the edge of the sea**.

Figure 3 Traditional hand-made Bajau lepa lepa boats

With increasing **governmental pressures** regarding citizenship, cross-border migration and conservation of natural resources, they are being forced to take up more sedentary ways of living. **Inland relocation of the community through governmental efforts** have mostly fallen through as they are unable to adjust to the new surrounding and have eventually returned to their original coastal areas. **Islamization of the nomadic Bajau** is another incentive for inland settlement of the social group which helps them perform regular prayers at ease. (Sendera, Mohd, Nornis, Saidatul, & Hj, 2008)

9.2.2.1 TRADITIONAL SETTLEMENT PATTERNS

Derived from the form of traditional *lepa-lepa* and *boggo-boggo* boats of the Bajau community, is the spatial layout of Bajau housing. The housings are stilted over the water where the individual boats once plied. Their coastal dwellings consist of three primary sections – the **bow area** for fishing; the **mid-section** for sleeping; and the **stern area** for storing food and cooking. As the number of units gradually increased, the individual units are connected to each other using narrow bridges of roughly 1.8m forming a water village of egalitarian character with no hierarchy of social structure depicted by the spatial morphology. (Iziq & Abdullah, 2015)

9.2.2.2 TRADITIONAL HOUSING UNITS

They are essentially social by nature. Their housing units are mostly devoid of private spaces. The space used for sleeping generally coincides with the guest accommodation area. As mentioned by Iziq and Abdullah in their study, the core spaces consist of a platform that serve as verandah to welcome guests and a single room for sleeping. The *kusih* or kitchen and the *jambatan* (wooden bridge) are variable that serve as a function of inter-neighborhood relationships. The housing units are made up of flimsy material wide wood from surrounding mangroves and raw materials from coral reefs.

Figure 4 Bajau settlements forming water village where units are connected by wooden bridges

According to a study conducted by Dacanay on folk architecture of Philippine, “The stairs, with three rungs above the water, leads a porch-like landing of irregularly-spaced boards, and to a one-room, two-door structure that is a combination sala and sleeping room without beds. The stairs are fenced like a small verandah at the top and on the landing one sees poles that serve as wash lines together with dried tree trunks, stumps and firewood.” (Dacanay, Rodrigo, Rosario, & Encarnacion, 1989).

9.2.2.3 RESILIENCE THROUGH TRADITIONAL KNOWLEDGE

Having a very intricate and deep relationship with nature, they are able to predict oncoming hazards by environmental conditions like color of the sky, calmness of sea and movement of aquatic life. In such cases, they abandon their houses and migrate to surrounding community areas where they have strong social connections. Their houses being made up of flimsy materials get washed away and are easily rebuilt. This ensures minimum loss life and assets, making the **community resilient to disasters through traditional knowledge system**.

9.2.2.4 POLITICAL IMPLICATIONS OF NOMADISM IN BAJAUS

Historically, the Bajau community have been sea nomads who avoided mainland in lieu of the conflicts and limitations of mainland settlements. They travelled across maritime boundaries and **refused to be identified with nations**. This led to them being viewed as intruders within political boundaries and they were heavily penalized when located. **Governmental pressure** gradually led them to move inland as land-based settlers, living at the edge of the sea.

9.2.2.5 IMPLICATIONS OF REGULATORY APPROACH TO CLIMATE CHANGE ON BAJAUS

Due to minimum contact with the mainland, they lagged behind in the international awareness movement towards climate change and conservation measures. The islands that were their habitats were eventually designated **"marine park"** status in1981. Crucial aspects of their culture like mangrove logging and spearing of fishes were criminalized, without their knowledge. Due to the gap in awareness, the social group continued with their daily practices that were now considered destructive to the ecosystem, and were heavily fined beyond their capacity when caught. **Lack of representation** led to decisions being enforced upon these individuals that rendered them vulnerable to political pressures. Their habits were destroyed and their burial ground were built upon.

International mass tourism was another threat to them. Being granted the status of marine parks and conserved ecosystems, **the habitat areas of the Bajaus were opened up to tourism**. With tourists moving within the intimate boundaries of this insular community, it was a form of deep shame and further marginalization of the members. Due to the National Integrated Protected Areas system, the settlers are being forced to move further inland. Regulatory pressures from NGOs and national governments criminalizes critical aspects of their traditions that render these individuals helpless with no alternate legal rights to land, building materials or fuel.

9.2.2.6 ECOLOGICALLY DESTRUCTIVE PRACTICES IN BAJAUS

Once a community that fished by **spear fishing technique** for survival, the community, gradually gave in to **modern trade economy** and shifted their fishing strategies from **sustenance to surplus** for economic benefits. During World War II, through soldiers, the social community was introduced to **dynamite** where they **bombed coral reefs** to avail raw materials for housing and could easily undertake mass fishing activities in reduced time.

Figure 5 Sama Bajau spear fishing - traditional Bajau fishing technique

The Bajaus were introduced to destructive fishing techniques by commercialized companies for exploitation. A Hong Kong based company introduced **KCN** to them, by which **they stunned the fishes** of a particular area and could sell them live. A contract was signed where the Bajaus could pay the

company back in fishes. Over time, these activities were considered destructive and **criminalized by the government** and against the international movement for climate change mitigation.

9.2.3 MOKEM BAJAU RESETTLEMENT IN THAILAND

Mokem is a faction of the Bajau community who **are land-based settlers**, residing in the coastal regions of Thailand. After the 2004 tsunami in the Indian ocean, the community was resettled to safer areas inland of **Au Bon Yai island** by government agencies. The housing units were enforced on them, without taking into consideration the cultural and traditional knowledge and lifestyle of the Bajau. The housing units were **crowded together in lines near the jungle**. The housing units had **impermeable walls**, unlike the traditional boat houses of the Bajaus that had permeable walls. The Bajaus have spiritual beliefs attached to the permeability of their housing units, where they believe that the spirits of their ancestors cleanse the interiors and keep the environment pure.

There was eventual introduction of **public infrastructure** like water system, public toilets, solar panel and electricity. *Maha Chakri Shirindhorn*, under Ministry of Culture was a foundation that sponsored the construction of new schools and paid for school teachers. The initiative, however, failed. The living conditions, with time turned out to be poor, causing wide spread dissatisfaction within the members of the community.

The Mokem tribes were **not used to living in large communities**, inland. There was **no system of shared responsibility** of public infrastructure and ack of knowledge of use that led to non-maintenance of the facilities, causing them to become unusable after a point of time. In case of sanitation, cheaply built toilets were inadequate. The sudden availability of **running water** led to greater use and consequent shortages. Waste and **stagnated water** was accumulated, turning into a breeding ground of mosquitoes, rats, cockroaches that caused **widespread diseases** like malaria, dysentery and tuberculosis.

There was **lack of information** about the new system of living and the social group was vulnerable to **marketing and misinformation**. There was a noted rise in consumption of sugar and babies were being fed with condensed milk, children drank coffee. There was a chaos in the lives of these individuals, coupled with extremely poor living conditions that led to a significant increase in diseases like high blood pressure and diabetes, with no medical facilities or treatment. **The resettlement program failed**. The Mokem eventually wanted to abandon their resettlement units and go back to their original land holdings, to a familiar environment and traditional cultural households.

9.2.4 SAMA BAJAU RESETTLEMENT IN PHILIPPINES

Sama Bajaus were resettled after the Zamboanga Siege to **Valle Vista resettlement in Philippines**. Philippines is the only country to adopt national action plans to end statelessness of the Bajau community members. According to national statistics, they’re one of the five ethnic populations who are at risk. 85% of the Zamboanga Bajau population have no documentation like birth certificates. The United Nations

High Commissioner for Refugees **(UNHCR)** and United Nations International Children's' Emergency Fund **(UNICEF)** has initiated a program to issue documentation to 2600 Bajau individuals.

The Catholic Relief Service **(CRS)** in collaboration with United Nations commissioned the construction of housing units in the Valle Vista resettlement when the resettlement plan by National Housing Authority (NHA) that incorporated cement and fibreboard housing units with iron sheet roofing failed. Four hundred Bajau families were accommodated there, along with the provision of civil documents like marriage and birth certification, and health surveillance.

In the housing program, the huts were 22 sq mt each, with **permeable latticed bamboo walls.** Built on stilts, they were placed **1.8 m above the slime strewn sea water edge**, surrounded by salt making fields ad mangrove swamps. This constituted an important part of the Bajau culture, where they believe that the salty water washes away the impurities of their households. The housing units were **connected by wooden bridges**, which often widened up at pockets forming informal market places that boosted their **microeconomy**. The women were taught weaving and sewing **to counter gender-based violence**.

Figure 6 Zamboanga Resettlement built in consultation with local Bajaus for housing units that are culturally and socially relevant and acceptable

Money was invested in *sari sari* stores and fish vending, among other economic ventures. They were taught financial management and book keeping that helped them sustain the stores and the economy so introduced to them. **Markets were interlaced with housing** to make them safe for women and children. There were support programs like housing, livelihood support and education programs. There was a need to provide water, electricity and sanitation, and an awareness program regarding the sustainable and appropriate use of these facilities.

The members of the Bajau community, through this initiative were brought out into the mainstream and empowered. The women were satisfied by the growing economy and facilities provided. The children, through documentation were able to go to schools and have formal education which promoted the growth, wellbeing and aspirations of the people. However, the older generations fear dissolution of traditional knowledge system by introduction of formal education. The equilibrium of their subsistence where a balanced mutuality of island microeconomy was getting lost where there was an established symbiosis between the land and sea tribes. Now, according to the ethnic group, the two factions of tribes have to learn to live together in enforced proximity to cater to the needs of modern trade economy.

9.2.5 ANALYSIS OF CASE STUDIES

9.2.5.1 ANALYSIS OF THE EFFECT OF CLIMATE CHANGE ADAPTATION MEASURES

The Bajau community, over the centuries have adapted to the various climatic phases. A community that has developed through closeness with the sea, they are sensitive to the slightest of shifts in sea conditions. Genetically adapted with enlarged spleens to facilitate deep sea diving, it is said that the Bajau children learn to swim before they learn to walk. Living with minimum carbon footprint for centuries, the modern trade economy has driven these communities into allegedly destructive means for sustenance. The free wanderers, in recent times, due to regulatory approach of countering climate change and citizenship movement, the community fonds themselves victims to national and international policies.

9.2.5.2 ANALYSIS OF VULNERABILITY

- Governance – Vulnerability due to **governance** is the most critical issue faced by the Bajau ethnics. Lack of public and private **representation** has caused the community to be marginalized. Regulatory approach to climate change by national and international organizations through **mitigation strategies** that involves preservation of mangrove ecosystems and criminalization of spear fishing, with no defined alternative fishing territories, their daily livelihood is threatened. The **habitats of this social group**, along the edge of the coast are being declared as **"no build zones"** and directly interferes with the most primitive aspect of their living.

- Access to Resources – Their only source of **building materials and firewood** being the **coral reefs and mangroves** swamps, have now been declared as **conserved and off-limit areas, often without their knowledge, that causes heavy penalization and often violent punishments**. There is **no designated alternate source** that has been suggested or allocated to the members of this community. This directly affects their **access to resources**.

In times of disasters, the community members, due to their avoidance and consequent refusal of citizenship by the government authorities and lack of ownership of landholdings, do not receive financial aid or assistance in times of natural and man-made disasters. **Poverty and tribal differentiations** drive deprivation of the people owing to **social hierarchies**. Often, to safeguard target groups, marginalized groups are left behind.

9.2.5.3 ANALYSIS OF RESILIENCE

- Traditional Knowledge and Culture – **Through traditional knowledge system** and human-ecology symbiosis has led to strong connection and sensitivity to sea conditions, the adaptive instincts of these individuals are dynamic. **Deep time knowledge** of the environment, accumulated and transmitted through the generations, contribute to **social memory** through oral mythologies and narratives. Through direct observations of nature, they are able to foresee and predict climatic hazards. Their **culture** of wanderers and strong social ties augments the resilience of these communities to the forces of nature. Their **disaster preparedness** is to abandon their temporary housing units and wander to neighboring Bajau areas in times of disaster predictions.
-
- Gap in Access Information – In recent times, with scientific information and political movements governing climate change, the community remains unaware of the current political scenario, legislations and policies. Living and predicting the present, they are unaware of the implication of climate change, reading only the present signs of abnormal climatic shift. the **gap in modern knowledge system** and awareness leads this community to the point of ostracization, deprivation and extinction.

9.2.6 **ANALYSIS OF RESETTLEMENT INITIATIVES**

Parameter	**Au Bon Yai Resettlement, Mokem, Thailand (Govt)**		**Vale Vista Resettlement, Sama, Philippines (UN)**		**Inferences**
	Implementation	**Response**	**Implementation**	**Response**	
Location	Inland, close to the jungle	Not used to living inland	Coastal edge	Traditional living environment inducing satisfaction and normalcy in living conditions.	Primitive environmental setting in the Vale Vista Resettlement led **to better acceptance of the housing**, as opposed to Mokem settlement where the inhabitants had a **tendency to back to their original settlements**
Settlement Pattern	Crowded, Linear	Not used to crowded community and linear settlement patterns	Clustered, connected by wooden bridges over slime and water	Traditional living environment inducing satisfaction and normalcy in living conditions.	Crowded linear pattern of settlement in **Mokem Bajau disrupted social patterns of egalitarianism** practiced in the Bajaus. Whereas, maintaining **primitive clustered pattern led to proper social functioning** of community within the settlement
Building Material	Cement and fibreboard, impermeable walls	Against spiritual beliefs where permeable walls are significant	Permeable latticed bamboo walls and wooden stilts	Traditional living environment inducing satisfaction and normalcy in living conditions.	The spiritual belief that their ancestor's spirits provide guidance and maintain the purity of their houses led the Bajaus to have permeable walls. **Non-compliance with this led to dissatisfaction and spiritual bias in the Mokem Resettlement**. **Proper ventilation** in the housing units was also disrupted. This problem was not faced in the Sama Resettlement where the community accepted their surrounding better.

Public Infrastructure	Public toilets, running water systems, electricity, schools	Lack of knowledge of use and shared responsibility leading to non-maintenance	Schools, water system, sanitation, electricity, medical surveillance	Individuals were taught the use of infrastructure resulting in proper usage of facilities	The **Bajaus lacked knowledge regarding the use and maintenance of public infrastructure as a shared responsibility** by the community. Thus, the Mokem resettlement failed. However, in the Sama Resettlement, **awareness programs regarding the same led to better management and maintenance** of the infrastructure provided.
Support Programs	Schools and teachers commissioned	Education and awareness through helped community get empowered	Financing and marketing, education, vocational training, awareness programs, women empowerment, legal documentation	Empowerment of through documentation, support programs and education, helped to bring them out into the mainstream and upliftment of community	**Legal documentation and provision of education led to acceptance of Bajau children and elders in schools and other sectors**. This helped in **mainstreaming** of the otherwise insular Bajau community in the broader public sphere in the Sama Resettlement. The Mokem provided a step forward for the community **but lack of documentation acted as a hindrance to mainstreaming**
Economic Support	Marketing and misinformation,	Spread of diseases and exploitation	Microeconomy through sari sari stores, weaving and sewing, fish vending marketplace	Helped boost economy and sustain livelihood of community	**Identification and address of problems embedded within the social and economic structure of the community led to dynamic upliftment and progress** of community, empowering members of the community inclusively, with emphasis on women in the Sama Resettlement. The Mokem Resettlement, due **to lack of**

					planning, led to exploitation of Bajaus by the market.

9.2.7 **OUTCOMES**

9.2.7.1 RESILIENCE OF BAJAU COMMUNITY

The Bajau community spread over South East Asia has, for thousands of years, **adapted to the natural and climatic changes**. **Deep time knowledge and local knowledge** has helped them resist disasters and dissolution in the face of catastrophes. Their **resilience lies in their flexibility, mobility and strong social ties that have fostered for centuries**. In the face of impending danger, their close and intimate understanding of their natural surrounding strengthened their perception of risk. They would abandon their boathouses and move away to safer areas. The houses made up of locally available materials through easy construction techniques would be rebuilt and a new settlement established**. Disaster resilience through mitigation, preparedness, response and recovery was embedded in their social memory**.

9.2.7.2 DOWNFALL OF BAJAU COMMUNITY

Although the trade economy and global war scenario had pushed them, in recent years towards **destructive methods of livelihood** like stunning of fishes and bombing of coral reefs – a drive undertaken to cater to the global shift from subsistence to surplus for economic motives. The **downfall of the eco culture**, thus, began. Avoiding citizenship and refusing to be identified with nations, the sea nomads liked to maintain their identity as free wanderers. Within **the political framework** of present times, this makes it difficult for the community to survive as they are often **captured as intruders and refused the basic rights** of free living.

9.2.7.3 VULNERABILITY OF BAJAU COMMUNITY

In recent times through politicization of climate change and **regulatory approach to climate change** mitigation, the fate of this ethnic community, living with minimum footprint for centuries has come to a dead end. Their **basic requirements of shelter along the coastline, food, livelihood and fuel, from mangrove swamps and coral reefs have been criminalized**, often without the knowledge of this community. Carrying on with their daily activities, they are caught and heavily penalized.

9.2.7.4 EFFECT OF RELOCATION ON BAJAUS

The national government, in recent times have made various attempts at relocating the Bajau community to **“safer inland”** areas where they are away from the direct forces of nature to reduce

their exposure and sensitivity. Through **mass reconstruction initiatives that have resulted after major disasters**, various housing programs were initiated. Often undertaken as generic mass housing programs, most initiatives have failed. The members of the insular community fail to accept these housing settlements as they **do not provide a link between the past and future**. Traditional and cultural values and not taken into consideration while planning these houses that either lead to poor living conditions or result in abandonment of the settlements so provided.

9.2.7.5 EFFECT OF SENSITIVE RECONSTRUCTION ON BAJAUS

The **Valle Vista resettlement in Philippines**, however, undertaken by humanitarian agencies like **UNHCR and CRS**, took into consideration the **social, cultural and economic dimensions of resettlement housing specific to the needs of the community**. Issues and gaps in the existing system were identified and addressed. Integrating **micro changes into the exiting fabric** of the Bajau tradition, resettlement was planned. Thus**, continuity in tangible and intangible terms helped the community adapt to the changes and develop for progress**. Comparatively successful, this resettlement is an example of sensitive approach to design through co-production of knowledge.

9.3 DISASTER RESILIENCE

9.3.1 RESILIENCE

Since the introduction of the term ‘resilience’ by theoretical ecologist, CS Holling decades ago, in 1973, the word has been further defined and has cascaded into the fields of psychology, physical sciences, disaster management, planning, geography and economics, to name a few. Most of the management policies and actions are pivoted around the concept. Hence different interpretations lead to different frameworks for such implementation. 2.1.1 Equilibrist Approach

The term ‘resilience’ was first introduced into public discourse by S. Holling in 1973, with its core lying in ecological literature. It emphasizes on the importance of state of equilibrium in the conceptual framework. The term has been defined in two different ways by Holling in ecological literature, given the initial assumption about the presence of a single or multiple state of equilibria.

As given by Carpenter, resilience can be best defined by three significant characteristics (Carpenter S. B., 2001) –

- The amount of stress that a system can absorb and still persist within a stable domain
- The degree of self-organization that a system is capable of
- Capability of learning and adaptation in a system

9.3.1.1 SINGLE EQUILIBRIUM

The **ability of a system to return to a steady state** (Aaron Strong, 2017)or to an equilibrium after a perturbation is known as Engineering Resilience. (Holling C. , 1973) Implied in this definition, is the existence of a **pre-existing or global equilibrium**, to which a system bounces back (Davoudi S, 2013) following a disturbance. Developed from economics, mathematics and physics, this definition of resilience is also called **‘engineering resilience’**, where emphasis is laid on **efficiency,** constancy, and predictability of a system. From an engineering point of view, the design motive is a singe operating objective for optimal performance. (Holling C. S., 1996) A similar conceptual framework of resilience is universally adopted in disaster studies. (Davoudi S, 2013)

9.3.1.2 MULTIPLE EQUILIBRIUM

The **amount of stress that a system can absorb** and still persist, ((ed.), 2013)before it redefines its structure by changing the parameters and dynamics that control its behavior. (Davoudi S, 2013) This was later known as ecological resilience. The emphasis lies on persistence, unpredictability, and change. Contrary to the efficiency of function in engineering resilience, ecological resilience aims at existence of function. (Holling C. S., 1996) Implicit to this understanding of resilience, is the existence of multiple states of equilibria, to which a system can bounce forth. (Davoudi, 2012a)

9.3.2 **EVOLUTIONARY APPROACH**

Despite a global vocabulary of equilibria embedded within the framework of resilience, recently, the thinking and practices are contested, with leading researchers arguing towards an evolutionary approach towards resilience, to cope with the dynamic nature of non-linear systems. (Carpenter S. W., 2005) This socio-ecological resilience views '**people and nature as interdependent systems**.' (Davoudi S, 2013) This perspective describes resilience as the ability of complex systems to change, adapt or transform after stresses (Carpenter S. W., 2005) – a process dominated approach, as opposed to outcomes.

Rather than aspiring for states of equilibrium, evolutionary approach refers to the **ability of complex systems to adapt and transform as a response to stresses**. Resilience, in this case, is viewed as an **emergent property** of systems. The interaction between structure and process leads to development of the system – a phenomenon known as **self-organization**. (Gunderson, 2000) It implies that the structure and the processes cannot be viewed as disjunct entities but interact organically. In this concept, resilience is always in a state of transformation, constantly responding to the natural processes, and is imperative to the understanding of how society responds to volatility and unpredictability. (Jon, 2019)

Table 1 The aims and foci of equilibrist and evolutionary resilience demand different planning approaches (Source: White & O'Hare in Environment and Planning C: Government and Policy 2014)

	Equilibrist Resilience	**Evolutionary Resilience**
Aim	Equilibrist Existing normality Preserve Stability	Adaptive New normality Transform Flexibility
Focus	Endogenous Short-term Reactive Atomised	Exogenous Medium to long-term Proactive Abstract
Planning Approaches	Techno-rational Vertical integration Building focus Homogeneity	Socio-cultural Horizontal integration Societal focus Heterogeneity

Resilience concepts	Characteristics	Focus on	Context
Engineering resilience	Return time, efficiency	Recovery, constancy	Vicinity of a stable equilibrium
Ecological resilience	Buffer capacity, withstand shock, maintain function	Persistence, robustness	Multiple equilibria, stability landscapes
Social–ecological resilience	Interplay disturbance and reorganization, sustaining and developing	Adaptive capacity transformability, learning, innovation	Integrated system feedback, cross-scale dynamic interactions

Table 2 Comparison of Engineering, Ecological and Socio-ecological Resilience (Source: Folke, 2006)

9.3.3 **ADAPTIVE CYCLE**

The concept of Resilience is aligned with **systems thinking,** in which, *"when considering systems of humans and nature (social-ecological systems) it is important to consider the system as a whole. The human domain and the biophysical domain are interdependent"* (Walker, 2006) Resilience thinking emphasizes on how systems change and cope in the face of disaster. Three concepts, imperative for the understanding of systems thinking are (Walker, 2006) –

- Human beings live and operate within social systems that are inseparably interlinked with the ecological systems they are embedded in
- The socio ecological systems are complex adaptive systems which do not proceed in a linear, predictable, and incremental manner
- Resilience provides a structure for viewing such socio-ecological systems as a complete system, operating over various scales and time.

A significant theme to understanding resilience is the idea of how systems are dynamic and change over time. Researchers, through various have observed that there are four phases through which natural systems proceed with time (Umberto, 2012) Known as the **Adaptive Cycle**, it elucidate how a system organizes itself in response to a world that is constantly changing –

- Rapid growth or exploitation phase (r phase) (Umberto, 2012)
- Conservation (k phase) (Umberto, 2012)
- Creative destruction or release (omega) (Umberto, 2012)
- Reorganization (alpha) (Umberto, 2012)

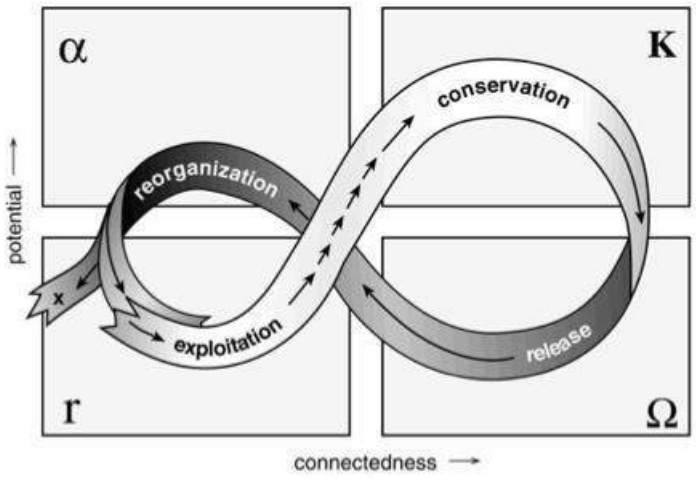


Figure 7 The Adaptive Cycle (Source: ESDN, Quarterly Report, 2012)

9.3.3.1 RAPID GROWTH OR EXPLOITATION PHASE

This period is characterized by rapid growth of a species as new opportunities and resources are exploited. The interconnectedness with ecological systems are weak during this phase. An example would be the emergence and formation of new societies.

9.3.3.2 CONSERVATION

The transition from rapid growth phase into the conservation phase is slow and incremental. Materials gradually accumulate and connections stabilize. The operations happen over a larger time and space domain. As the interconnections increase, the internal regulations become stronger. As the rigidity of the system increases, the resilience decays.

9.3.3.3 CREATIVE DESTRUCTION OR RELEASE

The transition is rapid. The longer the conservation and greater the rigidity attained, shorter will be the time taken to topple the system. On release, the reinforcing interactions within the system, break. The social, natural and economic capital is disturbed. However, it provides the starting point for reorganization and creative renewal. This phase is generally chaotic.

9.3.3.4 REORGANIZATION

As the system topples, options to reorganize open. The reorganization phase is generally marked by an anchor. From this phase, the previous cycle may repeat, a new pattern may emerge, or there may be a complete collapse, causing the system to degrade.

9.3.4 FEEDBACK LOOPS

Usually a system passes through the four phases, however, it is not mandatory. In the adaptive cycle, two broad loops dominate the direction of progress. (Umberto, 2012)

- **Fore loop** – also known as the front or forward loop, it is characterized by a transition into a stable and conservational phase, which increases the well-being of the system (Umberto, 2012) (Md. Wasiul Islam, 2018)
- **Back loop** – is generally characterized by uncertainty and experimentation. It is the phase for maximum potential to be achieved and may initiate a creative or destructive phase. (Umberto, 2012)

Memory is the sum total of experiences and learnings of a system, that provides a basis and context for renewal, experimentation, innovation and self-organization, after a disturbance. (Umberto, 2012)

9.3.5 ADAPTIVE MANAGEMENT

For management in a post-disturbance scenario, for resilience, there are three approaches that are generally taken (Gunderson, 2000) –

- To wait for a system to return to an acceptable state – however, the benefits of the system may forego during the wait
- To actively manage the system for return to a desirable state
- To admit an irreversible change, initiating adaptation towards an altered system.

A multidisciplinary approach to resources management, Adaptive Management acknowledges the dynamicity of nature and suggest that humans must respond to the situations by conforming

to it. Unpredictability and uncertainty will always be a feature of managed ecosystems. It recommends that while policies satisfy social objectives, they must be subjected to continuous modification and be flexible to enable adaptation to uncertainties. Structured to make learning more efficient, adaptive management considers trial and error to be a default model for learning. Learning and adaptation is going to take place through the inevitable process of experience. (Gunderson, 2000)

It is a cyclical process with four major components: learning, describing, predicting, and doing. Learning consists of monitoring and evaluation, describing involves models for summarizing and representing systems, prediction is used to test policies (Md. Wasiul Islam, 2018) and proposed actions, often through simulation, and doing require management of experiments. (R.M, 2009)

9.3.6 RESILIENCE AND SUSTAINABILITY

The United Nations Brundtland Commission, in 1987, defined **sustainability** as" *meeting needs of the present without compromising the ability of future generations to meet their own needs."* (One Health in Action, 2019) The World Summit for **Sustainable Development** (WSSD), in Johannesburg, in 2002, enumerated three pillars of sustainable development –

- **Economic development**
- **Social development**
- **Environmental protection**

In terms of sustainability, a resilient system, in a 'desirable' state is better equipped to continue to sustain quality of life, while being subjected to disturbances. (Walker, 2006) In this, resilience is normative, similar to sustainable development. The wide issues relating to sustainable development that the world is facing today, would benefit from resilience thinking, where, instead of discrete entities, human beings are considered a part of the ecological system. This approach shall more effectively help in solutions to "cope with, adapt to and shape change." (Umberto, 2012)

However, resource optimization as an approach to sustainability, may be counterintuitive. A valid argument is, optimizing elements of a complex system for a definite goal, may diminish the system's resilience, given the lack of redundancy. Here, the key to sustainability lies in enhancing the resilience of the system as a whole, and not in optimization of individual components of the system as discrete entities. (Walker, 2006)

9.3.7 RESILIENCE IN DISASTER RISK REDUCTION

Disaster Resilience is defined as “the ability of a system, community or society exposed to hazards to resist, absorb, accommodate and recover from the effects of a hazard in a timely and efficient manner, including through preservation and restoration of its essential basic structures and functions” (UNIDSR, 2009). The approach to environmental planning through resilience acknowledges the volatility and unpredictability of natural systems, that require flexibility in implementation.

Three core and integrated dialogues that were responsible for the integrating resilience into wider management discourse, post 2015 were – (Jon, 2019)

- the Sendai Framework for Disaster Risk Reduction 2015 – 2030, adopted by member states at the World Conference on Disaster Risk Reduction (WCDRR) in Sendai, Japan;
- the United Nations Sustainable Development Goals (SDGs), 2015
- the Conference of Parties (CoP) where the United Nations Framework on Climate Change (UNFCCC) was signed at Paris Climate Conference in 2015

All the three agreements highlighted the significance of the idea of resilience in tackling complex environmental issues to reduce disaster risk, to advance sustainable development and take climate action through adaptation and mitigation.

9.3.7.1 SENDAI FRAMEWORK FOR DISASTER RISK REDUCTION 2015

Hyogo Framework for Action (HFA), framed by the United Nations, defined its aim of “building the resilience of nations and communities to disasters” (WDCRR, 2005) with a focus on disaster losses. **Sendai Framework for Disaster Risk Reduction**, the successor to HFA (Brendan Howe, 2017) was framed in the third United Nations World Conference on Disaster Risk Reduction, was a disaster risk focused approach. Aim - “the substantial reduction of disaster risk and losses in lives and livelihoods and health, and in the economic, physical, social, cultural and environmental assets of persons, business, communities and countries.” (WCDRR, 2015)

9.3.7.2 SUSTAINABLE DEVELOPMENT GOALS 2015

Also known as Global Goals, the Sustainable Development Goals were adopted by the member states of United Nations in 2015. It was a prompt that aimed at ending poverty, protecting the planet and ensuring peace by 2030. There are seventeen such goals in the areas of health, education, gender, energy, equality, climate change, and more. (UN, The Sustainable Development Goals Report 2019,, 2019)

Table 3 Sustainable Development Goals adopted from UNDP, 2015 (Source: Author)

Sustainable Development Goal	Domain
1	No Poverty

2	Zero Hunger
3	Good Health and Well Being
4	Quality Education
5	Gender Equality
6	Clean Water and Sanitation
7	Affordable and Clean Energy
8	Decent Work and Economic Growth
9	Industry, Innovation and Infrastructure
10	Reduced Inequality
11	Sustainable Cities and Communities
12	Responsible Consumption and Production
13	Climate Action
14	Life Below Water
15	Life on Land
16	Peace, Justice and Strong Institutions
17	Partnerships for the Goals (IGES, 2020)

9.3.7.2.1 Sustainable Development Goal (SDG) 11

Aim – “To make cities and human settlements inclusive, safe, resilient and sustainable.”

Some of the targets of the goal, aiming at resilience include –

- To increase the number if cities and human settlements adopting and implementing the policies substantially, to move towards “resource efficiency, mitigation and adaptation to climate change, resilience to disasters”, while developing in line with the Sendai Framework (Johnson, 2017)
- “Support least developed countries, including through financial and technical assistance, in building sustainable and resilient buildings utilizing local materials” (UN, The Sustainable Development Goals Report 2019,, 2019)

9.3.7.3 PARIS CLIMATE CONFERENCE (COP21)

The CoP 21 – the Paris Climate Conference spearheaded international climate agreement, applicable to negotiating nations, to limit global warming with the recommendations of Intergovernmental Panel on Climate change. The agreement was signed with an “Action Agenda” aimed at holding the increase in global average temperatures to well below 2 degree Celsius above the pre-industrial levels and pursue efforts to keep rise of temperatures to 1.5 degree Celsius. (UN, COP21 conference on climate change, 2015)

9.3.8 **DISASTER MANAGEMENT CYCLE**

The plan of action of Hyogo Framework (2005) includes **strengthening disaster risk governance** at national, regional and global level for better management; **investing in disaster risk reduction** through public and private investments for prevention and reduction of risk; and enhancing disaster preparedness and to **"build back better"** in recovery, rehabilitation and reconstruction. (WCDRR, 2015)

Figure 8 Disaster Management Cycle (Source: UNFCCC)

Broadly, the phases are divided into four categories –

9.3.8.1 MITIGATION

Mitigation involves activities that aim at eliminating avoidable hazards and reducing the impacts of unavoidable disasters. It involves steps taken to reduce the frequency of occurrence of disasters through measure's like awareness **programs, regulation and safety codes, zoning and land use management, and operates at a policy level** through mediation of national or international organizations that either eliminate the causes that trigger disasters or aim to negate the economic, life and infrastructural losses suffered due to disasters.

9.3.8.2 PREPAREDNESS

The planning of response to disasters can be termed as preparedness. They aim at achieving a readiness when for disasters by ensuring with technology and management through national level

bodies. They enhance **response mechanisms** through rehearsals, warning systems, evacuation programs, short-term and long-term strategies, and resource inventories in case of national crisis.

9.3.8.3 RESPONSE

Response is the first step taken after disasters strike. It occurs at three levels – local, regional and global. It aims to aid **immediate support and maintain the basic physical and psychological needs of the affected population**. It serves to fill in the gap until permanent solutions are sought. It involves the strong association of humanitarian agencies for refugee transportation and provision of temporary shelter and resource inventory.

9.3.8.4 RECOVERY

After the initial stabilization of population with external aid temporary measures that support sustenance of life through infrastructure, recovery takes place. There is no distinct time phase at which response changes into recovery. It is a gradual shift towards more **permanent and sustainable long-term solutions** that aim at restoring normalcy through housing and economy, thus reducing vulnerability.

9.3.9 COMMUNITY RESILIENCE

Community resilience, broadly, has three general categorizations for definition – process definitions, that define it as an continuous process of change and adaptation; absence or adverse effect oriented definitions, that stress on the ability to maintain stable functioning; and, 'range of attributes' (Sudip Bhandari, 2020), that relate it to response-related abilities. Recent studies adopt the first definition widely. (Patel SS, 2017) As defined by Castleden and colleagues, with respect to disaster management, community resilience is "*a capability (or process) of a community adapting and functioning in the face of disturbance."* (Castleden M, 2011) The definition conformed to an evolutionary approach, which acknowledged the dynamic nature of systems, which resilience is a process of constant adaptation and change.

Another approach to community resilience, through equilibrium approach, is defined by United Nations International Strategy for Disaster Risk Reduction as, the "*ability of a system, community, or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner including through the preservation and restoration of its essential basic structures and functions"* (Ostadtaghizadeh A, 2015)

9.3.9.1 Elements of Community Resilience

The broadly overlapping elements in the definitions and concepts of community resilience, as analyzed by Patel SS and colleagues, are –

Local knowledge

Awareness regarding existing vulnerabilities in a community, and active mitigation of those vulnerabilities prior to a disaster, are considered to build resilience within a community. Sub elements within this category consist of

- **Factual knowledge base** – consists of the information, experience and education that is acquired in relation to disaster and disaster management
- **Training and education** – public disaster education through community training and exercises aimed at building local knowledge and capacity (Moore M, 2012)
- **Collective efficacy and empowerment** – community's shared ability to overcome a disaster, for instance, through self-reliance

Community networks and relationships

A well connected 'social network', determined by linkages within a community and social relationships, forming a cohesive whole, has positive effects on disaster management. Cohesion within a community is defined by the nature of these links. These factors are also emphasized as important aspects of social capital, consisting of bonding, linking and bridging.

Communication

Effective communication is imperative for resilience and requires a diversification of mode of communication and content.

- **Risk communication –** must provide accurate information about the disaster (Sonny S. Patel. M. Brooke Rogers, 2017) and possible threats. (Chandra A, 2013) Castleden proposed integration of steps for efficient risk communication within appropriate social context, into detailed vulnerability analysis and awareness initiatives for the community. (Castleden M, 2011)
- **Crisis communication** – consists of provision of updated information regarding ongoing impact and relief efforts. Flow of information was critical while conducting relief efforts. (Ganor M, 2003)

Health

Important aspects of health are pre-existing health of a community and provision of health facilities post disaster. Health vulnerabilities should be addressed before a disaster for building resilience.

(Patel SS, 2017) Improvement of **health services** may be undertaken by adopting training and capacity building exercises at hospital level for handling increased influx of casualties, as implemented by Asian disaster Preparedness Centre (ADPC). At the same time, quality care **for physical and mental health**, is given importance in resilience building. Immediate trauma and secondary long-term stressors are sensitive issues concerning post-traumatic management. (Ganor M, 2003)

Governance/ Leadership

Governance and leadership mould the crisis handling capabilities of a community.

- **Infrastructure and services –** support the ability to efficiently and effectively respond quickly.
- **Public involvement and support** – include local participation and representation in planning of strategies for response and recovery to disaster. It adds to sensitivity in strategic planning and community empowerment.

Resources

Consisting of tangibles and intangibles, availability of resources and their distribution is significant to community resilience. They broadly include "*natural, physical*, *human, financial, and social resources."* (Pfefferbaum RL, 2011) Fairness in allocation of resources is known as distributive justice. (DM., 2007) For physical recourse, possession along is important, along with the knowledge to harness these resources and allocate them within community. (Coles E, 2004)

Economic Investment

Direct and indirect costs of a disaster are substantial and need to be addressed. Addressing post disaster situations involve (Patel SS, 2017)–

- Economic programming to ensure cost effective interventions
- Financial resource distribution
- Economic development of infrastructure related to post-disaster

Preparedness

These measures were suggested to ensure sustainable management of recovery and response, to reduce the harm to community. (Patel SS, 2017) Risk assessment and community drills prior to disasters had were likely suggestions that have proven effective. (Chandra A, 2013) Relocating built infrastructure or flood proofing of structures prior to disaster were effective solutions. (Carlson J, 2012)

Mental outlook relates to attitudes and perspectives while facing uncertainty, and generally occurs in a post disaster or pre-disaster scenario. It constitutes an important component that shapes a community's willingness to persist, while facing uncertainty. (Patel SS, 2017) "Acceptance of uncertainty and change" (Bahadur AV, 2010) form a prerequisite to adaptability. Risk perception too, is an important cultural tool that help in disaster preparedness.

9.3.10 PARAMETERS FOR ANALYSIS

Through absorbing and overcoming stresses, a community continues to sustain. However, if an external intervention is required in a community to increase its resilience, memory plays a significant role in preventing disruption of the social networks and acceptance of the interventions. The pillars for sustainable development provide a basis for analysis of the impact of such communities -

- **Environmental** – As a community is a part of an ecological system, the environmental factor formed the basis of analysis, where the interrelationships between nature and community members were studied. With respect to resilience to natural disasters, the arrangement of **settlement, cluster, building technology** and relation to **natural vegetation** were studied. Serving as a basis for preparedness of a community against the natural disasters, interaction with environment also determines the degree of flexibility and adaptability in the mental outlook of a community.

- **Social** – Collective knowledge and risk perception are direct consequences of the social networks embedded within the structure of a community. **Social nodes and infrastructure** determine the mapping of such community networks, as gathering and sharing of knowledge are purposed around these spaces. Sustenance of the social networks are critical points when interventions are planned.

- **Economic** – Economic dimension, dominated by **livelihood** plays an important role in the degree of vulnerability in a community and the process of recovery. The **repercussions and responses** are influenced by prevailing economic conditions. In the long run, future **expansions** are a consequence of enhanced economic conditions.

10 SITE STUDY

10.1 LOCATION

Figure 9 Mandarmani, East Midnapore, West Bengal (Source: Author)

Mandarmani is in the coastal district of East Midnapore, *Purba Medinipur,* in local language, in towards the south of West Bengal. It is one of the two districts that practice marine fishery, along with brackish water fishery for prawn cultivation. The marine catch is a part of khoti culture discussed above, that is processed into dried fish. The area lies within the Very High-Risk Zone for cyclones, on the coast of Bay of Bengal.

10.2 SITE SURROUNDINGS

Figure 10 Site Location (Source: Author)

Along with fisheries, Mandarmani, lying close to the beach resort Digha, has gained recent popularity as a weekend budget getaway destination, popular for its beaches and away from the bustle of the city. The site lies at the end of the coastal stretch, bounded by the tidal confluence on the West, where Mandarmani estuary meets the Sea. The area is surrounded by coastal forests, protected from gales and storm surges by surrounding sand dunes that rise to a height of 13m to the South. The north is defined by fisheries and agricultural households, with the NH 117B, a 5.5 m heavy vehicular road, lying in between. To the west of the site lies the resorts with varied architectural character. Dominated by cottage resort character, it is interspersed with multistoried hotel as well.

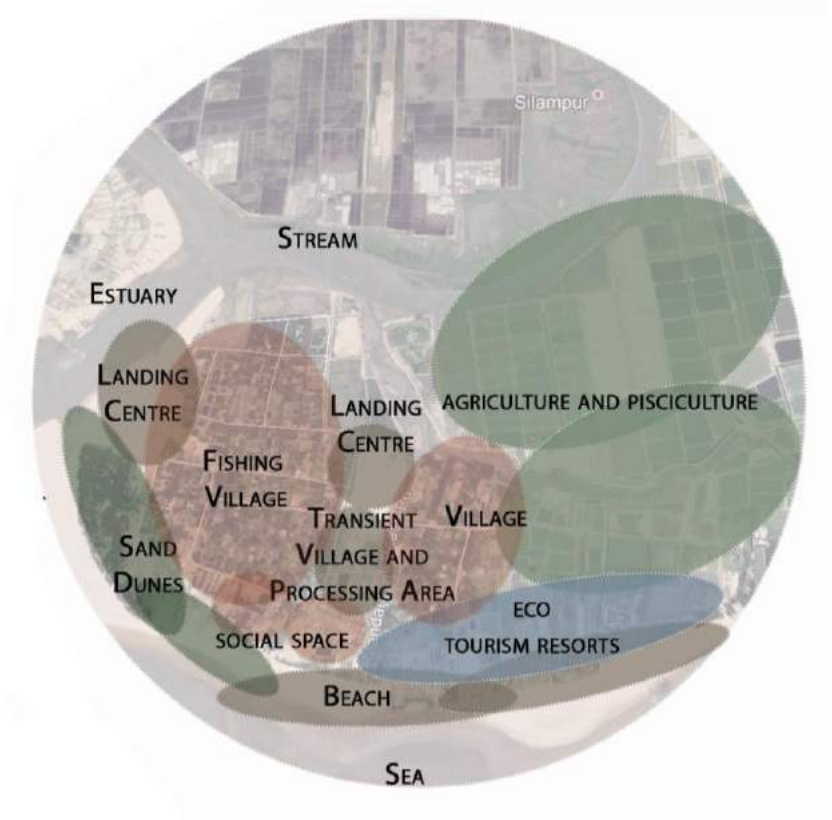


Figure 11 Tentative Spatial Relationship around the Site (Source: Author)

10.3 CONNECTIVITY AND ACCESSIBILITY

Mandarmani lies at 170 km from Kolkata, well connected by road. The tourists mainly visit the destination by car. The fisheries sector operates though trucks for delivery of goods and export. Some of the catch is distributed to the nearby markets. The nearest city is Contai, at 17 km from the village. The closest marketplace is Dadanpatrabrar, at 10 km from Mandarmani.

Figure 12 Mandarmani Connectivity (Source: Author)

CONTAI RAILWAY STATION

DIGHA RAILWAY STATION

CONTAI BUS STOP

Figure 14 Transit points to Mandarmani

Contai Railway station is at 17 km from Mandarmani village. It is the nearest down. Recently, Mandarmani has come under the jurisdiction of the Digha-Shankarpur Development Authority (DSDA), under the Kalindi Gram Panchayat. Digha is the nearest main city, with access to a railway station, while the nearest bus stop is at Chawlkhola, at 9 km from the location.

The modal split for transportation involves reaching the nearest city through road or railway, followed by auto rickshaws or pedestrian movement to the villages.

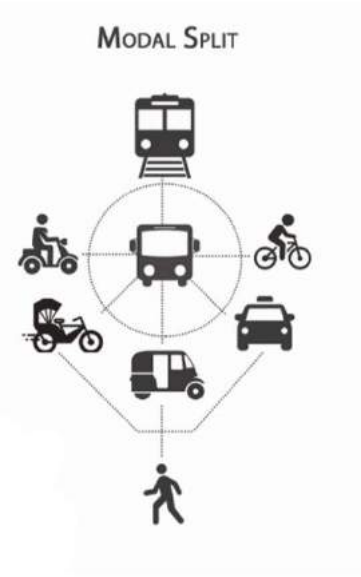


Figure 13 Modal Split (Source: Author)

10.3.1 **Road and Transportation on the Site**

The site is well connected to the city through a 5.5 m highway that is being expanded to connect Tajpur, a similar khoti with Contai, to enhance connectivity of the khoti villages. This is a major heavy vehicular road, connecting the landing centers. The rest of the roads on the site are for light traffic, mostly used by pedestrians or cycles.

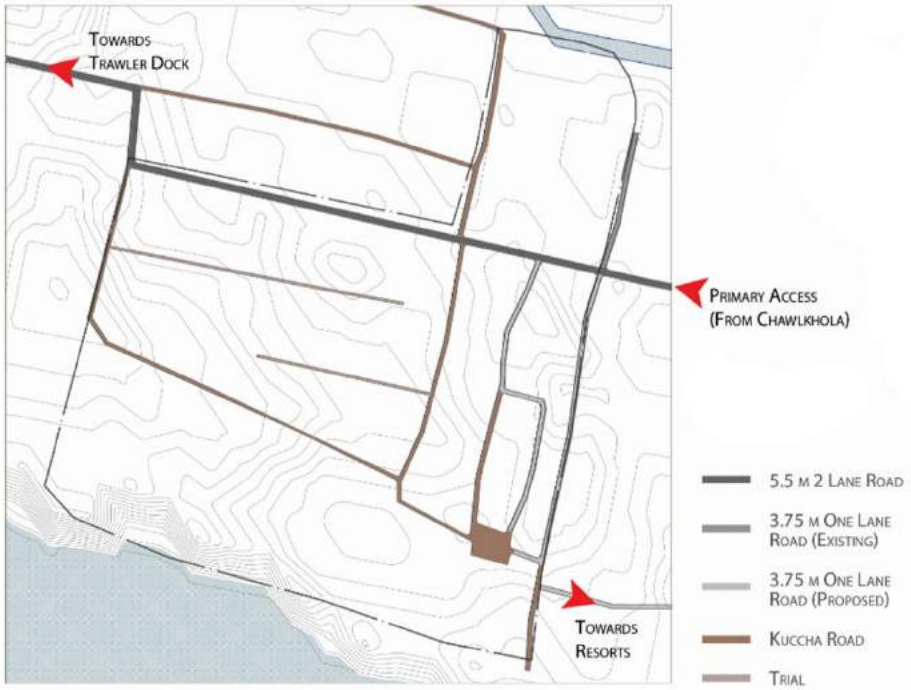


Figure 15 Roads (Source: Author)

Figure 16 Transportation (Source: Author)

10.4 CONTEXT STUDY

10.4.1 BUILDING MATERIALS

10.4.1.1 Architecture of Surrounding Tourism Hubs

The architectural style is dominated with RCC and brick masonry structures. Urban in character, they have influenced the building choices and aspirations of the nearby villagers to a great extent, where the construction of pucca houses has evolved to become a symbol for status and progress.

Built form: Eco tourism resort with single storey, stand alone cottages, a reception and dining hall

Construction: RCC and Brick Masonry

Vegetation: Landscaped with a variety of palms, coconut trees, and annual flowering plants

Figure 17 Marino Beach Resort, Mandarmani (Source: Author)

Sana Beach Resort

Built form: Eco tourism resort with single storey, **stand alone cottages**, a double storeyed reception and dining hall with **sloping roof** and **earthen** ambience.

Construction: RCC and Brick Masonry with stone cladding and terracotta tiles

Vegetation: Landscaped with a variety of palms, coconut trees, and annual flowering plants

Figure 18 Sana Beach Resort, Mandarmani (Source: Author)

Viceroy Beach Resort

Built form: G+3 Structure with doubly loaded corridor, a colonnaded entrance and a grand entrance lobby

Construction: RCC and Brick Masonry

Vegetation: Landscaped with a variety of palms, coconut trees, and annual flowering plants

Figure 19 Viceroy Hotel, Mandarmani (Source: Author)

10.4.1.2 Architecture of the Villages

The Village architecture is dominated by kuccha structures, with temporary roofing systems. Most of the buildings that are pucca have roof made of asbestos or corrugated iron sheets. A very few pucca structures belong to the owners of the fishing businesses or *bahardars.*

10.4.1.2.1 Effect of Cyclones on Structures

The houses exhibit a deep understanding of the nature of cyclones and how a cyclone affects a building. In the direction of direct force, an overturning effect takes place, which tends to uproot the house, detaching it from roof and foundation connections. While the drag caused on parallel surfaces and leeward vortex cause the walls and roof surfaces to be pulled out due to pressure differences, causing the building to burst open.

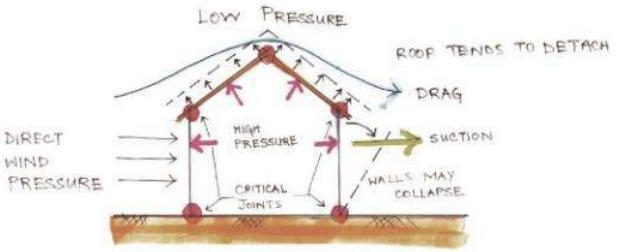


Figure 20 Effect of cyclone on structure (Source: Author)

10.4.1.2.2 Strategies for Resilience

Staggered arrangement of non-engineered structures with interspersed vegetation, lowers the velocity of wind, minimizing damage done to structures. Tunnel effect of wind increases wind velocity. While linear arrangement of buildings can be observed along the roads, the structures with such arrangement tend to be semi engineered.

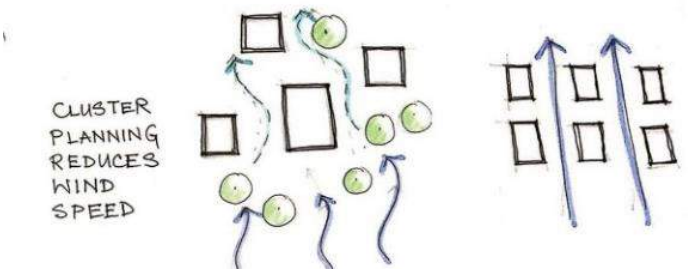


Figure 21 Cluster Planning (Source: Author)

Permeability of structures allows dissipation of the direct force of wind and minimizes pressure differences, reducing damage to surfaces and connections. Permeability also allows diffused light and wind circulation within buildings, increasing thermal comfort.

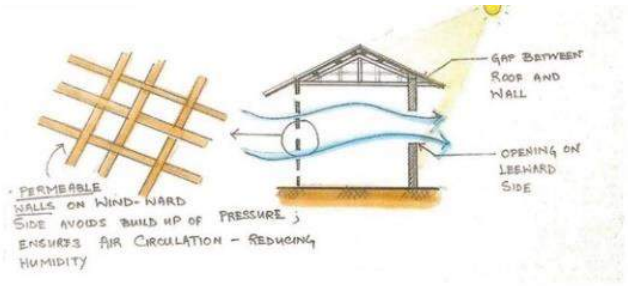


Figure 22 Permeable surfaces (Source: Author)

The stress on **roof connections** are dissipated by leaving a gap between the wall and roof, while building strong structural connections. Hip roofs are commonly seen in the area. Hip roofs minimize negative pressure on the roof surfaces, reducing detachment. Overhangs and balconies, that generally cause overturning and failure, increasing stress on connections, are avoided in the area.

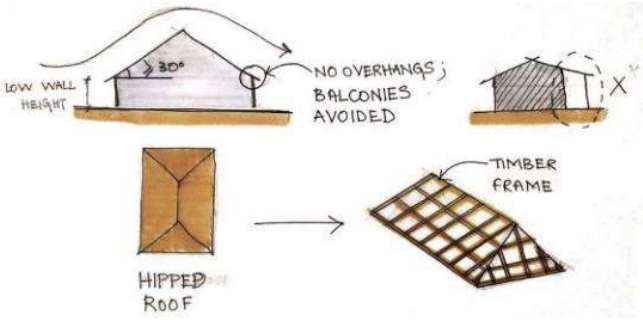


Figure 23 Hipped Roof Detail (Source: Author)

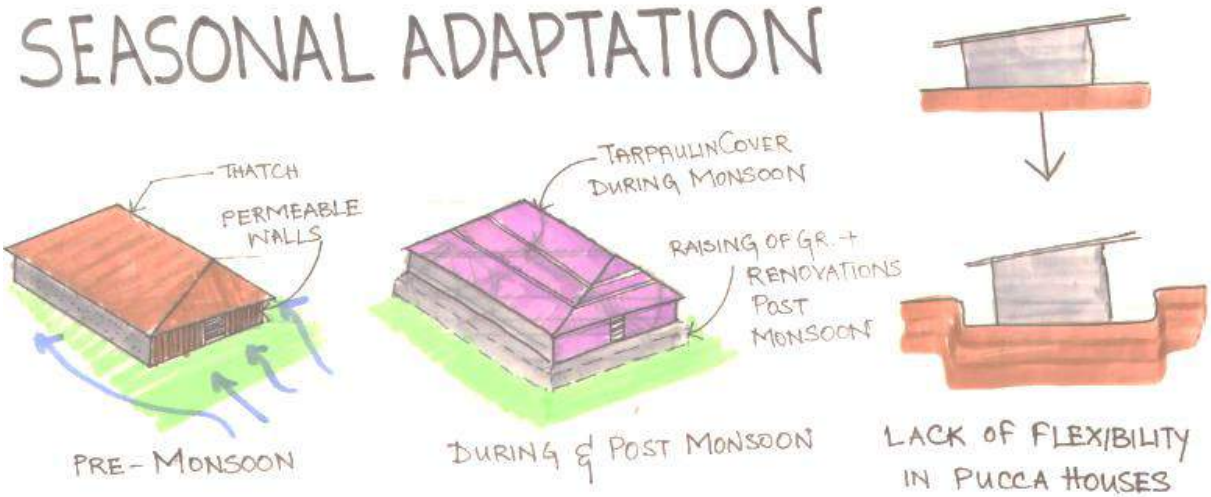


Figure 24 Seasonal Adaptations (Source: Author)

Seasonal Adaptations

The resilience of the community lies in its flexible nature. Before monsoons, the walls of the buildings are exposed to the natural weather forces, and the permeable walls allow ventilation and prevent humidity. However, during the monsoon season, the walls and thatch are covered and secured using tarpaulin and fastened using fishing nets and ropes. The damages to the

structures, minor in nature, are repaired after every monsoon, which acts as a mandatory act of maintenance, involving the whole family. The plinth and floor level is also adjusted after every monsoon season as the ground level is shifting in nature. The pucca structures, with a fixed elevation generally suffer from lower ground level than the surrounding areas due to sand and mud accumulation on the plots near the coastline, leading to water logging and ingress.

Bio Shield

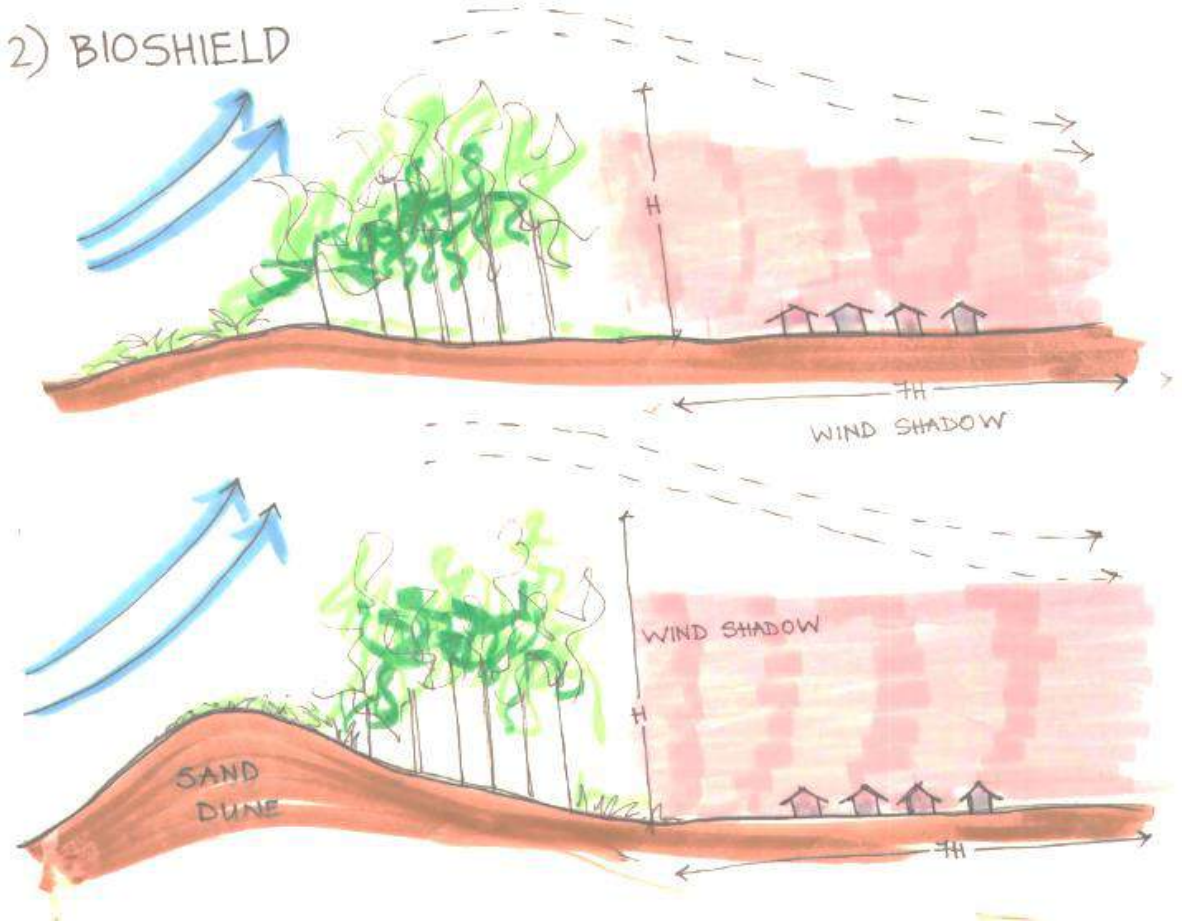


Figure 25 Bio shield in Mandarmani (Source: Author)

The settlement lies in the wind shadow of the coastal forests and sand dunes that protect the inland areas from storms and natural hazards. The sand dunes are effective in protection against storm surges and tidal waves while the coastal forests protect the settlement from the strong gales and cyclonic winds. The recent deforestation is hampering the protection of the settlement, leading to increased damage of built environments and livelihoods.

10.4.2 BYE LAWS

10.4.2.1 Land use

Mandarmani, under the Kalindi Gram Panchayat, is under the jurisdiction of the Digha-Shankarpur Development Authority (DSDA). Consisting of Residential Zones (Zone R), Agricultural Zones (Zone AG), Special Purposes (Zone SP2) and green spaces (Zone G), the demarcation of functions are:

Development Control Zone R – Comprises of areas that are principally used for Residential purposes but are mixed with other uses

Development Control Zone AG – Comprises areas that area principally used for Agricultural Purposes but are mixed with other purposes

Development Control Zone SP2 - Comprises areas that area principally used for Special Purposes but are mixed with other uses. The area is used as a fishing harbor under Benfish.

Development Control Zone SP2 - Comprises areas that area principally used for Green spaces and organized green spaces. The 200 m buffer of green belt along the coastline of Bay of Bengal, demarcated under CRZ falls under this zone.

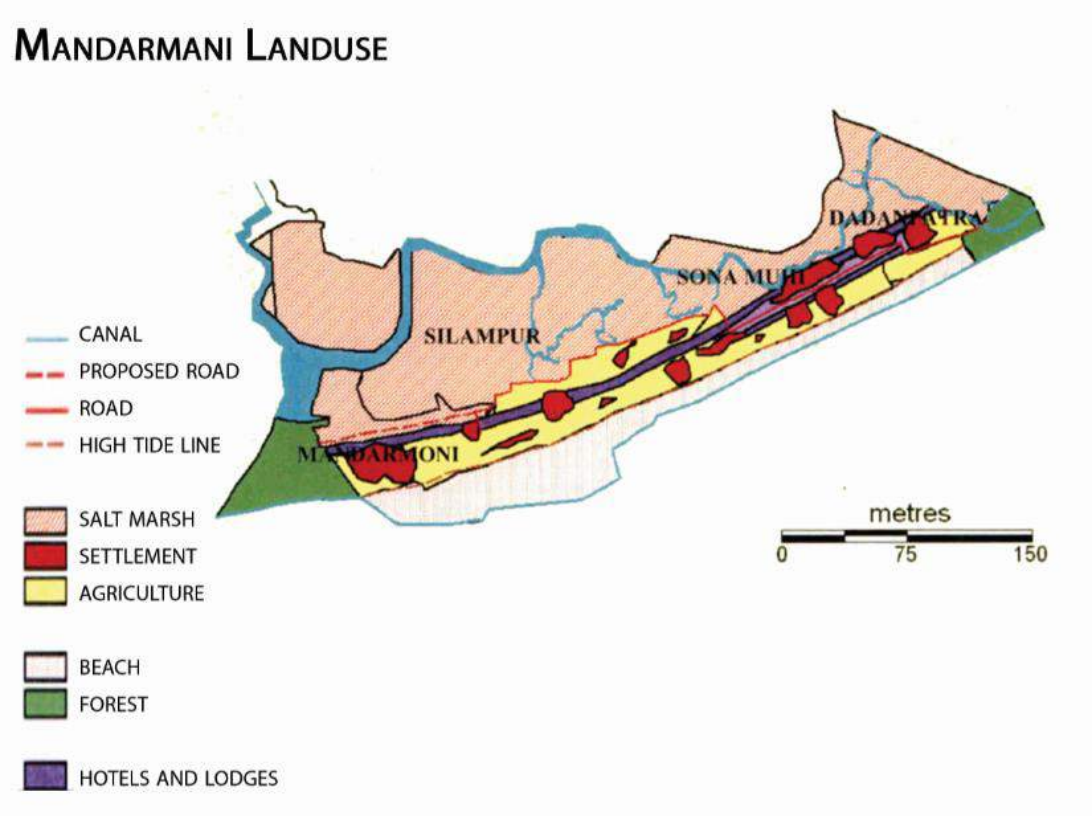


Figure 26 Mandarmani Land use (Source: DSDA)

10.4.2.2 Regulation for control of Building Operations under W.B.P (GPA) Rules, 2004

10.4.2.2.1 Exemptions

1. No permission from Gram Panchayet shall be necessary for erection of any thatched structure, tin shed or tile shed without brick wall, covering an area not exceeding 18 sq. m. Such a structure should not cover more than three-fourth of the land
2. No permission from Gram Panchayet shall be necessary for the repair of an existing structure or building, unless

    a. Structural changes are involved
    b. Change in existing area is involved
    c. Addition of projection from existing structure or building ground on upper floor level

10.4.2.2.2 Approach or Passage Road

1. Every structure or building shall have an approach road or passage road from a public road of minimum 1.8 m
2. If an existing passage or road over which the public have a right of way is less than 1.8 m wide, the plot holders on either side of such passage or road shall keep a front set back in such a manner as to allow a front set back of 0.9 m on either side of the road and a rear set back of 1.8 m.

10.4.2.2.3 Maximum Coverage of Residential Building

1. The maximum building coverage of an individual plot shall be two-third of the total area for a residential building. One-third of the total plot area that shall be kept vacant shall include front, side and rear set back spaces.

10.4.2.2.4 Construction of Residential Building

1. The area of a habitable room shall not be less than 6 sq. m. with a minimum width of 2.5 m.
2. The height if all habitable and multipurpose rooms shall not be less than 2.6 m from the surface of the floor to the lowest point of the ceiling

3. The height of the kitchen, water closet, bathroom, corridor or passage shall not be less than 2.1 m from the surface of the floor to the lowest point of the ceiling.

10.4.3 Coastal Regulation Zone Norms

10.4.4 CRZ Demarcation

1. CRZ I-A: Shall constitute the following ecologically sensitive areas (ESAs) and the geomorphological features which play a role in maintaining the integrity of the coast viz:
    a. Sand Dunes
    b. Mangroves (in case mangrove area is more than 1000 sq. m, a buffer of 50 m along the mangroves shall be provided and such area shall constitute CRZ I-A

2. CRZ III – B (NDZ): Land area upto 50 m from the High Tide Line along the tidal influenced water bodies in the CRZ III shall be earmarked as NDZ in CRZ III.

3. CRZ III – B: All other CRZ III areas with a population density of less than 2161 per sq. km, as per census 2011 base, shall be designated as CRZ III – B or in CRZ III – B

PERMISSIBLE ACTIVITIES	
CRZ III B (NDZ)	CRZ III B (NDZ)
1. REPAIRS OR RECONSTRUCTION OF EXISTING AUTHORISED STRUCTURE NOT EXCEEDING EXISTING FSI, PLINTH AREA AND DENSITY FOR PERMISSIBLE ACTIVITIES.	4. CONSTRUCTION OF UNITS OR AUXILIARY THERETO FOR DOMESTIC SEWAGE, TREATMENT AND DISPOSAL
2. AGRICULTURE, HORTICULTURE, GARDENS, PASTURES, PARKS, PLAYFIELDS, FORESTRY	5. FACILITIES REQUIRED FOR LOCAL FISHING COMMUNITIES SUCH AS FISH DRYING YARDS, AUCTION HALLS, NET MENDING YARDS, TRADITIONAL BOAT BUILDING YARDS, ICE PLANT, ICE CRUSHING UNITS, FISH CURING FACILITIES AND THE LIKE.
3. CONSTRUCTION OF DISPENSARIES, SCHOOLS, PUBLIC RAIN SHELTER, COMMUNITY TOILETS, BRIDGES, ROADS, PROVISION OF FACILITIES FOR WATER SUPPLY, DRAINAGE, SEWERAGE, CREMATORIA, CEMETERIES AND ELECTRIC SUB-STATION WHICH ARE REQUIRED FOR THE LOCAL INHABITANTS.	6. TEMPORARY TOURISM FACILITIES SHALL LIKE SHACKS, TOILETS OR WASHROOMS, CHANGE ROOMS, SHOWER PANELS, WALK WAYS CONSTRUCTED USING INTERLOCKING PAVER BLOCKS, ETC, DRINKING WATER FACILITIES, SEATING ARRANGEMENTS ETC.

Table 4 CRZ Permissible Activities CRZ IA (Source: Author, adapted from Coastal Regulation Zone (CRZ) Notification 2018 and Environmental (Protection) Rules 1986)

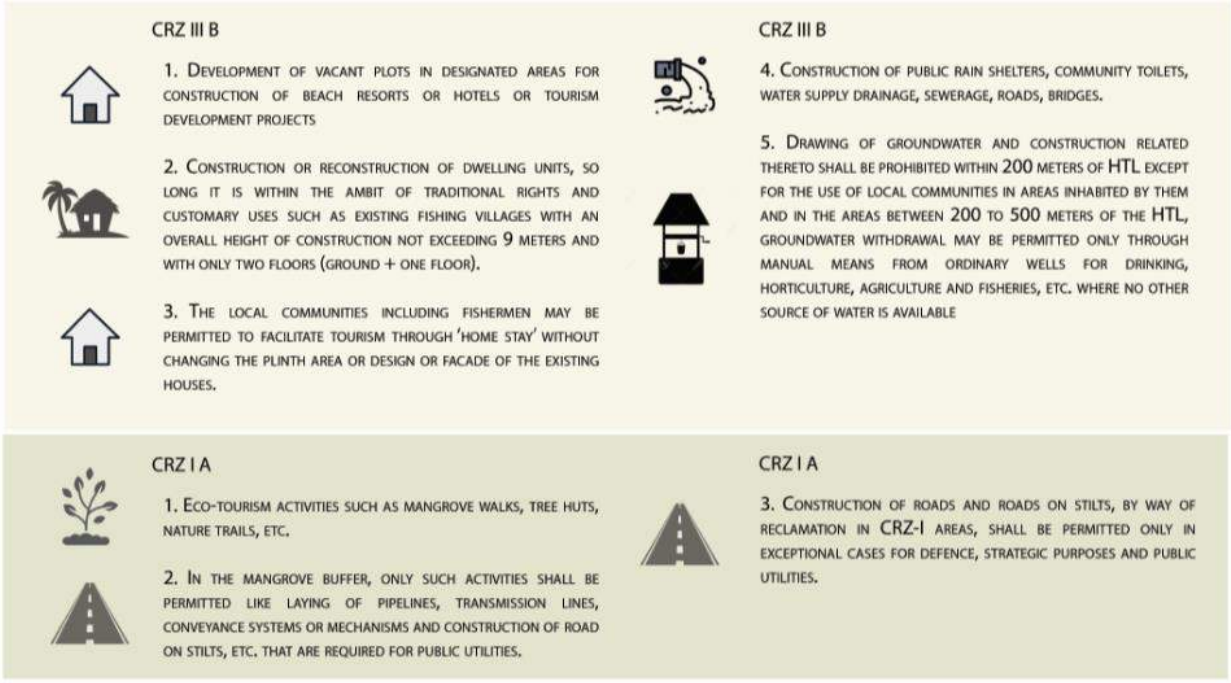


Table 5 CRZ Permissible Activities CRZ III (Source: Author, adapted from Coastal Regulation Zone (CRZ) Notification 2018 and Environmental (Protection) Rules 1986)

10.5 SITE CHARACTER

10.5.1 SERVICES ON SITE

10.5.2 Electricity

Supplied by West Bengal State Electricity Company Limited (WBSEDCL), under the rural electrification (RE) scheme, WBREP: A 950 crore project undertaken and completed recently in Purba Medinipur District, it is supplied from Ramnagar Substation. The capacity being 17.6 MVA, the substation is 33/kV supplier.

10.5.2.1 Sewerage system

The sewerage system is proposed to be undertaken and monitored by Public Health Engineering Department (PHED), West Bengal, where, wastewater shall be treated before discharging into the sea. However, the hotels and resorts violate the norms and the service is not yet accessible to the rural communities.

10.5.2.2 Water Supply

Water supply is monitored dan implemented by PHED. There is a provision for piped water supple (PWSS) in the Kalindi Gram Panchayat. However, it is absent in the rural settlement areas. In the existing site, water supply is through community tube wells installed in pubic areas and some private houses. The tube wells range between a depth of 150 m to 250 m, for fresh water supply that is non-saline in nature. The water at shallow depth is non potable and saline. The yield range of the tube wells are more than 800 LPM or sq. m per day.

10.5.2.3 Solid Waste Disposal

Hand operated wheelbarrow for collection of solid waste from resorts and community spaces are practiced. However, the practice is nonregulated and unorganized. The is lack of segregation of waste with open vats being constructed for storage of waste. Uncontrolled dumping is a common phenomenon.

10.5.3 VEGEATION ON SITE

Figure 27 Natural Vegetation Map (Source: Author)

10.5.3.1 COASTAL FOREST

Vegetation on the site consists of coastal forests, and trees planted in the settlement region of the village. The coastal forest consisting dominantly of Casuarine equistofolia trees (*jhau, in local language) and* Pandanus, a species of mangrove (*keya),* aalong with the coastal sand dunes, form the bio shield, protecting the inland areas from the storms originating in Bay of Bengal. The thrust of the strong winds or gales are taken by the forest, while the settlement lies in the wind shadow region. The dendritic roots of the mangrove trees also protect the sea from receding into the land by stabilizing the landforms. Casuarina trees were planted in large number by an afforestation drive for coastal protection by the state government through social forestry.

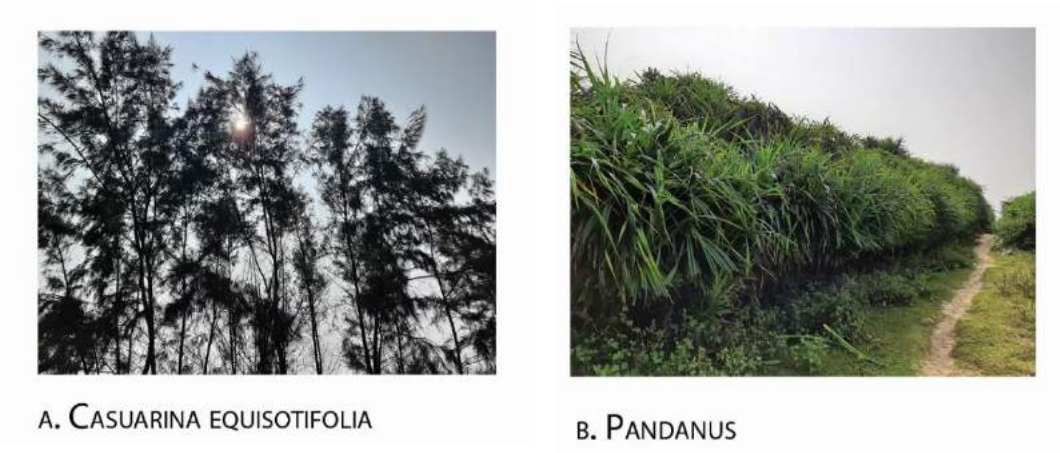


Figure 28 Coastal forest (Source: Author)

10.5.3.2 VEGETATION ON THE SITE

Trees found in abundance in the settlement region mostly belong to the category of palms, like Areca catechu (Beetle Nut) and Cocos nucifera (Coconut trees) that are fibrous and flexible in nature, to withstand the high winds without breaking. Other trees include Anacardium occidentale (Cashew nut) and Acacia auriculoformis trees.

Some fruit and flower breaing trees can also be found in the region. In recent times, due to the fall in economy, the community is diversifying to vegetabke farming and poultry for consumption and limited production of surplus for supply to local markets and resorts.

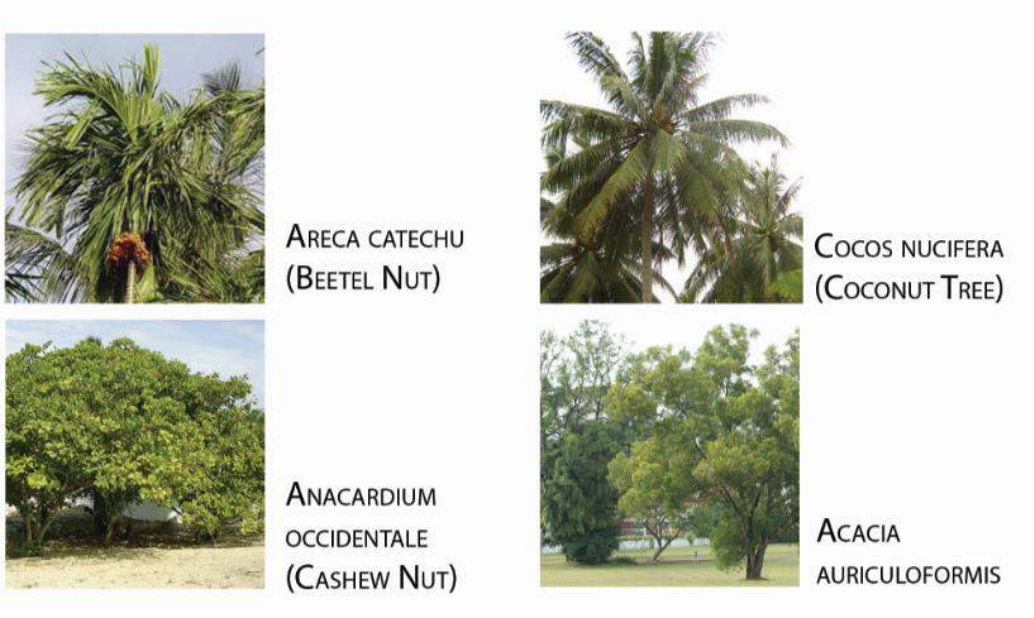


Figure 29 Trees found in settlement (Source: Author)

10.5.4 **RELIEF MAP**

The topography of the region is dominated by ancient sand dunes that protect the region from inundation during storm and tidal surges. The maximum storm surge in the area has been recorded at 12.5 m while the sand dunes rise to a height of 14 m, within the site. The coastal sand dunes along with the coastal forests construct a bio shield to protect the settlement from cyclones. The fontal zone and the back dune zone are critical for the evolution of dune landscapes The frontal zone is covered with grass and vines, while the back dune zone harbors the shrubs and herbaceous plants, that eventually gives way to the coastal forests. However, in recent times, the sand dunes are being mined while the forests are subjected to deforestation, opening the land to devastation in case of a cyclone.

The contours define the southern edge of the site, separating the settlement from the beaches. The northern edge is bounded by a tidal inlet, which serves as the jetty point for the trawlers. The land drains towards the tidal inlet, with intermediate troughs marking the lowest points on the site.

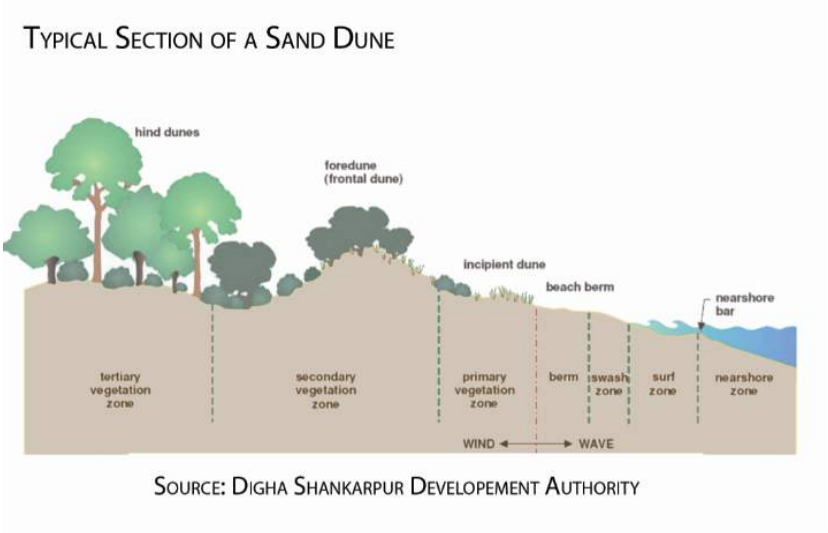
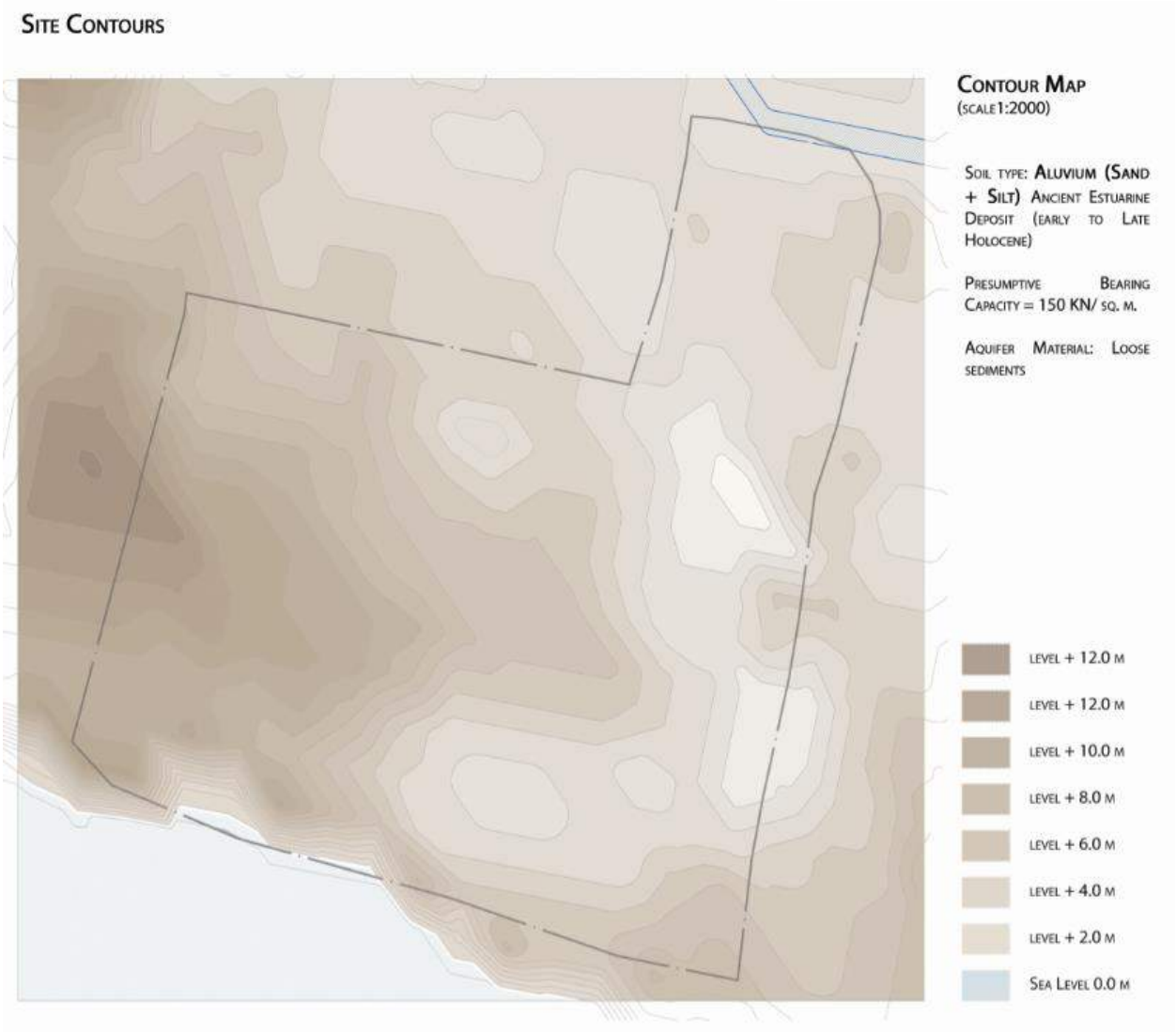


Figure 30 Typical Section of a Sand dune (Source: LUDCP DSDA)



10.5.5 SOIL AND WATER TABLE

The soil type in the region is Alluvium, with a mixture of silt and sand, depending upon the distance from the sea. As the distance increases, the percentage of sand in the soil mixture decreases. The are deposits of ancient estuarine soil, dating back to the Holocene period. The presumptive bearing capacity of the soil is 150 kN/ sq. m which the aquifer material is mostly loose sediments.

The water table is at a depth of 11m from the ground level. These is a marked rise of water table up to 7m after the monsoon season. However, the water available at this depth is saline and non-potable. Potable water is available at 150m from the ground level – the depth at which tube wells are installed.

10.5.6 WATER BODIES

The site area is bounded by the Bay of Bengal to the South, while the north is bounded by a tidal inlet. There exist several man-made ponds on the site, for practicing inland fishing in brackish waters. Recently, the brackish water fisheries have been formalized by Benfish under West Bengal State Fisheries Ltd. A prawn aquaculture pond has been dug at one of the troughs that would form an inundation zone during monsoon for controlled aquaculture, drawing water from the saline tidal inlet. A prawn processing unit has been set up.

Figure 31 Types of Water bodies on the Site (Source: Author)

Figure 32 Water Bodies Map (Source: Author)

10.6 CLIMATIC DATA AND INTERPRETATION

10.6.1 CLIMATE

The climate of Purba Medinipur is Tropical Maritime. The average temperature ranges between 25.5 and 35 degree Celsius, with temperatures rising to 38 degrees in summer. The annual variation of temperature is minimal. Rainfall occurs unevenly during monsoon, with spells of heavy rainfall. The average rainfall is 1752.6 mm annually.

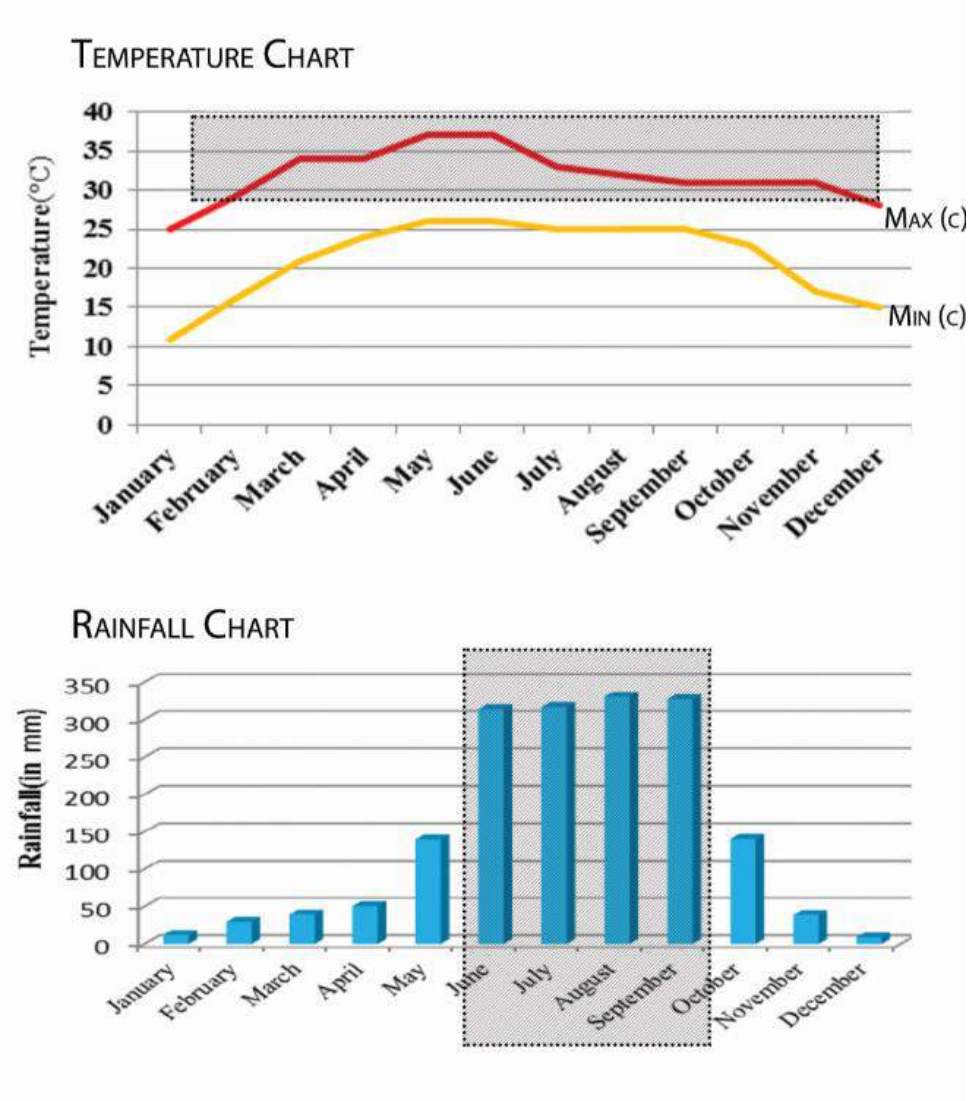


Figure 33 Temperature and Rainfall Charts (Source: Disaster Management Plan 2015, Purba Medinipur)

There are 4 marked seasons –

1. Cold, dry weather from December to February
2. Hot, humid weather from March to May
3. Monsoon period lasts from June to September
4. Post Monsoon period prevails in October and November

Over 70 per cent of the rainfall is received between the monsoon season between June and September, with the humidity levels varying between 70 per cent to 90 per cent throughout the year.

Figure 34 Climatic Data (Source: Author, adapted from Indian Meteorological Department)

10.6.2 **CYCLONE SUSCEPTIBILITY**

Cyclones from Bay of Bengal is a common feature of this region during the prevailing South-West Monsoon current. In the district, there are five major coastal blocks – Khejuri II, Deshaparan, Contai-I, Ramnagar-I and Ramnagar-II, which are affected annually by cyclones and floods. Mandramani is under the jurisdiction of the Khejuri-II administrative block. The devastating

cyclones generally occur between the months of October and November. The years marking devastating cyclones are –

1. 1800s – 1833, 1864 and 1867
2. 1900s – 1942, 1988, 1997
3. 2000s – 2009, 2020

The cyclones are dominated by vortices air motions, which progressively advance form the interior of the Bay of Bengal towards the coast. Heavy rainfall over and near the cyclonic disturbances are characteristics features. 32% of the cyclones cause flooding due to the coincidence of shore winds with tides.

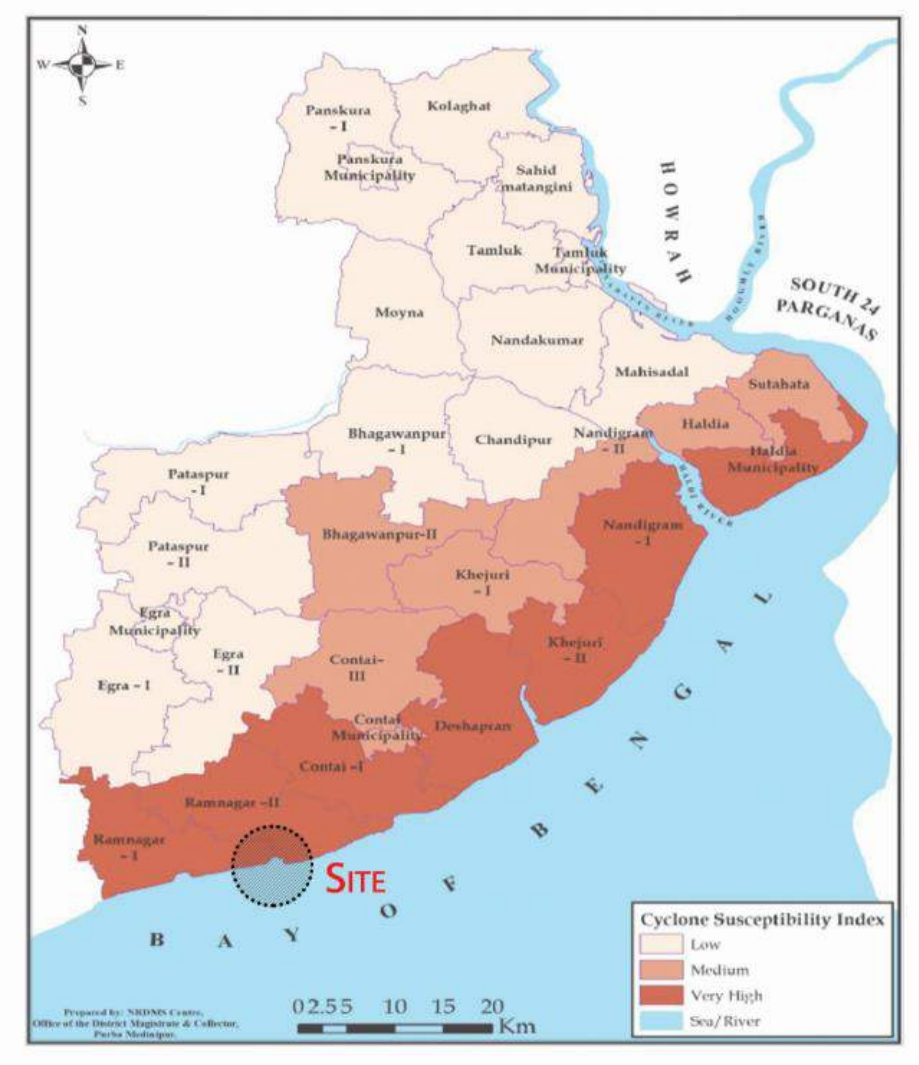


Figure 35 Cyclone susceptibility Map, Purba Medinipur (Source: Disaster Management Plan 2015, Purba Medinipur)

11 THE SETTLEMENT

11.1 THE PEOPLE

11.1.1 OCCUPATION

The first mention of the settlement was in the topographical map of India, 1956, as a fisherman village. Fishermen are mainly involved with brackish water fishing of prawns. West Bengal, with its short coastline of 64 km produces 75 per cent of the total brackish water cultivated land in India, comprising of 35,000 hectares under the use. Marine fishing and inland fisheries are other sources of income. There has been formalization of the fishing sector in Mandarmani recently through Benfish – the primary body of fishermen co-operatives, under the West Bengal State Fishermen's Co-operative Federation Ltd. (An organization under Department of Fisheries, Govt. of West Bengal)

The fishing season is active after the monsoon season and begins in mid-October. It is heavily influenced by the south west monsoons. The fishing economy also provides an impetus for other economies for transport and retail, with stockists procuring fish directly from the fishermen.

Other sources of income include cash crop cultivation of coconut, cashew nut and beetle nut trees in the salty areas and sand dunes. Salt production is another source of income. The economy is also heavily influenced by agriculture.

Recently, there has been heavy development in the tourism sector in the area, owing to its proximity to Digha, scenic beaches and serene environment. With the first hotel was established in 2001, *Tarangamala,* at present, there are 297 hotels operating in the area. The rapid expansion, however, has been unplanned and is causing degradation of the environment through unplanned development, sand mining of the dunes and deforestation of mangroves and coastal forests, leading to coastal erosion and higher exposure to the hydro-hazards originating in the volatile Bay of Bengal. The hotels violate the CRZ norms and are constructed within the coastline, with only one hotel lying in the zone earmarked for construction.

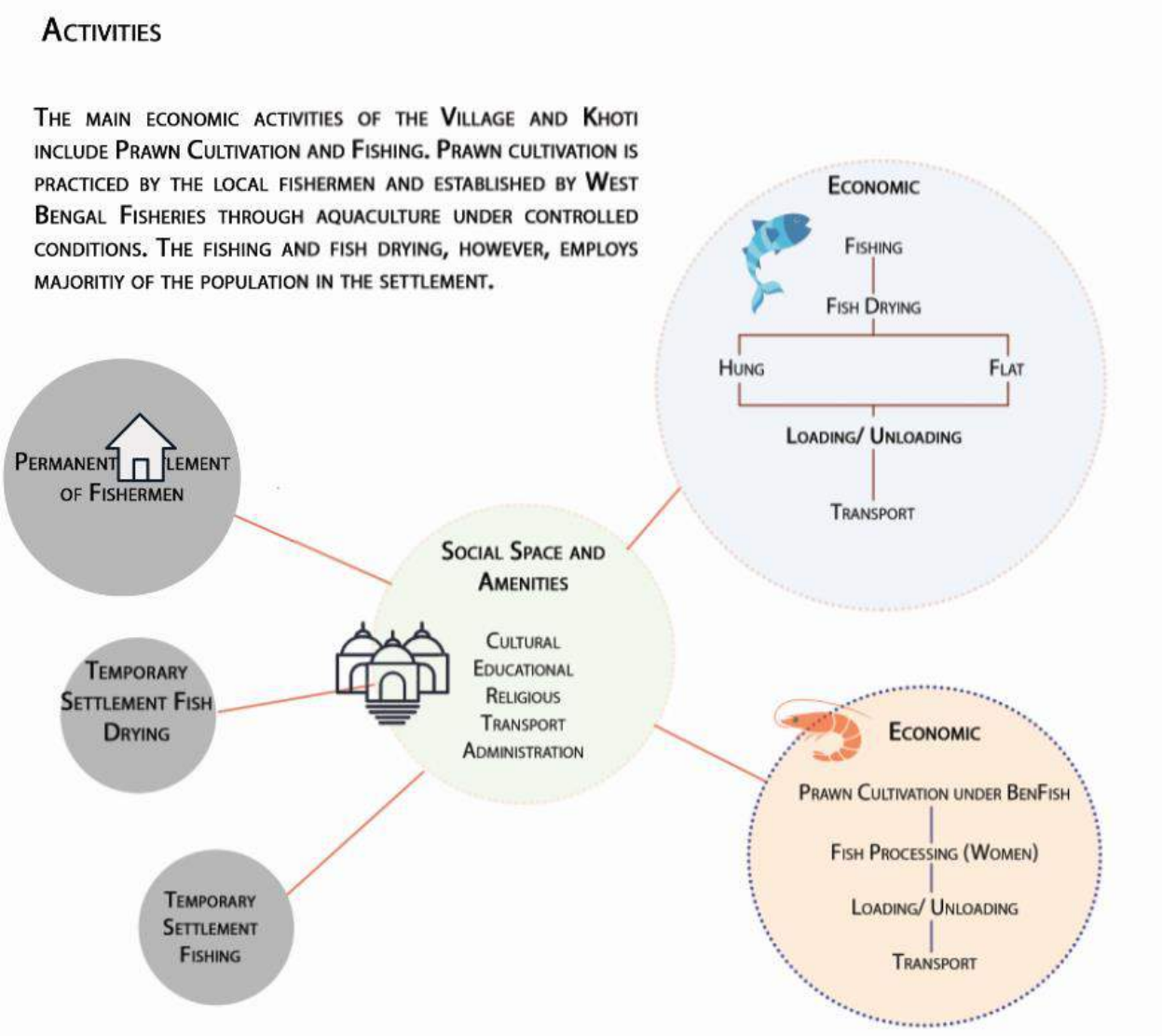


Figure 36 Economic Activities and Interlinkage of Communities

11.1.2 **LIFESTYLE**

The fishermen, before going out into the sea at high tide through the tidal creek surrounding the site, worship the goddesses Ganga and Manasa – the deity of river Ganges and the deity of snakes respectively, praying for the safety pf their lives and a productive fishing excursion. The return is at high tides. The fishing boats ply on a regular basis while the fishing trawlers are at the sea for 10 to 12 days. The end of the fishing season is marked with a gathering for the worship of the goddesses. Much of the time of the fishermen is taken up by the fishing livelihood, with the family involved in net mending and fish processing. These are major social activities, which are carried out in sheds and semi open spaces.

The staple diet consists of locally grown rice, vegetables from gardens within their own plots and fishes that are caught. Making the community self-reliant in terms of produce of food – an important aspect that helps them cope incases of disasters when the supply chains are disrupted.

The women of the village are gradually diversifying into fish processing units set up by Benfish for prawn cultivation for livelihood and increased income to counter the fall in economic conditions of the families due to climate change related issues like fall in marine productivity and reduced buffer between disasters that incur a repetitive cost for reconstruction.

In the transient community, there is heavy interlinkage between the spaces of work and living quarters. The lives and livelihoods come together with spatial manifestation of the same. The materials used for fish processing, like bamboo mats and tarpaulins are often used as building materials for the houses of the transient community.

11.1.3 **FISHERMAN VILLAGE**

The village is characterized predominantly by kuccha structures, with materials that are locally available on the site. They include Hogla leaves (dried leaves from local trees), split bamboo and woven bamboo mats, bamboo as major structural members and mud walling. The roofing material varies between thatch, asbestos and tiled roof. The tiles are most widely used as they are resistant to cyclones. In case of damage, the fragmented nature of the material makes the damage to the skin localized, preventing the need for major renovations and repairs.

The cluster patterns, on analysis of existing clusters, emerged to be introverted. They branch off from the roads that connect the infrastructure linearly through roads, in the form of trails. The entrance if generally into an open space, flanked by ponds, hidden from sight through the presence of trees, making the village experience such that the built is negligibly noticed from the trails. The clusters consist of three to four houses, sharing common toilets, if present, poultry and ponds. The joint family system is maintained in the clusters, with different members of the family living in different dwelling units within the same plot of land. In some houses, tube wells and small temples for goddess ganga and goddess manasa are present.

Land is owned by a *patta* system – leased out for a period of 99 years, by the government to the villagers. The plots are jointly owned by the clusters. In recent times, the village has expanded along the roads in a linear development, with a few pucca structures taking shape on the site.

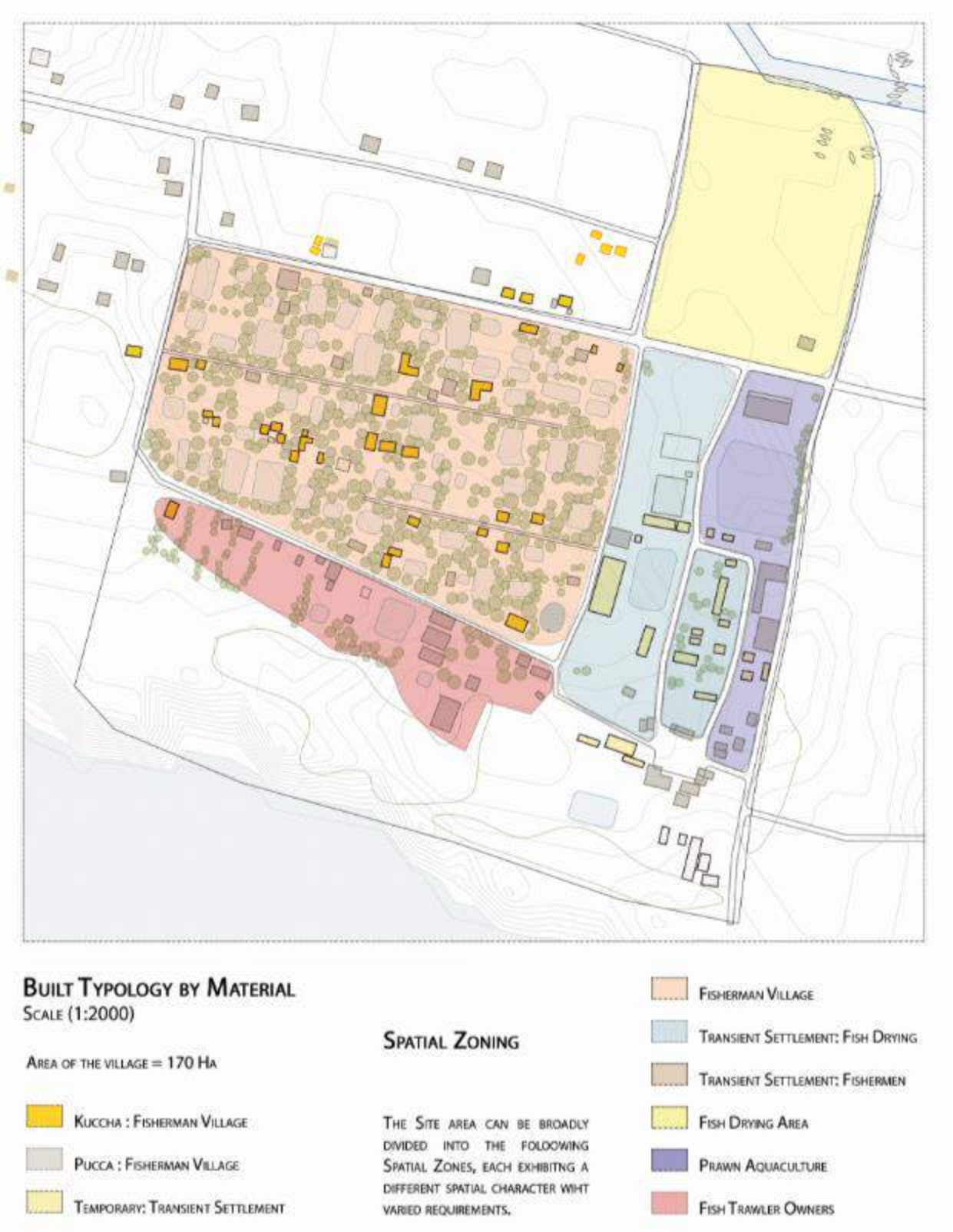


Figure 37 Community Distribution and Built Typology

11.1.4 TRANSIENT COMMUNITY

The transient community is characterized by the migrant fishermen, who come from east and west Medinipur, Orissa and some parts of Assam. There are two segregations in the community on the basis of their role in the fishing practice – the fishermen and the fish dryers. A spatial hierarchy can be observed on the site based on the amount of time spent on a site and the basis of ownership of the houses they live in. The fish processors are settled for a period of five months and are based near the landing centers. The land is leased to them annually and they build their own shelters with the use of local materials.

The fishermen are accommodated near the commercial square and temple. They follow the practice of worshipping the goddesses before venturing into the sea. The houses are owned by bahardars or owners of the fishing business. They are employed as wage labors by the bahardars while food and accommodation are provided. The *ghuti* centers supply the necessities for living on the sea in the trawlers. This transient village is one of the 44 that are established along the coast of Bengal.

11.1.5 SOCIAL SPACES

The two communities interact at the social space which consist primarily of the temple ground and the commercial hub, supplying materials for daily subsistence, a cloth store, a general store, a medical dispensary, and a food stall. These areas are frequented by the men of the society.

For the women, the social spaces are the economic spaces where other villagers gather for work. The major activities are fish and prawn processing. A *Mahila Samiti* office governs the prawn aquaculture area. Other spaces are semi shaded spaces where net mending is practiced in the evenings and the areas with community tube wells where the women gather for collection of water. The tube wells are provided at the temple square and near a toilet set up for common use at a short distance from the settlement area.

The children socialize at the schools and sometimes accompany their parents to work. The ramps and the staircases of the cyclone shelter present acts as spaces for children to play. Sports and other activities are performed in the open grounds in the village. The children often help in the various cycles of fish processing, the former being a livelihood that involves the whole family.

Note: Refer sheets (Annex I) for detailed analysis on community

Figure 38 Social Spaces within Community

12 CASE STUDIES

Through absorbing and overcoming stresses, a community continues to sustain. However, if an external intervention is required in a community to increase its resilience, memory plays a significant role in preventing disruption of the social networks and acceptance of the interventions. The pillars for sustainable development provide a basis for analysis of the impact of such communities –

- **Environmental** – As a community is a part of an ecological system, the environmental factor formed the basis of analysis, where the interrelationships between nature and community members were studied. With respect to resilience to natural disasters, the arrangement of **settlement, cluster, building technology** and relation to **natural vegetation** were studied. Serving as a basis for preparedness of a community against the natural disasters, interaction with environment also determines the degree of flexibility and adaptability in the mental outlook of a community.

- **Social** – Collective knowledge and risk perception are direct consequences of the social networks embedded within the structure of a community. **Social nodes and infrastructure** determine the mapping of such community networks, as gathering and sharing of knowledge are purposed around these spaces. Sustenance of the social networks are critical points when interventions are planned.

- **Economic** – Economic dimension, dominated by **livelihood** plays an important role in the degree of vulnerability in a community and the process of recovery. The **repercussions and responses** are influenced by prevailing economic conditions. In the long run, future **expansions** are a consequence of enhanced economic conditions.

12.1 LIVE CASE STUDIES

12.1.1 BAKKHALI, WEST BENGAL

Figure 39 A View of Bakkhali Beach

Figure 40 Bakkhali, West Bengal, India (Source: Author)

12.1.1.1 Location

Bakkhali is a fishing village, in the jurisdiction of Namkhana Police Station, South 24 Paragnas district. Situated near the Frazergunj beach, it is popular for its fishing culture and as a popular weekend tourist destination, in the state of West Bengal, India. It is an example of a socio-culture, that has evolved in response to its climatic conditions – hot and humid climate, with frequent cyclonic disturbances. Situated next to Sunderbans, in the Southern periphery of West Bengal, bounded by Bay of Bengal on the south, it exhibits a topography consisting of long stretches of beaches, ancient sand dunes, mud flats, estuaries, sand flats and swamps of mangrove.

12.1.1.2 Climate

Due to proximity to the Bay of Bengal, Bakkhali has a maritime climate, with minimum temperature variations. A hot and humid climate climate persists, with an average wind speed of 6.1 knots. Summer season lasts from March util May, with a recorded maximum temperature of 42 degree Celsius and humidity of 52% in March and 80% in July. The area receives heavy rainfall between mid-June and mid-September.

12.1.1.3 Connectivity and Proximity to Infrastructure

Bakkhali is well connected to the capital city and other important cities through bus stops. The connectivity map shows its distance from various transit points. However, within the village, van rickshaw is the only mode of transport.

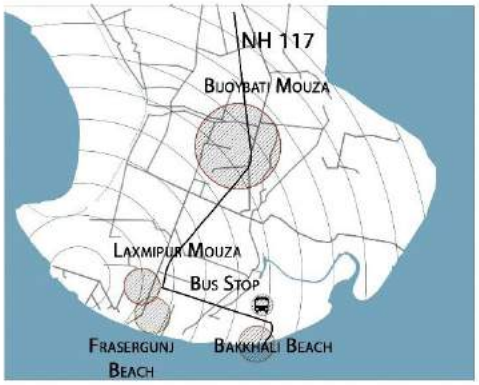


Figure 42 Connectivity Map, Bakkhali (Source: Author)

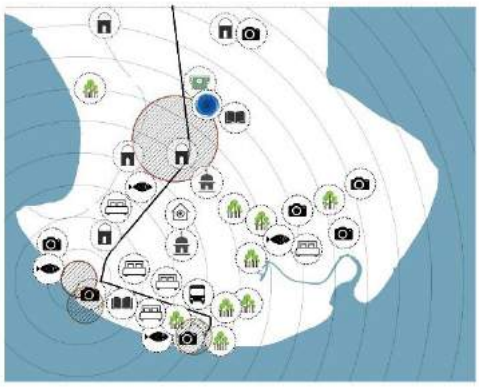


Figure 41 Proximity Map, Bakkhali (Source: Author)

Figure 43 Types of Structural Failures due to cyclone Bulbul (Source: Author)

12.1.1.4 Types of Failure During Cyclones

- **Heavy to very heavy damage** – major damage to structure and non-engineered buildings, along with uprooting of trees and other devastations.
- **Moderate damage** – damage of non-engineered structures beyond usable limit. Wall and roof connections were most vulnerable.
- **Minor damage –** damages to buildings where repair work can be done without vacating the houses. Minor adjustments were done temporarily.

12.1.1.5 4.1.5 Economic Resilience

- **Occupation** – Bakkhali is perceived to be a popular tourist destination, known for its budget hotel and weekend getaway. Apart from this, the village is popular for its fishing culture and agriculture. A *khoti* culture is established within this area, where migrant fishermen from inland areas and neighboring states of Orissa and Assam live in temporary settlements for the months of October to March for dry fish cultivation and processing.

- **Building Materials** consist of mud wall and thatch, bamboo, metal roofing and a few masonry structures.

Figure 44 Building Materials are local, making structure economically convenient (Source: Author)

12.1.1.6 Social Resilience

Figure 45 Social Nodes, and their Spatial Layouts (Source: Author)

12.1.1.7 Resilience through Preparedness Interventions

12.1.1.7.1 Preparedness

A **cyclone shelter** had been established in a Bijoybati Mouza, at a distance of 5 km from Bakkhali. The cyclone shelter was designed on a school ground, Bijoybatibati Parvartah FP School. An early warning system was established, that would notify the local administration about a cyclone,

Figure 46 Bijoybati Multipurpose Cyclone Shelter (Source: Author)

3-4 days in advance. The villagers would be evacuated to the cyclone shelter, which would have food inventory and power back up. Built at a height of 1.5 m from the ground level, the cyclone shelter was protected from floods.

12.1.1.7.2 Recovery

After a disaster, food would be supplied to the villagers for a week, through community initiatives. A tarpaulin would be provided to each family as damage compensation and temporary relief.

12.1.1.8 Impact on Community

Even though the intervention did not interfere with the community structure, and was aimed at increasing resilience of the community, certain practical difficulties were faced –

- 1.5 m height was stilted, leaving the building footprint on ground, inaccessible. This led to stagnation of water that was eventually responsible for the spread of water borne diseases and breeding of mosquitoes.
- The cyclone shelter lay dormant throughout the year, with limited access, as opposed to the ideal condition mentioned in NDMA guidelines, where a secondary function, such as school activities could be carried out
- The early warning system was often overlooked due to low risk perception within the community, leading to non evacuation of houses before a cyclone
- The recovery measure was not sufficient, as heavy losses and structural damage was incurred on the occasion of a cyclone, that led to economic and social stress, with safety and shelter of individuals threatened.

12.1.2 ORISSA DISASTER RECOVERY PROJECT, KESHPUR, GANJAM, ORISSA

Figure 47 View of the Housing Developement fromt the highway (Source: Author)

Figure 48 Ganjam district, Orissa (Source: Author)

12.1.2.1 Location

Keshpur is a fishing village in Orissa by Chilika Lake, in the Ganjam district, in Orissa, India. The Village, Keshpur, selected for the Study was under the jurisdiction of Behrampur Municipal Corporation. Cyclone Phailin devastated the non-engineered structures within the village, leaving hundreds homeless. Hence, the villagers were relocated to Keshpur, the present housing site. Located in a forest clearing abutting the highway, it is now home to 120 families.

12.1.2.2 Connectivity

Located abutting the highway, the housing project lies in proximity to the market area. However, accessing the market requires commute through the highway, increasing the number of accidents and reducing safety and health of individuals.

Figure 49 Infrastructure and Services at Keshpur (Source: Author)

Figure 50 Connectivity of the site (Source: Author)

12.1.2.3 Memory

A typical fishermen village (documenting Rambha) in the Ganjam District in Orissa, is characterized by linear development of infrastructure, with perpendicular streets serving as housing colonies. Social spaces are markets, temples and schools. Houses consist of joint family systems, with local building materials.

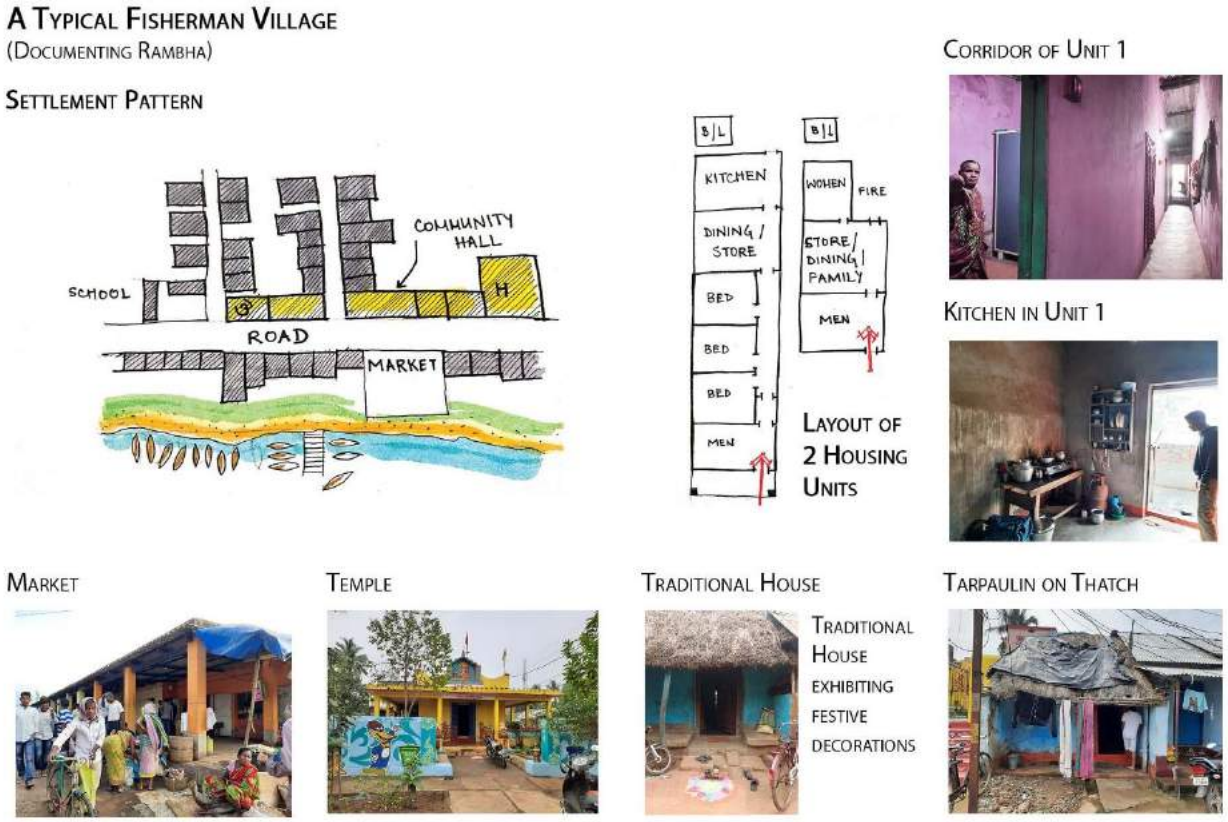


Figure 51 Data obtained through mental maps and photographic documentation (Source: Author)

12.1.2.4 Relocation Housing

An Owner Driven Construction of Houses (ODCH) initiative, every family (with an average household size of 5) received Rs. 3,24,000 for the consruction of their houses, along with a design sanctioned by the municipality. The resettlements were to be aided with the construction of a Community Hall and an Anganwadi. The Anganwadi, however, was not constructed. The housing project was a row house development. Each plot of land was 1000 sq ft, with 300 sq ft built up area, per family.

Infrastructure provided were – electricity supply, water supply, drainages. Internal and approach roads.

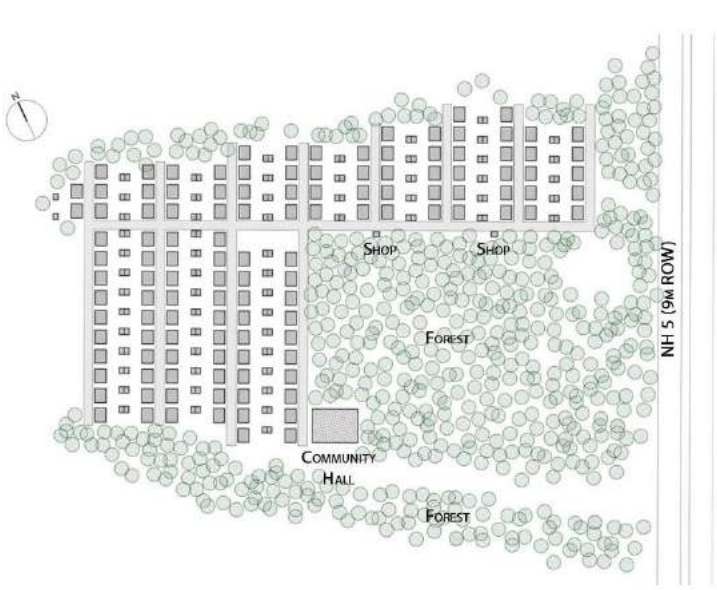


Figure 52 Site plan of Keshpur, ODRP Housing (Source: Author)

Figure 53 Images of ODRP Housing Units (Source: Author)

COST = 3,24,000 INR

INSTALLMENT	CONDITION	COST (IN INR)
1	SIGNING ARGREEMENT	20,000
2	CONSTRUCTION UPTO PLINTH	50,000
3	CONSTRUCTION UPTO ROOF	1,00,000
4	CASTING OF ROOF	50,000
5	REMOVAL OF CENTRING	50,000
6	AFTER COMPLETIONIN ALL RESPECT	30,000
7	LATRINE	24,000

Table 6 Cost components for ODRP, Orissa (Source: DPR, ODRP, Ganjam)

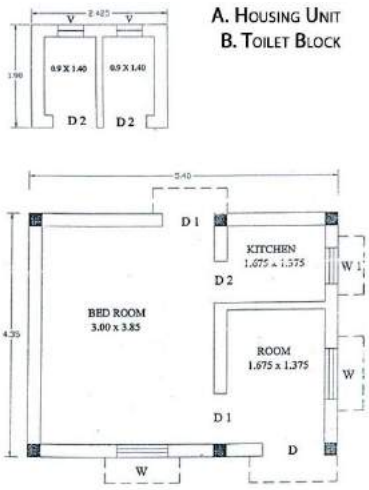


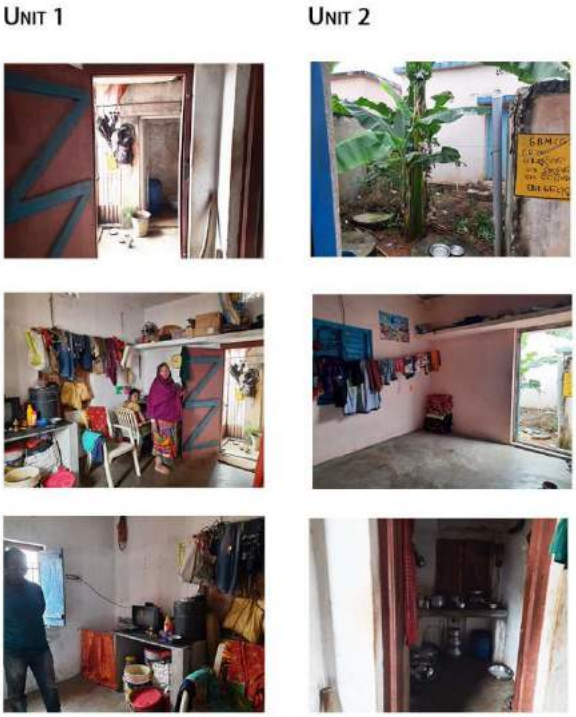
Figure 54 Technical Drawings of ODRP Housing (Source: OSDMA)

12.1.2.5 Adaptations

12.1.2.5.1 Community Level

Plinths of adjoining houses translated into social spaces for women. Ancillary streets were used by children to play, in general. Stalls for chai and other necessities were used as gathering spaces for men. Within the structure of formal layout, informality was taking shape in the form of shops and non-designated gathering spaces.

Figure 55 Photographic documentation of informal social spaces (Source: Author)



12.1.2.5.2 Unit Level

The maximum degree of adaptation was observed in the open space provided between the toilet block and the housing unit. One family used it as a backyard for washing and growing plants, while another family extended the covered area, to create a kitchen space. The units were used as a combination of kitchen, storage, sleeping area, study, and entertainment area.

Figure 56 Photographic documentation of Units (Source: Author)

12.1.2.6 Impact on Community

The housing project, with its planned layout and 'one size fits all' approach, disrupted the community structure of the villagers, proving to be detrimental to the resilience of the community.

12.1.2.6.1 Safety

- Being located in a forest clearing, the families are regularly attacked by wild boars and other animals. It is also located on an elephant trail, making it dangerous for the houses and individuals on the periphery.
- Located on a plot of land abutting the highway, the individuals have to access the nearest school, market and economic centre through the highway, increasing the number of accidents

12.1.2.6.2 Economic

- The livelihood of women has been hampered as they ancillary fishing activities that would be carried out in home premises has been lost, thus, sole economic dependence is on the men and their uncertain fishing productivity

12.1.2.6.3 Social

- Social structure and hierarchical self-governance within the community lies disturbed
- A disconnect from joint family system has resulted in loss of social and cultural connections

12.1.3 POONTHURA FISHING VILLAGE, KERALA

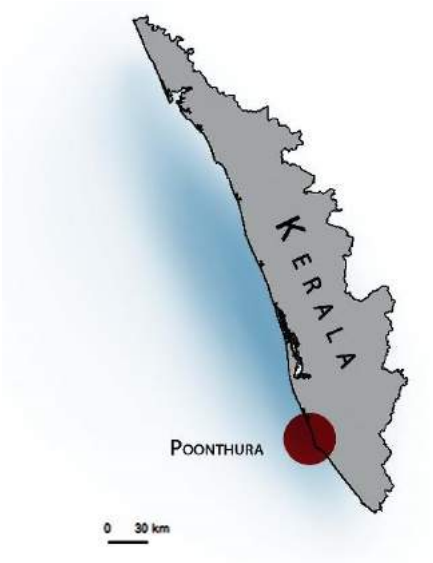


Figure 57 Poonthura, Kerala (Source: Author)

12.1.3.1 Location

A fishing village near the capital city, Thiruvananthapuram. It is a large settlement made up of a series of settlement clusters, predominantly comprising of tribal people whose main occupation is fishingThe people of the village are from various religious backgrounds, who have settled in communal groups. However, it has a majority of Christian population and, hence, has received a lot of welfare aid form the Christian missionaries.

It is situated near the coast, with a series of backwaters cutting across the housing clusters. Frequent storms in the area, along with receding sea shore, would leave many villagers homeless. The housing project aimed at relocated these fishermen to safer areas, at a short distance from their settlement.

12.1.3.2 Connectivity and Infrastructure

The fishing village is well connected to a market area, with infrastructure like school, community hall, medical office and fish storage plants. The St. Thomas Church is considered to be a major landmark in the area.

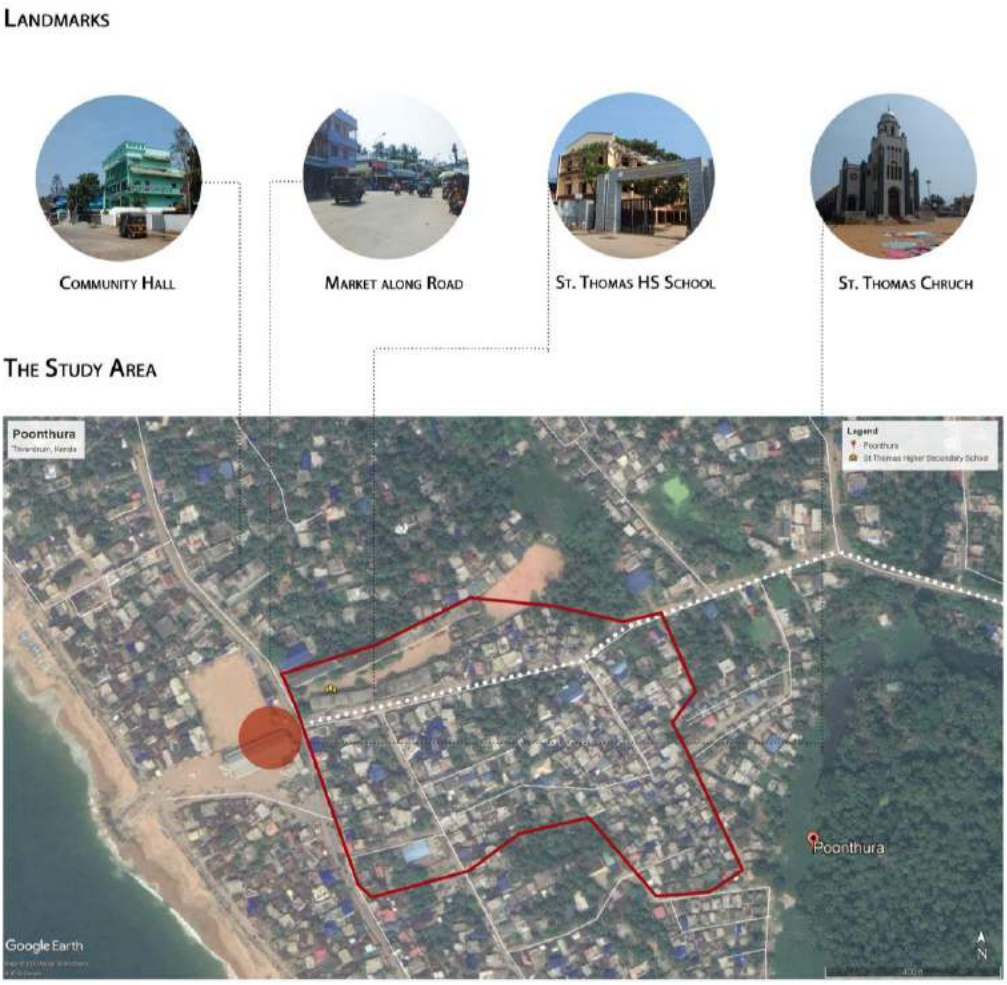


Figure 58 Connectivity and landmarks (Source: Author)

12.1.3.3 Memory

Being a tribal society, the people are by nature insular and had a well-defined family and caste organization. Construction of housing is considered to be a community activity and, hence, the mediation of an outside architect is very difficult. Moreover, the difficult environment in which the tribal people live and the limitations of their resources has led to a long-term neglect of development activities in this area.

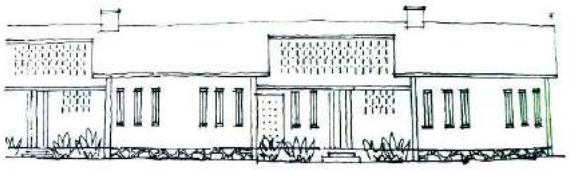


Figure 59 Elevation (Source: Laurie Baker Center)

12.1.3.4 Relocation Housing

The creation of courtyards adjoining every property, in a staggered row, acted as wind catchers, shielding the houses in case of storms. Continuous lattice work on the façade protected the interior.

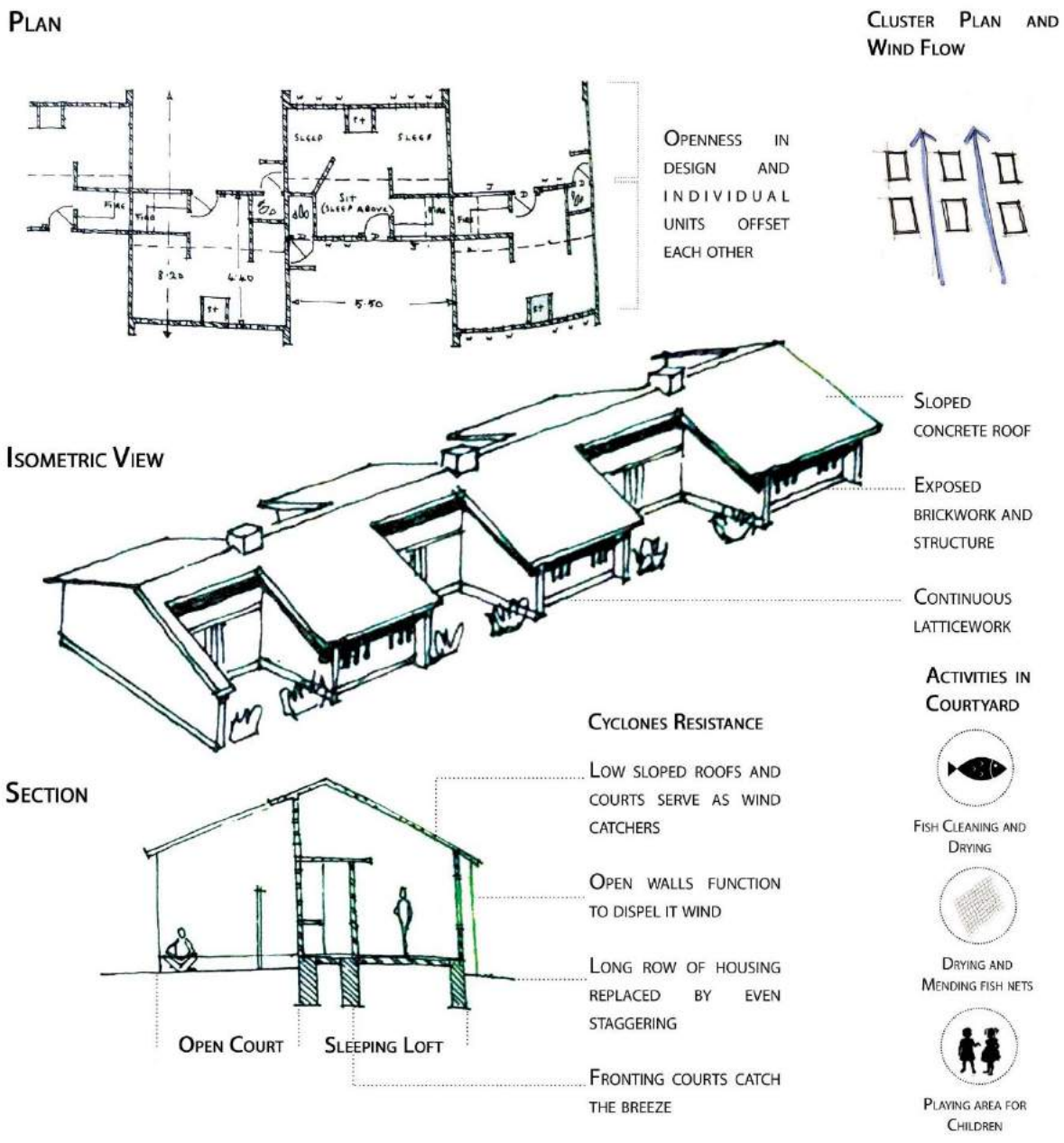


Figure 60 Presentation drawings and concepts (Source: Laurie Baker Center and Author)

12.1.3.5 Adaptations

Documenting almost 40 years after the construction of the houses, the adaptations and evolution that took place after occupancy were mainly documented in the survey.

12.1.3.5.1 Evolution of Settlement

In the absence of infrastructure, the villagers would return to their original lands, construct temporary houses and reside. They would move back into these houses only during monsoons. However, as accessible, infrastructure and services on the site was facilitated, the settlement

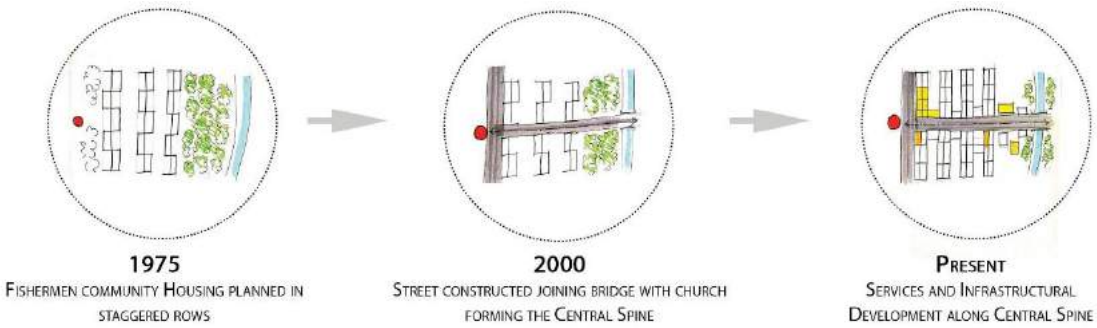


Figure 61 Evolution of Settlement, Poonthura (Source: Author)

thrived.

12.1.3.5.2 Evolution of Housing Units

The housing units went through incremental vertical and horizontal expansion, as the design facilitated incrementality and provided opportunity for growth.

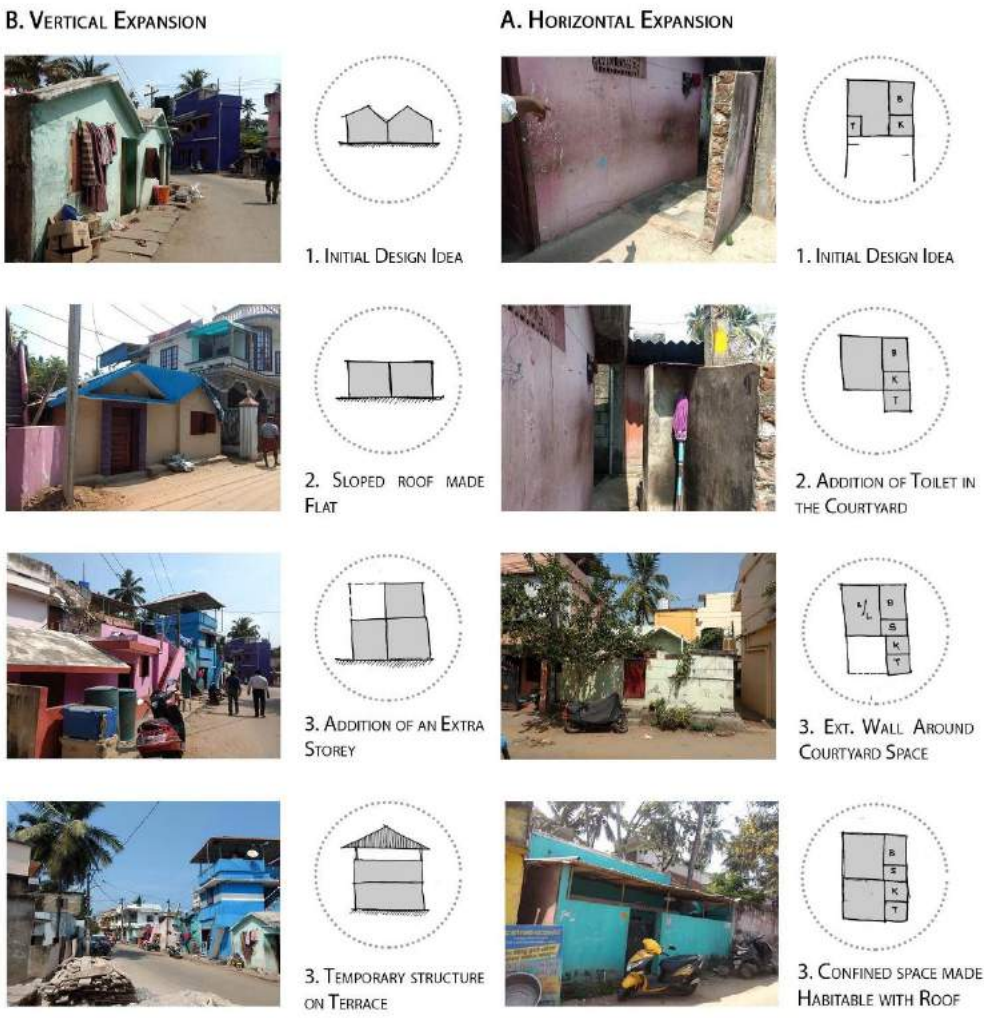


Figure 62 Spatial adaptations in Poonthura (Source: Author)

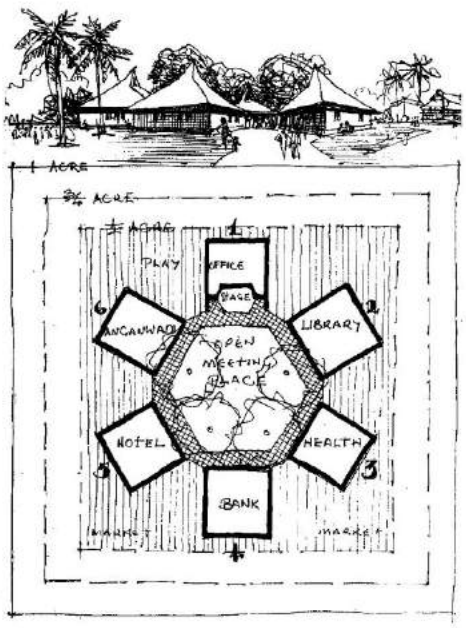


Figure 63 Half Acre Plot Community Space (Source: Laurie Baker Center)

12.1.3.6 Experimental Design

The design of the houses was experimental in nature and lacked the necessary infrastructure required for a community to thrive. Due to this, the housing proposal was initially rejected by the fishermen community.

12.1.3.6.1 Half Acre Plot

The architect, Laurie Baker, promoted the idea of a community space, where on half an acre plot, basic essential infrastructure like school, *anganwadi,* library, hotel, bank, office, a cultural open space and a health care facility could be located.

12.1.3.7 Impact on Community

Even though the scheme was initially rejected by the villagers, the gradual introduction of infrastructure, services and accessibility through road construction, helped the community thrive.

- The design of the plots provided opportunity for incremental growth.
- Use of construction practices known to the local fishermen allowed easy expansion of the houses
- Spaces for gathering and informality emerged, increasing social resilience and forming hubs for economic opportunity
- The development of the houses were observed to be linear with the development of the road, along the progressive development of facilities like play schools, workshops and shops.

12.1.4 **ANALYSIS AND INFERENCES**

12.1.4.1 Evolutionary Resilience

The rural settlements, over the years have evolved as a part of socio-ecological systems, inextricably interdependent. is concept, resilience is always in a state of transformation, constantly

responding to the natural processes, and is imperative to the understanding of how society responds to volatility and unpredictability. (Jon, 2019)

However, with the advent of climate change, natural systems have become increasingly volatile and unpredictable. An increase in frequency and intensity of natural hazards have been observed. This has affected the ability of human beings to cope with, adapt to and transform. Ultimately, leading to the need for external interventions.

Some of the parameters that are evident in the process of self-organization are discussed below -

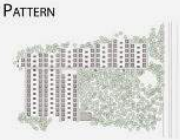
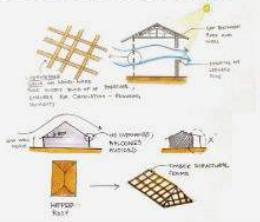
Case Study	Bakkhali	Poonthura, Kerala	ODRP, Orissa	Inferences
Relevance	1. Local Context 2. Climate Adaptation 3. Cyclone Resistance	1. Vocational Need Incorporation in Housing 2. Cyclone Resilience 3. Factors of Expansion	1. Impact of Rehabilitation on the social and cultural dimensions of a community	
Project Typology	Traditional Village	Community Housing Redevelopment	Community Housing Reconstruction	
Disaster	Cyclone, Storm Surges, Coastal Erosion	Cyclone, Receding Sea Shore	Cyclones	
		Environmental | Safety | Preparedness		
Settlement Pattern	Linear Pattern Predominant  Linear pattern along the road, Scattered settlements in the interior	Staggered Rows 	Linear Pattern 	Tendency of settlements to develop linearly along abutting road and organically inwards
Vegetation and Cluster Planning	Wind Breaks  Trees acting as wind breaks, preventing funnel effect	Funnel Effect  In the absence of vegetation, cluster planned to allow wind to pass without hindrance		Vegetation used to channelize or block wind flow as a measure of cyclone resilience
Building Techniques	a. Permeable Walls b. Regular Shapes, No Overhangs 	Continuous lattice work: to let winds pass without hindrance Open walls: to dispel the force of winds 	a. RCC Columns b. Masonry Walls for structural stability against cyclones 	1. Techniques and Materials familiar to community are better accepted and implemented 2. Structural stability through securing corners of a reular shaped plan
Services	Water Supply: Community Tube Wells	Water Supply: Piped Water Supply Drainage: Covered Drains to river, causing Clogging of the River	Water Supply: Piped Water Supply from OHT Drainage: Covered Drains to Chilika	Water Supply and Drainage of primary importance while settlement planning. Presence of electricity in all.

Table 7 Comparative Analysis of Economic, Safety and Preparedness (Source: Author)

12.1.5 **4.4.2 Economic and Social Resilience**

Economic Resilience refers to the ability to sustain economy, either through stability or transformation, according to circumstances. The economy of individuals aids in the stage of recovery in the disaster management cycle. Expansions through incrementality is a factor governed by economy.

Social Resilience refers to the ability of the system to persist through adaptation of social structures. In housing projects, often, a discontinuity of social frameworks leads to reorganization and transformation of community structures.

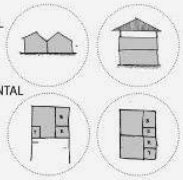
	Economic | Esteem | Recovery			
Repurcussions and Response	Greater intensity and frequency of cyclones causing widespread destruction, demanding better resilience.	Initial rejection of Housing Redevelopment provided due to lack of community infrastructure	Rehabilitation posing threat to safety and loss of livelihood due to its location. Socio-cultural disruption.	Presence of amenities, degree of convinience, mental maps and safety decide acceptance of a rehabilitation
Predominant Livelihood Patterns	Fishing and related activities a. Fishing b. Fish Drying 	Fishing and related activities a. Ice Plant b. Fishing boats 	a. Fishing b. Boat Making 	Fisherman communities, having a rigourous lifestyle exhibit high linkage between social, economic and housing spaces
Expansion	Horizontal single storeyed expansion predominant in the form of standalone additions forming clusters 	a. Vertical b. Horizontal 	Horizontal expansion in the form of confinement of open spaces for utilitarian purposes 	Horizontal expansion prevalent, with a pattern of temporary confinement followed by permanent expansion

Table 8 Comparative Analysis of Economic Resilience, Esteem and Recovery (Source: Author)

	Social | Belongingness | Response			
Social Nodes	Religious; Fishing Activities; Market 	a. Markets Places for Community; b. Religious structures like Church 	a. Women: Plinths of houses; b. Men: Shops and Tapris 	Economic spaces, Religious spaces, Infrastructure and spaces for collection of water serve as primary Social Spaces
Infrastructure	a. School b. Cyclone Shelter 	a. Community Hall b. School c. Health Facility d. Anganwadi 	a. Community Centre b. School in the vicinity 	Infrastructure acts as anchor points for settlement development and help in acceptance of rehabilitation housings
Memory	Traditional House Layouts 	a. Built open relationship - open space used for storage and mending of nets and catch b. Living in close proximity to the Sea - Interlinking of vocation with housing 	a. Joint family system b. Markets as social and economic anchors c. Festivals and Culture 	The embodiment of memory within a housing project determines the degree of acceptance and user changes
Discontinuity		Rehabilitation Plan 	Rehabilitation Plan 	Allowing sufficient space for user changes, expansion, embodiment of memory and livelihood within housing.

Table 9 Comparative Analysis of Social Resilience, Belongingness and Response

12.2 LITERATURE CASE STUDIES

12.2.1 THE GRAMEEN BANK PROJECT, BANGLADESH

The Grameen Bank in Bangladesh was started in 1976 by Mohammed Yunus of Chittagong University, in Jobra Village. The aim was to provide credit to rural landless poor for income generating activities at low interest – 16% without requiring collateral. The organization was established as an independent bank in 1983. Out of 16 decisions taken by rural co-operatives, two that led to the establishment of The Grameen Bank Housing Project in 1984, were –

Decision 3 – We shall not live in dilapidated houses. We shall repair our homes and work towards constructing new houses at the earliest.

Decision 9 – We shall build and use pit-latrines

The aim was to provide loans for cyclone resistant housing with durable roof for protection against rains and floods. The houses can be developed to suit local context and available resources. The target users of the program were landless rural poor of Bangladesh, due to their vulnerability to disasters. The priority for receiving the financial assistance were –

1. Landless, homeless, and complete have-nots
2. Landless, having les than 0.5-acre land
3. Female loanees and women having no earning male members

12.2.1.1 The Response

As per the survey of 116 house loan borrowers in Tangail, Dhaka and Rangpur Zones by Bangladesh Institute of Development Studies. The major responses were –

1. Protection from cyclone and rain
2. Better security of belongings
3. Decreased intensity of diseases owing to unhealthy living conditions
4. This led to better quality of work
5. Increase in social dignity of the house owners
6. Increased capability for mental stress, increasing resilience

12.2.1.2 Reduction of Disaster Vulnerability

The model for reduction of disaster vulnerability is by poverty alleviation through economic generation through micro credit system. This increases the economic capacity for the poor to take loans for housing, thereby increasing resilience. The cost of a housing unit was estimate at 10,000TK (Rs. 3,00,000 approximately). Two standard housing models were available – a basic housing model and a standard housing model, marked by an area limited to greater than 20 sq. m. respectively.

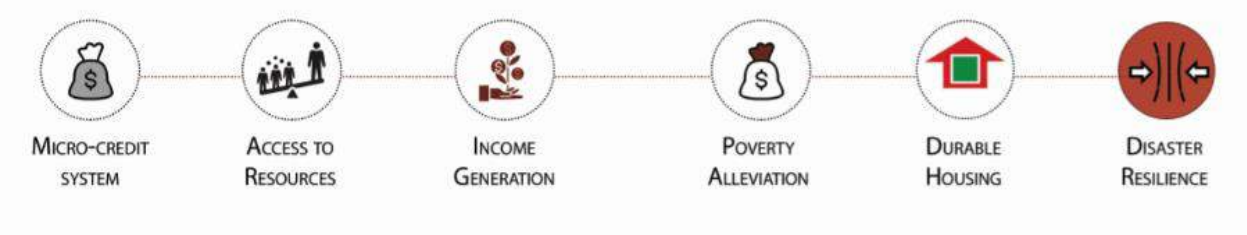


Figure 64 Process of Disaster Vulnerability (Source: Author)

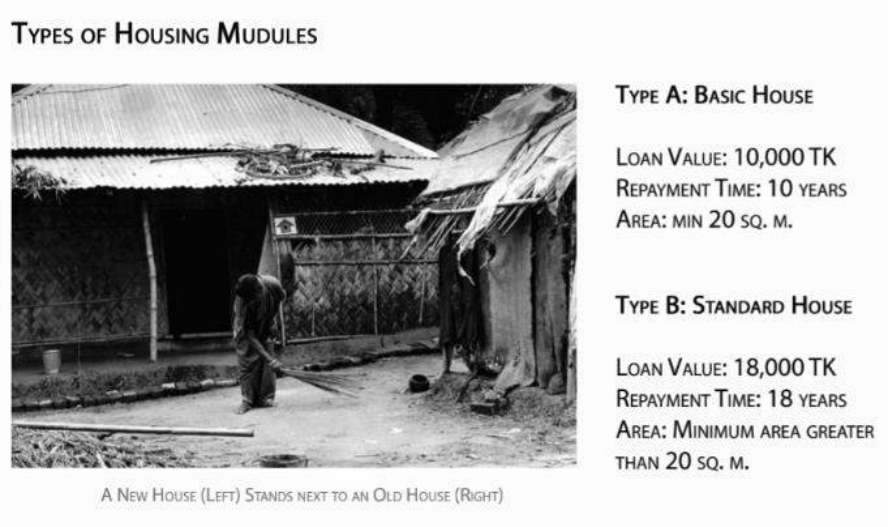


Figure 65 Housing Modules Proposed (Source: Author)

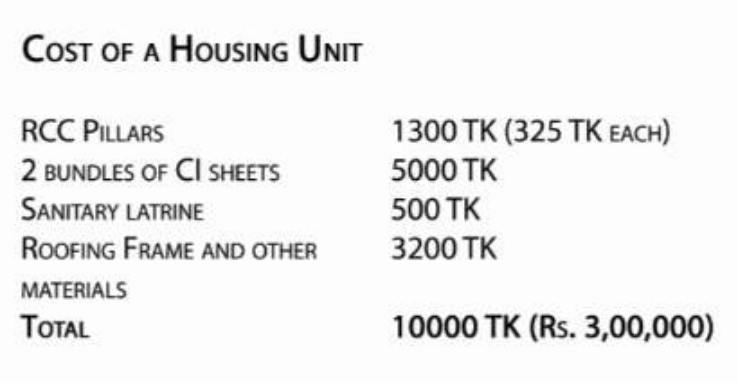
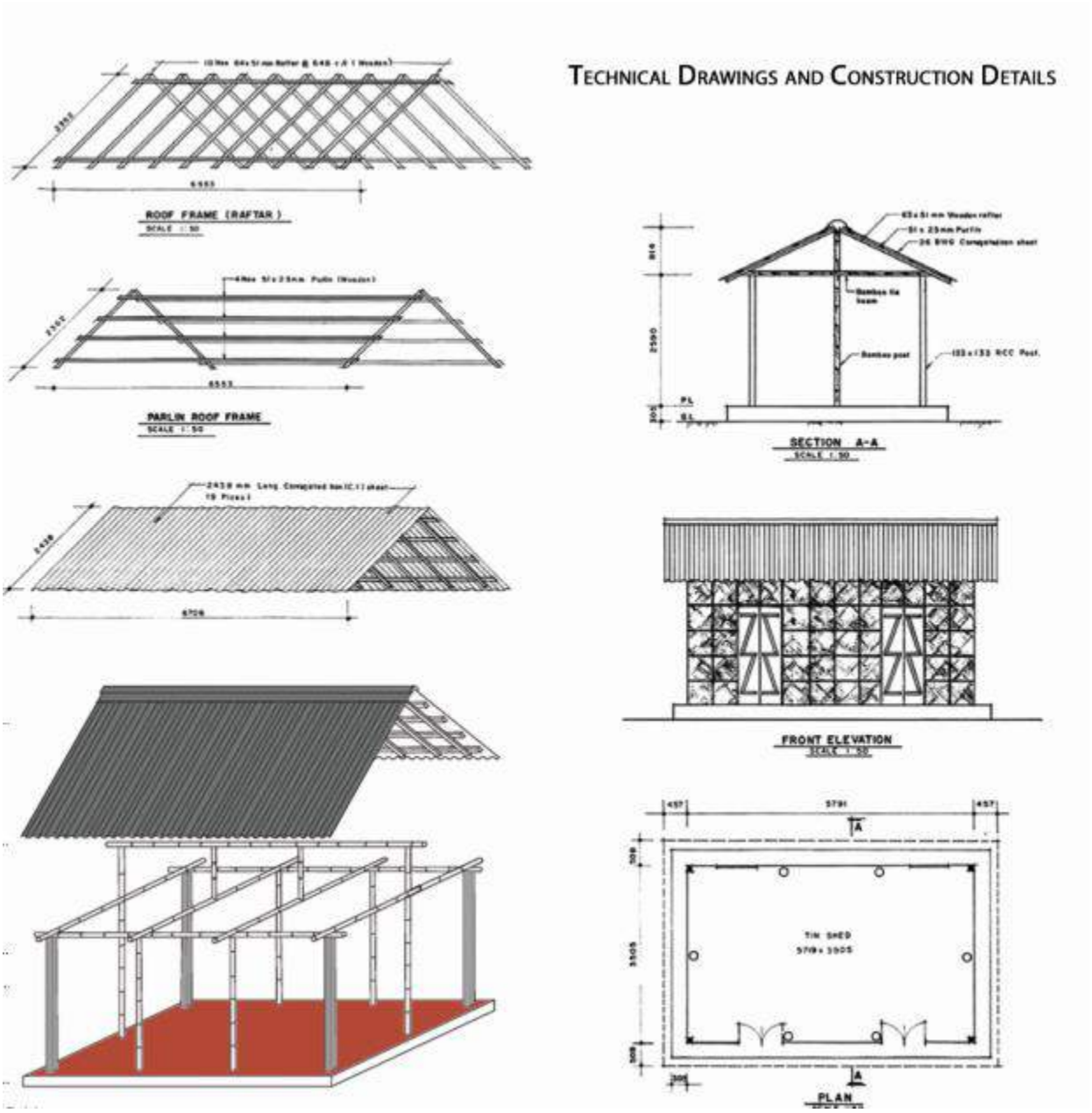


Figure 66 Costing for the Houses (Source: Aga Khan Foundation)

12.2.1.3 Structural Considerations

The construction of the houses proposed by the Grameen bank foundation were based on strengthening the structural frameworks to allow the buildings to withstand the wind load and protect the floors from [the impact of flooding. The corners were reinforced with concrete pillars, with intermediate pillars of local materials. The roof was made of corrugated iron sheets. Gable or hip roofs were suggested roof typologies to made them efficient during cyclones. There was

provision for latrines, implicating emphasis on sanitation to improving the standard of living and prevent diseases. The material of the plinth could vary. The houses were mainly owner driven constructions, allowing them to be adapted to the needs and choices of the inhabitants of the houses.



The Construction Process

Laying of Plinth

Construction steps

Basic Plot: Concrete Slab Foundation and RCC Columns

Roofing of Bamboo

Completed House, Aluminium

Components of the Housing

Pit Latrine Units

Construction of plinth

Reed Walls Infill

Window with rush siding reinforced with bamboo

Completed House, Bamboo.

12.2.2 **Post Tsunami housing in Muslim Fishing Village, Kirinda**

Figure 67 Site Location, Sri Lanka (Source: Author)

The housing project provides 100 houses in a Muslim fishing village in the region of Tissamaharama, on the south-east coast of Sri Lanka. Following the destruction caused by the 2004 tsunami. Shigeru Ban's aim was to adapt the houses to their climate, to use local labour and materials to bring profit to the region, and to respond to the villagers' own requirements through direct consultation. For example, kitchens and bathrooms are included within each house, as requested by the villagers, but a central covered area separates them from the living accommodation, as stipulated by the government. The covered area also provides an entertainment space from which women can retreat to maintain privacy. Local rubber-tree wood was used for partitions and fittings, and compressed earth blocks for walls.

12.2.3 **Objectives**

1. To adapt the Houses to the Climate of the Region
2. To employ local labour and use local materials to generate economy
3. To respond to requirements through direct consultation

Figure 68 Impact of the Development (Source: Archdaily)

Figure 69 Site Planning of Kirinda (Source: In-Habitat)

12.2.3.1 Planning of the Units

A conservative Muslim community, the privacy of the homes was of utmost importance while planning the units. The building norms required separation of the kitchen and toilets from the living quarters while the community preferred integration of the same for the purpose of privacy. This was solved by the addition of a covered courtyard that acted as family spaces but could be separated from the household through partitions. The area may be used for eating, socializing, net mending and other activities.

12.2.3.2 Issues faced post occupancy

1. Louvred clerestory leading to excessive dust accumulation in the interiors
2. Louvred clerestory is often blocked to maintain the interiors clean
3. Lack of Privacy of women as bathroom and kitchen are separated by courtyard, in case there are guests
4. Visibility of Open Courts in Linear Arrangement of Houses
5. Blocking of Ventilation and Sources of Light leading to dark rooms, with odour from the toilet and kitchen

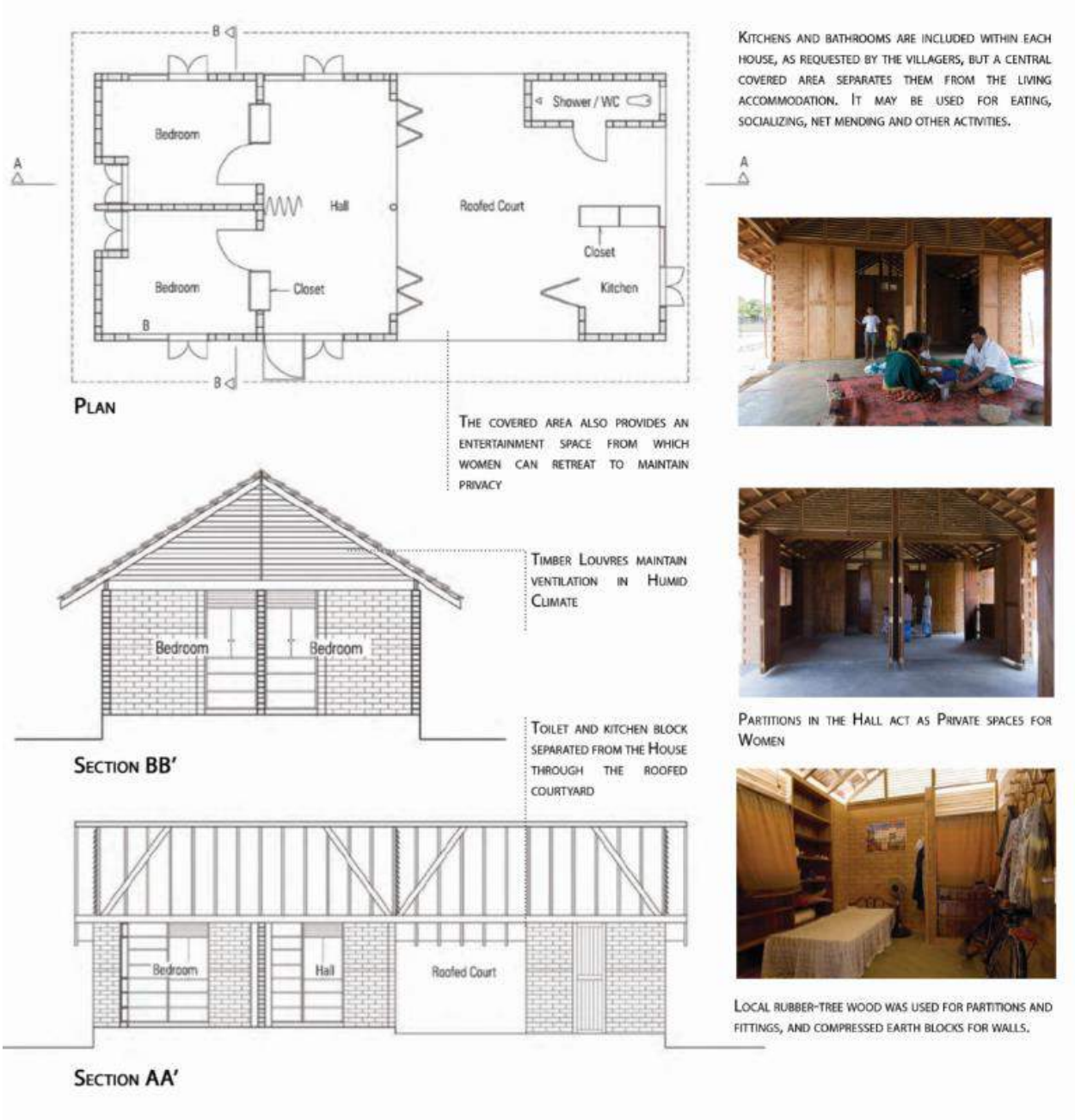


Figure 70 Technical Drawings of Kirinda Housing (Source: Adapted from In-Habitat)

12.2.4 **INFERENCES**

Structural inferences were drawn from the project at Bangladesh, where a framework, protecting the critical points were proposed, while providing ample opportunity for adaptation to local materials. Incrementality was catered to through the use of local materials and simplicity of design, accommodating progress in the society.

Through the case study at Kirinda, inferences regarding the sensitive design of community spaces and houses, for fishermen were derived. The use of materials and spatial morphology informed and designed with participation of the local fishermen. Multifunctionality and flexibility were important components of the design which allowed the economy of the project to be reasonable, while providing spaces for community usage.

12.2.4.1 ENVIRONEMNTAL PROTECTION

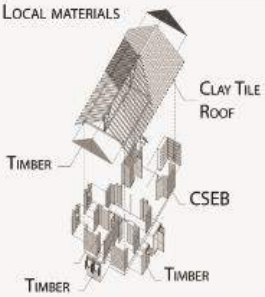
CASE STUDY	BANGLADESH	KIRINDA, SRI LANKA	INFERENCES
RELEVANCE	1. STRUCTURE OF HOUSES 2. DRR THROUGH ECONOMIC AND HABITAT SECURITY	1. MATERIALS AND TECHNOLOGY 2. REVITALIZE SOCIAL AND CULTURAL ASPECTS OF A SOCIETY	
PROJECT TYPOLOGY	STRUCTURAL DESIGN	POST DISASTER REDEVELOPEMENT	
DISASTER	CYCLONES, FLOOD, TROPICAL STORMS	TSUNAMI, CYCLONES, STORM SURGES	
SETTLEMENT PATTERN		LINEAR PATTERN PREDOMINANT  LINEAR PATTERN ALONG THE ROAD, SCATTERED SETTLEMENTS IN THE INTERIOR	TENDENCY OF SETTLEMENTS TO DEVELOP LINEARLY ALONG ABUTTING ROAD AND ORGANICALLY INWARDS
VEGETATION AND CLUSTER PLANNING		BIO-SHIELD  150 M BUFFER VEGETATION AND STRATEGIC PLANTATION OF TREES AS BIO-SHIELD	VEGETATION USED TO CHANNELIZE OR BLOCK WIND FLOW AS A MEASURE OF CYCLONE RESILIENCE
BUILDING TECHNIQUES	A. CI ROOF SHEET B. CONCRETE COLUMNS C. PLINTH 	LOCAL MATERIALS 	1. TECHNIQUES AND MATERIALS FAMILIAR TO COMMUNITY ARE BETTER ACCEPTED AND IMPLEMENTED 2. STRUCTURAL STABILITY THROUGH SECURING CORNERS OF A REULAR SHAPED PLAN
SERVICES		DRAINAGE: DRAINAGE REARRANGED ACCORDING TO TOPOGRAPHY	WATER SUPPLY AND DRAINAGE OF PRIMARY IMPORTANCE WHILE SETTLEMENT PLANNING. PRESENCE OF ELECTRICITY IN ALL.

Table 10 Comparison of Environmental Protection (Source: Author)

12.2.4.2 SOCIAL DEVELOPMENT

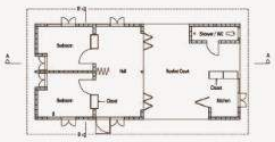
Social Nodes		A. Women: Courtyards of Houses; B. Men: Mosque and Market 	Economic spaces, Religious spaces, Infrastructure and spaces for collection of water serve as primary Social Spaces
Infrastructure	Funding and Construction of Educational Pre Schools		Infrastructure acts as anchor points for settlement development and help in acceptance of rehabilitation housings
Memory	A. Clustered pattern B. Thatched Houses with Mud or straw walls C. Close proximity to ponds and agricultural fields as economic generators 	A. Thatched Houses with Mud or straw walls B. Proximity to religious nodes C. Vegetation of consisting of Coconut trees 	The embodiment of memory within a housing project determines the degree of acceptance and user changes
Discontinuity	Not Apparent. Continuity maintained through materiality, function and spatial morphology. 	Rehabilitation Plan 	Allowing sufficient space for user changes, expansion, embodiment of memory and livelihood within housing.

Table 11 Comparison of Social Development (Source: Author)

12.2.4.3 ECONOMIC DEVELOPMENT

	Bangladesh	Kirinda	Inferences
Repurcussions and Response	Rehabilitation exhibiting a positive impact on society with respect to disaster resilience and economic conditions.	Immediate relief in post disaster scenario. Issues related privacy and leading to blocking of courtyard and poor ventilation.	Presence of amenities, degree of convinience, mental maps and safety decide acceptance of a rehabilitation
Predominant Livelihood Patterns	Miscellaneous	Fishing and related activities	Fisherman communities, having a rigourous lifestyle exhibit high linkage between social, economic and housing spaces
Expansion			Horizontal expansion prevalent, with a pattern of temporary confinement followed by permanent expansion

Table 12 Comparison of Economic Development (Source: Author)

12.3 OUTCOMES

Local communities evolve through the process of trial and error across various time and scales, while being embedded into the socio-ecological systems. The interaction of processes and structure lead to the development of the system, which is dynamic. The inherent reorganization leads to resilience, that can be translated a sa community's ability to cope with, adapt to and sometimes, cross over thresholds to allow transformation.

However, with radiative forcing superseding estimated forcing, natural systems are changing at an unforeseen pace. For this, external interventions are required to help communities persist, enhance resilience, and ultimately progress. Aspects critical for the development of resilience within communities are –

- **Memory**
- **Future aspirations**
- **Infrastructure**
- **Economic generator**

12.3.1.1 MEMORY

Memory is the knowledge and experience acquired and accumulated through generations of trial and error, to persist and absorb stresses. Resilience persists and reestablishes itself through **collective memory** of a community – the entity involved in **regeneration and reorganization** to accommodate sustenance during disturbances. It provides a **link between the past and the present**, which, if disrupted, may lead to collapse of the social, psychological and economic structure of the given community.

12.3.1.2 FUTURE ASPIRATIONS

The progress of a community is rooted in their aspirations to survive, sustain and thrive. **Adaptability, flexibility and continuity** are essential design parameters to accommodate the future aspirations of a community. Through economic upliftment, a community aims **at better quality of life and social standing**. The housing or redevelopment of a community through provision of infrastructure, services and living quarters that symbolically or physically represent prosperity and upliftment, are accepted by communities. However, **generalization and imposition of altered way of life needs to be avoided**.

12.3.1.3 INFRASTRUCTURE

Infrastructure such as **school, *anganwadi*, health care, financial institutions** and **economic** opportunities, and basic services like **electricity, water supply, sanitation and waste disposal** provide a baseline for the development and resilience of a community. **Shared infrastructure** lead to efficient utilization of resources.

12.3.1.4 ECONOMIC GENERATOR

An important aspect of resilience, **economic generator and economic diversification** is a possible solution o resilience, that aids in absorption, recovery or adaptation after a disturbance. A single mechanism often does not guarantee resilience. Hence, uncertainties are catered to by redundancy and diversification. An economically stable community is better equipped in terms or access to resources, representation and economic capacity.

12.44.5 INTERRELATIONSHIP BETWEEN DESIGN PARAMETERS

As observed from the study, while designing housing programs, a sensitive approach **to understand prevalent the social, economic and ecological dynamics of a community** makes it easier for communities to accept the resettlements. A further investigation into the issues faced by the community leads to integration of developmental strategies within existing community structures. However, it is important **to weave the interventions into the existing patterns**, to provide **continuity** between the past and the present. This prevents loss of identity within the community and leads to better acceptance of living quarters, which are otherwise, mostly abandoned.

12.4.1 ENVIRONMENTAL RESILIENCE

Traditional communities live in harmony with the ecological system, where adaptation to environmental factors forms the backbone of resilience. The settlement patterns, clustering of buildings and strategic positioning of building, with respect to natural vegetation and landform forms the **first layer of environmental protection**. Building technology and spatial morphology is **molded by natural forces** such as climate, wind movement, raw material availability and contextual setting. The communities mostly evolve through advanced understanding of environmental forces. This forms an integral part of the **traditional knowledge system**. Predominantly, a **linear development** along roads enhance tunnel effect which is countered by **staggering of houses** within a cluster. Trees and wind breaks act **as wind breaks** while permeability minimizes wind pressure, influencing **circulation**.

12.4.2 SOCIAL RESILIENCE

The **social networks** in a community fosters **sharing of knowledge and cohesiveness** within a community. The response phase after a disaster is greatly augmented by these networks. However, external interventions often lead to disruption of such social networks due to limited understanding of social systems. While **social nodes and community infrastructure** form the basis of development of such networks, they also are indispensable in formation of **collective identity**. In traditional communities, the architecture of the community follows the **architectural language** of private dwellings. Forming a part **of continuity** for future generations, these nodes become symbols of **aspirations and memory**.

12.4.3 **ECONOMIC RESILIENCE**

After a disaster, the **economic burden** on a community becomes of paramount importance. Forming the foundation **of recovery and reconstruction** efforts, they also symbolize aspirations **through incrementality and expansion**. Disruption of livelihood is one of the major consequences of a disaster. **For practice-based communities**, the **livelihood being heavily interlinked with the shelter**, interventions that are not context specific, often cause a disruption and collapse in economic structure.

The interdependence of the various factors analyzed to form a part of a wider system is discussed in the matrix below. The possible features that are dominated by the intersection of factrs are mentioned.

Figure 71 Interlinking of Design Parameters (Source: Author)

HOUSING

FISHERMAN VILLAGE HOUSING

	Area per unit	No of units per household	No of households		Total Area
Covered areas					
Resilient Unit - Multipurpose	23	1	80		1840
Incremental Additions					
Kitchen	10	1	80	1	800
Room	10	1	80	1	800
Other additions	Variable according to indicidual choices				
				Total	3440

Outdoor Spaces	Cluster Size	Area per cluster	No per cluster	Total number		Total Area
Shed	Varied	40	1	3		120
Washroom/ Toilet	4	8	1 or 2	30		240
Open Spaces	Varied according to design					
					Total	360

TRANSIENT COMMUNITY - FISH PROCESSORS

Housing Modules	18	1	150		2700
Open Spaces	As per plot requirements				
				Total	2700

TRANSIENT COMMUNITY - FISHERMEN

	Area per unit	No of units in a building	No of buildings		
External Unit	54	6	3		972
Room 1	9	2			18
Room 2	13	2			26
Common Space	9	1	12	3	10
				Total	54
Toilets	39	2	3		234
Entrance foyer	15	1	3		45
Store Room	15	1	3		45
Corridor	55	2	6		660
Shaded spaces	26	4	3		312
Terraces	26	4	3		312
Courtyard	79	1	3		237
				Total	2268
			Total Area for Housing		8800

Table 13 Area Program for Housing

CYCLONE SHELTER

Medical Centre Block

		Area per unit	No of units	Total
Floor 1				
	Entrance Lobby	35	1	35
	Clinic	13.5	1	13.5
	Store	10	1	10
	Examination	7.5	1	7.5
	Toilet 1	4.5	1	4.5
	Nurse Chamber	4	1	4
	Ward	14	1	14
	Toilet 2	3.5	1	3.5
	Staircase	10	1	10
	Circulation	5.5	1	5.5
				108
Floor 2				
	Room 1	10	1	10
	Room 2	14	1	14
	Kitchen	9.5	1	9.5
	Toilet	11	1	11
	Circulation	30	1	30
				74.5
Floor 3				
	Future Expansion			108
			Total	290.5

School Block

		Area per unit	No of units	Total
Floor 1				
	Primary Section	64	1	64
	Kitchen	30	1	30
	Store	15	1	15
	Circulation	36	1	36
				145
Floor 2				
	Administration	15	1	15
	Teachers' Room	15	1	15
	Classroom 1	24	1	24
	Library	54	1	54
	Circulation	60	1	60
				153
Floor 3				
	Classroom 2, 3, 4	15	3	45
	Classroom 5	20	1	20
	Circulation	45	1	45
				110
			Total	408

Community Block

		Area per unit	No of units	Total
Floor 1				
	Comminity Hall - Open	134	1	134
	Entrance Foyer	45	1	45
	Staircase	18	1	18
	Toilet	27	1	27
				224
Floor 2				
	Comminity Hall - Closed (Mid day meal)	155	1	155
	Toilet	27	1	27
				182
Floor 2				
	Workshops for School	92	1	92
	Store Room	14	1	14
	Toilet	27	1	27
				133
			Total	539

Covered spaces for circulation	**50**		
		Total Area for Cyclone Shelter	**1300**

Table 14 Area Program for Cyclone Shelter (Source: Author)

ANGANWADI	
	Area
Classroom	48
Kitchen	13.5
Store	20
Examination and Counselling	30
Training room	50
Toilet block	24
Toilet 2	10
Shed	17
Covered walkway	75
Angan	
	287.5
Total Area for Anganwadi	**300**

SHOPS	
Shop - closed	80
Shop - semi open	55
Total Area for Shops	**135**

TOTAL BUILT UP AREA	**10535**

Table 15 Area :program for Anganwadi and Shops

14 CONCEPT DEVELOPMENT

14.1 DISASTER RECOVERY

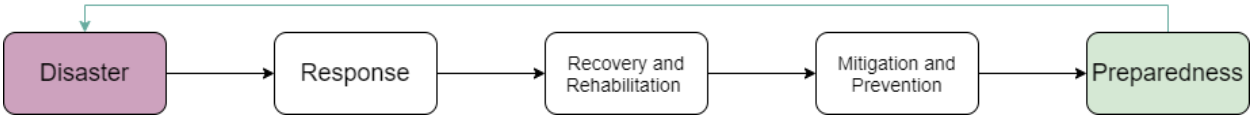


Figure 72 Disaster Management Cycle (Source: Author, adapted from UNFCCC)

The disaster recovery in after cyclone Amphan was planned according to the disaster management cycle, as proposed by United Nations.

14.1.1.1 Recovery

After the initial stabilization of population with external aid temporary measures that support sustenance of life through infrastructure, recovery takes place. There is no distinct time phase at which response changes into recovery. It is a gradual shift towards more **permanent and sustainable long-term solutions** that aim at restoring normalcy through housing and economy, thus reducing vulnerability.

14.1.1.2 Response

Response is the first step taken after disasters strike. It occurs at three levels – local, regional and global. It aims to aid **immediate support and maintain the basic physical and psychological needs of the affected population**. It serves to fill in the gap until permanent solutions are sought. It involves the strong association of humanitarian agencies for refugee transportation and provision of temporary shelter and resource inventory.

14.1.1.3 Preparedness

The planning of response to disasters can be termed as preparedness. They aim at achieving a readiness when for disasters by ensuring with technology and management through national level bodies. They enhance **response mechanisms** through rehearsals, warning systems, evacuation programs, short-term and long-term strategies, and resource inventories in case of national crisis.

14.2 DESIGN STRATEGIES TO COMBAT COVID-19

Designing for shelter and community spaces in a scenario that involves fighting a disease and at the same time, trying to carry on with life, as most of the communities in the lower strata live on a hand to mouth existence, depending on daily pay and heavy seasonal work. Thus, spaces need to be designed to accommodate human activities while maintaining hygiene and economy.

14.2.1 LIGHTWEIGHT AND FLEXIBLE ARCHITECTURE

Flexibility would allow transformability of the buildings in case of need, to compartmentalize and modify space to suit the community. Adjustable walls and screens in an open plan layout would allow maximum flexibility, while protecting the interior spaces from harsh weather condition and weather hazards. Buildings could easily be constructed for temporary usage, to accommodate the various functions, for example, medical hubs, isolation facilities, awareness campaigns, and more, as was evident from the recent developments surrounding the coronavirus disease.

14.2.2 REDUNDANCY AND MULTIFUNCTIONALITY

Flexibility of spaces was a significant factor in the design of the building components. The **public and mass residential buildings** were developed with **minimum permanent internal partitions**. Internal partitions were developed of local split bamboo walls, to facilitate easy flexibility to accommodate multifunctionality of spaces. Open spaces were open to **temporal usage** to keep the character of the village alive.

At the time of cyclones, the community building, through open plan, separated by flexible partitions and walls could be transformed into a cyclone shelter, to accommodate people, at the same time, to allow social distancing, the screens could be used to compartmentalize space to accommodate families.

14.2.3 WATERPOINTS

In the existing site, common toilets and sanitation facilities are provided away from the main access and pedestrian points. Provision of toilets and points for handwashing near the entrances of the buildings or near public spaces was an essential feature that was incorporated into the design to ensure hygiene. The common toilets are housed in a single unit for better maintenance of the structures and facilities.

14.2.4 OPEN AND SEMI OPEN SPACES

Major activities have been planned around open and semi open spaces to allow ample sunlight and wind circulation in the activity areas. Acting as hygiene and a natural disinfectant, natural light and wind is effective in killing germs and removing humidity and dampness from structures – the breeding grounds for diseases. Locating the open spaces in areas with proper natural drainage facilities, the stagnation of water at these points are also prevented, avoiding unhealthy circumstances.

14.3 SETTLEMENT PLANNING AND ARCHITECTURE

Established to protect the community from cyclones, the cyclone shelter shall be deemed as **a community asset**, translating into a **school and community building** during normalcy. It would also function as – **Medical Center, Market Spaces, Space for recreation, Space for economic activities, Extension to Vocational training center, Cultural activities, Weekly Market**. Hence it would act as a major social space for gathering within the community, facilitation **social integration and resilience**.

14.3.1 REVIVAL OF COASTAL FOREST

One of the major reasons for the widespread devastations were attributed to the **deforested coastal forests**, that failed to reduce wind velocity. Thus, they must be revived for **protection against cyclones and land stabilization**.

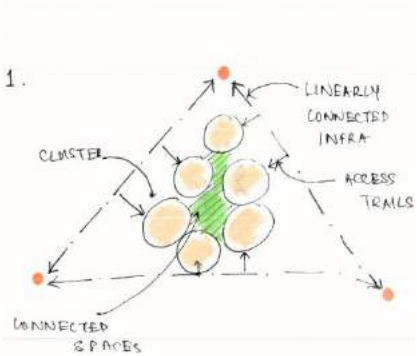


Figure 73 Settlement pattern (Source: Author)

14.3.2 SETTLEMENT PLANNING

Respecting the settlement pattern of the existing community, spatial patterns were derived and incorporated into the settlement planning. Some of the attributes include **linear linkage between infrastructure with introverted clusters connected through pedestrian trails**.

14.4 CLUSTER PLANNING

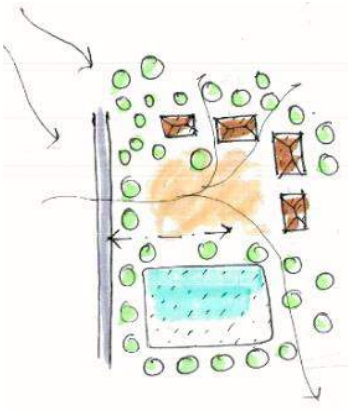


Figure 74 Cluster Analysis (Source: Author)

Various clusters within the existing community were analyzed to understand the spatial relationship between units in the clusters, typically inhabited by **joint families**.

14.4.1 UNIT DESIGN

After the initial emergency shelter, when the inhabitants of the village would return to their allotted plots, leaving behind the emergency shelter to be occupied by the transient community, every house, if provided with **one cyclone resilient unit**, would be able to **secure their assets and a basic shelter** after every cyclone, minimizing economic loss and trauma

14.4.2 STRUCTURAL INTERVENTION

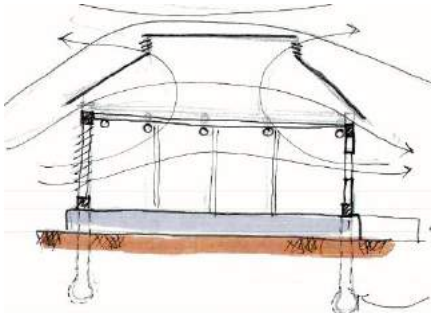


Figure 75 Structural Intervention (Source: Author)

Modular structures using wattle and daub panels, and split bamboo with Hogla leave panels – **local materials**, upgraded to add flexibility are proposed. The critical corners are reinforced with **steel I-sections,** to resist the wind loads. **Permeability** in the upper levels of the structures neutralize pressure and prevents overturning of the building or disintegration due to pressure differentials.

14.5 SERVICES

Water treatment and electricity through solar panels were introduced **to prevent pollution of ground water** due to seepage of grey water **and prevent power unreliability** due to frequent outages owing to storms, respectively.

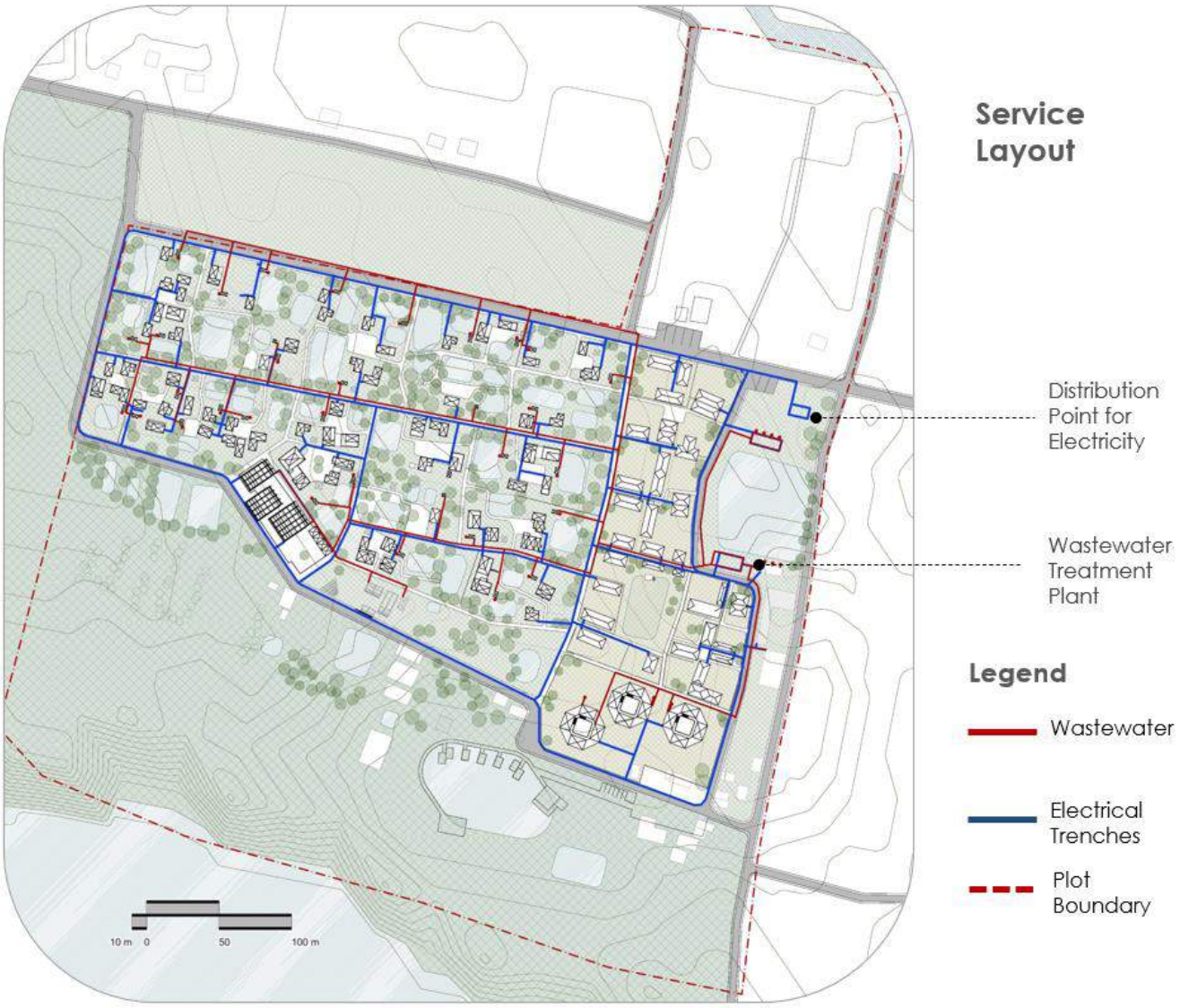


Figure 76 Proposed Service Layout on the Site (Source: Author)

14.5.1 **WASTEWATER MANAGEMENT**

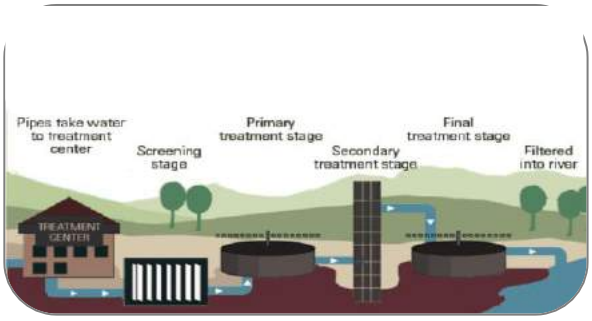


Figure 77 Grey Water Treatment Process (Source: Clean Water: Design of an efficient and feasible water treatment plant for rural South-Bengal)

The site faces the major issues of ground water pollution through seepage of grey and wastewater into the soil. A grey water treatment plant is proposed that would treat the grey water and discharge it into the ponds for aquaculture, which is ultimately connected to the tidal inlet abutting the site.

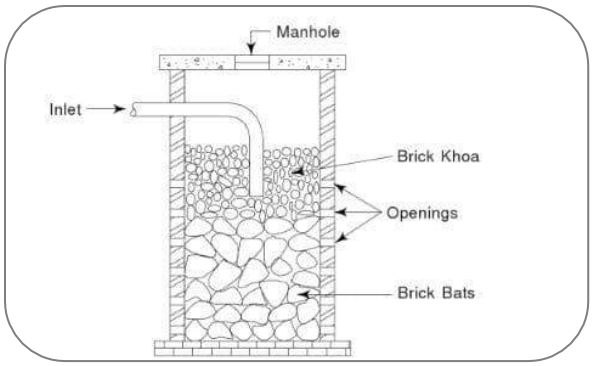


Figure 78 Soak Pit for Blackwater (source: The Constructor)

Soak pits for black water would allow the black water to seep into the ground, and later on, the solidified waste could be used as fertilizers on individual vegetable patches and community farming.

14.5.2 **SOLAR POWER**

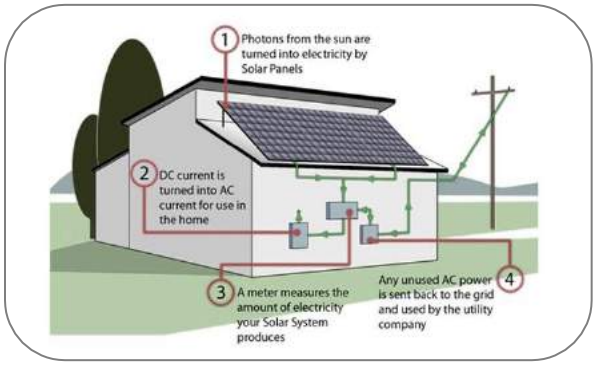


Figure 79 Solar Power Supply (Source: dynamicpowersystems.in)

The issue of frequent power outages and unreliability of the electricity due to snapping of overhead wires during cyclones is countered by provision of solar panels for individual houses, reducing the energy consumption per capita. The excess [power is fed into a central grid for power back up at the distribution point, to be used by individual houses in case of power failure. This increases the energy reliability in the community.

15 DESIGN DEVELOPMENT

The design concept initially began with the development of preparedness strategies within the site to make the community resilient to the frequently occurring cyclones and storms that would cause disrupt lives and livelihoods of the villagers. This would reduce their economic capacities, thus the capacity to adapt and recover from the losses suffered. Thus, the aim was to aid the society to be able to better cope with the natural disasters through built environment modification and intervention.

However, as Cyclone Amphan made landfall causing widespread devastation, decimating kuccha structures, and leaving many homeless, the layer of disaster recovery was added to the existing disaster preparedness measures.

15.1 EFFECT OF THE CYCLONE ON BUILT ENVIRONMENT

The open deforested coastal forests failed to reduce the velocity of the wind, making the area susceptible to the strong vortex winds, that were a characteristic feature of the cyclone. The structures made of RCC and brick masonry suffered minimum damage. However, the asbestos roofing sheets and plastic roofing material, due to their insufficient fixing and shape suffered heavy damage. The trees collapsed on structures, causing them to fail. The coconut trees and other varieties of palms suffered minimum damage. Most of the kuccha structures on the site were completely decimated. The roof and foundation connections were the major points of failure. Mud walls, due to lack of anchorage overturned while the roofs, being lightweight and not properly secured at the joineries, collapsed.

Majority of the structures on the site consisted of structures that were kuccha in nature, due to restrictions upon building the roofs of the residential housings with concrete slabs. The housing for the transient community too was devastated, leaving them to be rebuilt when the migrant fishermen reach the site. The poly houses - structures made fir fish drying and processing through organic methods, being made of ETFE and being lightweight collapsed.

Figure 80 Collapsed Kuccha House (Source: Photo obtained from village over electronic source)

Figure 81 Collapsed Kuccha House (Source: Photo obtained from village over electronic source)

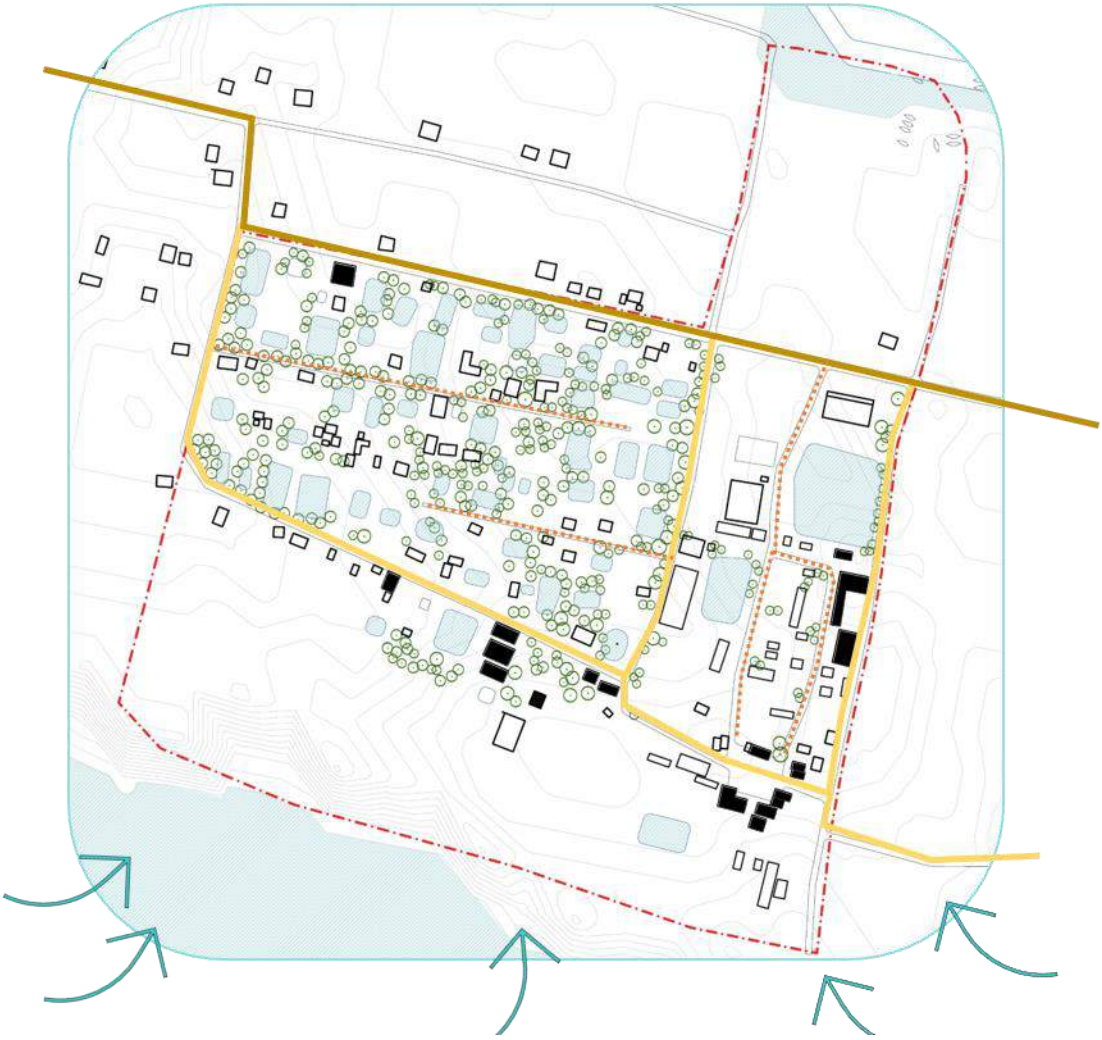


Figure 82 Existing buildings that suffered minimum damage on site (Source: Author)

15.2 PLANNING FOR DISASTER RECOVERY

The disaster recovery process was initiated to restore the lives of the community members to functioning, with space for progress. The planning was done to preserve the inherent qualities of the site. The character of the site was to be maintained to allow the community to better accommodate to the design interventions planned.

The road layout was maintained on the site. However, trails and pathways leading up to each plot was introduced using the existing layout as a blueprint, as according to the norms, a 1.8 m road must be provided as an access to each plot of land. The ponds on the site were preserved to leave the economy undisturbed. The existing trees were also preserved, on the site. The dominant vegetation consisted of beetle nut, coconut trees, bamboo groves and cashew nut trees. Fruit and flower bearing trees were also found in the settlement area.

The pucca structures on the site that were left undisturbed included mainly the Khoti office (established by Benfish), the Temple complexes – mainly the Shiva Temple and the Ganga Temple, the commercial shops including grocery, cloth store and chai and food stall. The prawn aquaculture and processing building set up by Benfish were also unaffected and were sought as shelter during the storm. The aquaculture building also consisted of a storage, residential facilities for staff and a *Mahila Samiti* Office.

The land area belonging to the transient community lay unoccupied by villagers at the time of landfall of the cyclone as the fishing season had not yet began. Moreover, owing to the coronavirus disease and the lockdown imposed, mobility to the site was maintained at minimum. Thus, a proposal to utilize the land for setting up temporary emergency shelters was made. The temporary shelters would be inhabited by the villagers whose homes had been decimated by the cyclone.

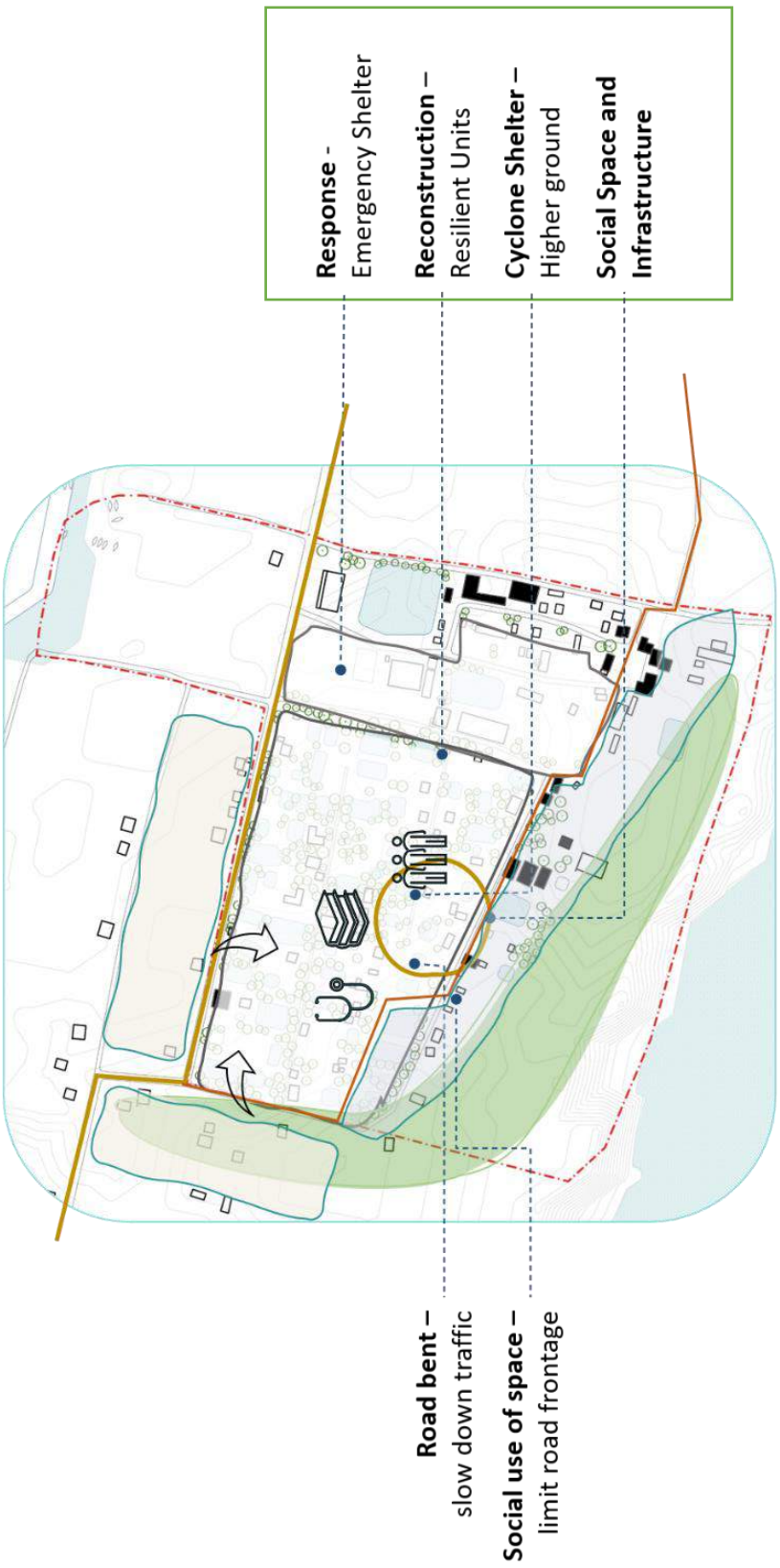


Figure 83 Disaster Recovery (Source: Author)

15.2.1 **RESPONSE – EMERGENCY SHELTER**

Aid from the government for shelters included provision of tarpaulin for covering the damaged areas, as a temporary measure. Emergency shelters could be set up from the bamboo members that were present on the site, as a remainder of the houses belonging to the temporary community. After the erection of the shelters, that require an average of three labors and one day to construct, as per the information collected through conversations on the site, they could be occupied till the original allotted plots of the villagers are cleaned and the basic shelter constructed.

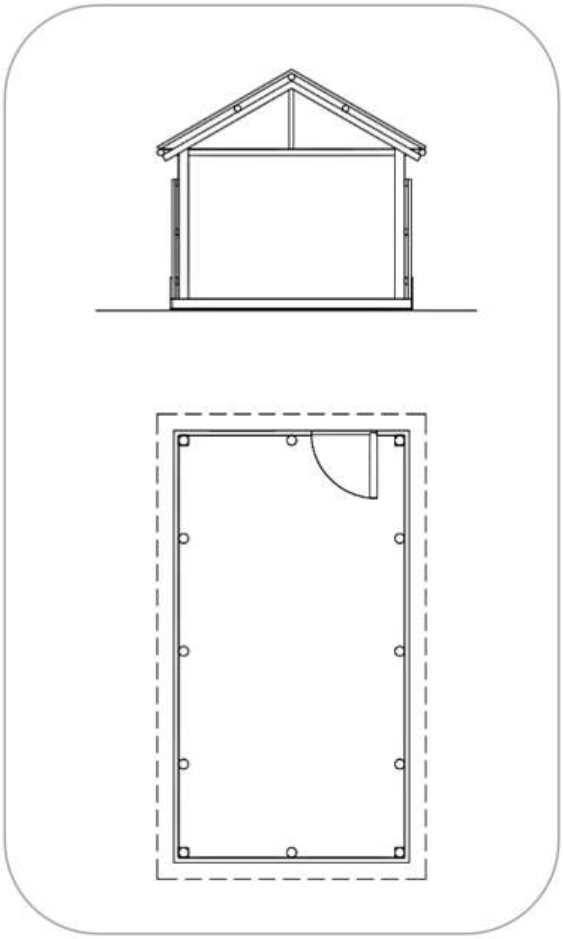


Figure 84 Unit Plan and Section of Temporary Shelter

Figure 85 Key plan

Figure 86 Image of Existing Shelters on the Site (Source: Author)

After which, the villagers could move back to their respective houses, leaving behind the emergency shelter to be occupied by the migrant fishermen and fish processors after they reach the site fir the fishing season. Thus, instead of a plot destroyed by cyclone, the villagers could live in the shelters constructed. Upgradations may take place from that stage, to suit the needs of the community.

The transient community lives such that their lives are heavily interlinked with their livelihoods. The fish processing activities of the fish processors are carried out on a plot of land with their temporary shelters. The land is owned by the government, leased out on a yearly basis to the community members to build their own shelters.

The various activities and daily chores are performed on the same plot of land, with a common toilet for water requirements, which lie in proximity to their housing areas. The sense of community is strong as the daily lives are shared within the community.

Figure 87 Cluster Plan and Section for Transient Fish Processors (Source: Author)

15.2.2 **RECONSTRUCTION – DESIGN**

Figure 88 View of Housing Cluster in Fishermen Village (Source: Author)

Figure 89 Village Cluster Key Plan (Source: Author)

Reconstruction of the resilient houses could begin shortly after the response phase, consisting of construction of the emergency shelters, where food is provided by the government aids and non-governmental organizations for the first 7 days after the landfall of the cyclones. The design of the resilient units would include upgradation of the existing techniques of building, through the introduction of composite use of concrete plinth and strip foundation for stabilization of the critical points. The connections between bamboo members could be stabilized using MS bars as reinforcements and steel gusset plates, instead of making the connections through rope ties. The idea would be to provide a single unit to familiarize the community with the construction techniques through the use of local materials and upgradation of existing techniques, so that incrementality becomes a possibility without the need for external help, while maintaining a uniform architectural language throughout the village.

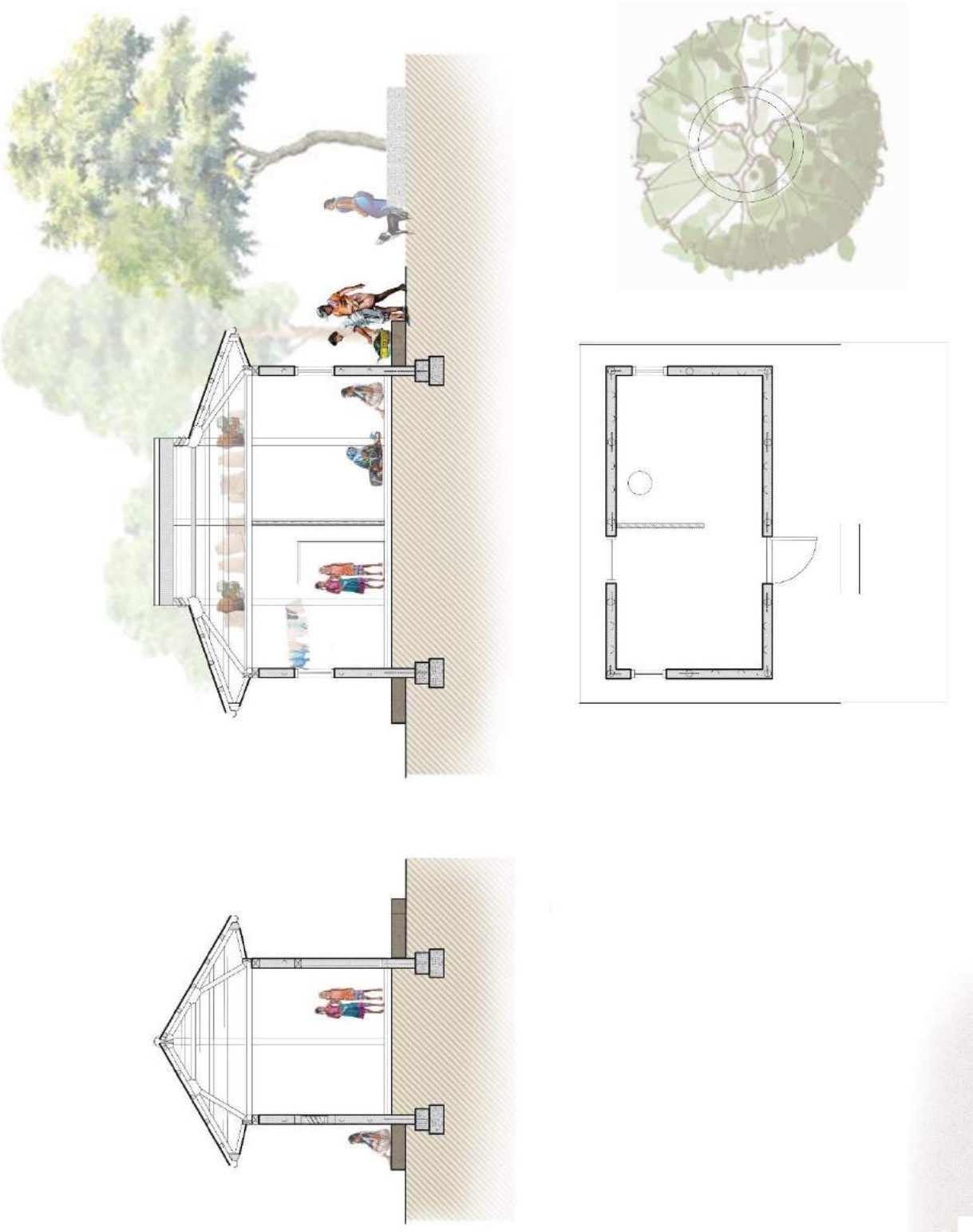


Figure 90 Unit Plan and Sections of Prototype Housing Unit (Source: Author)

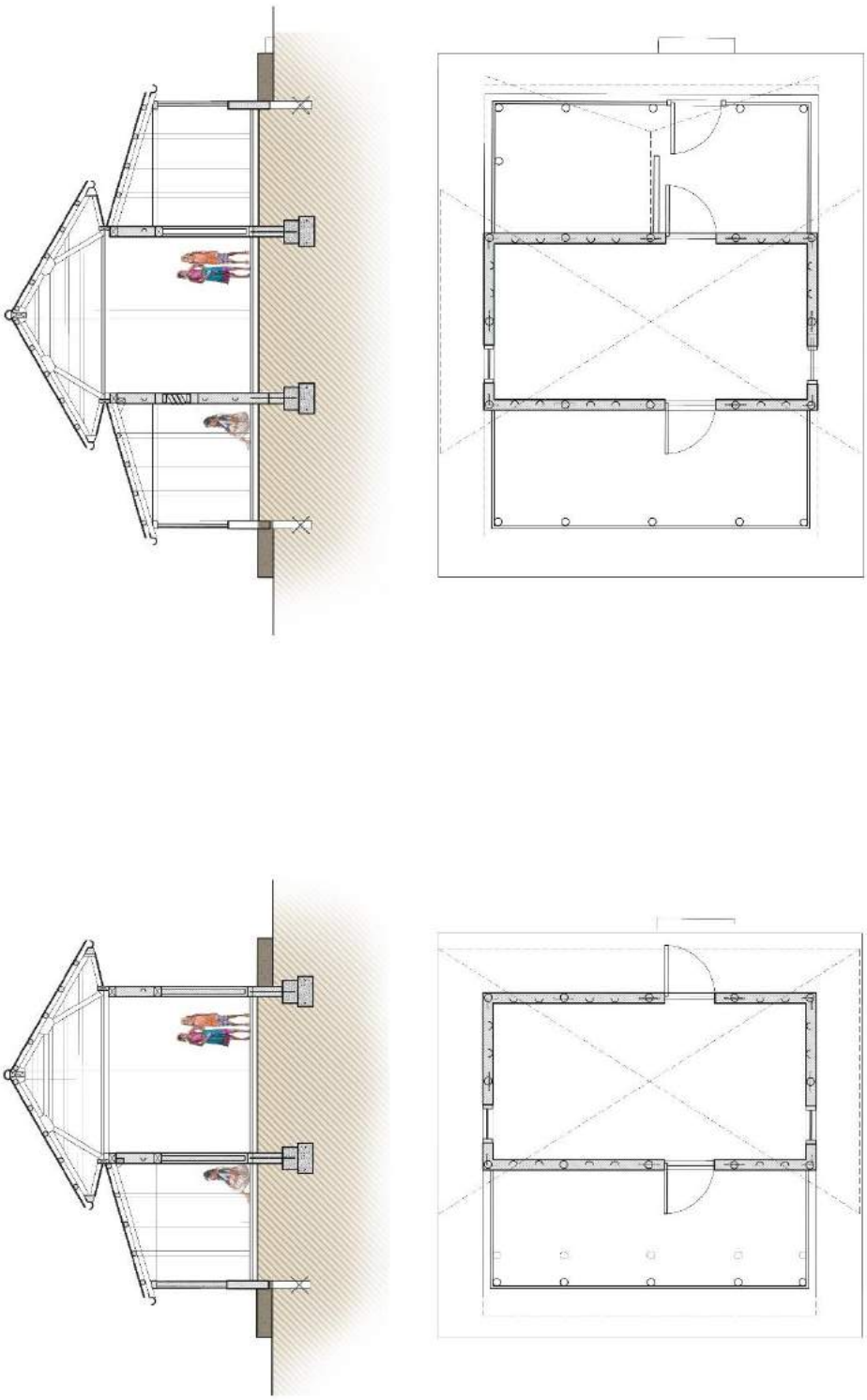


Figure 91 Example of Incremental Expansion (Source: Author)

15.2.3 RECONSTRUCTION – TIME, COST AND PROCESS

15.2.3.1 COST

COMPONENT	MATERIALS	LENGTH	WIDTH	HEIGHT	QUANTITY	Units	UNIT RATE	COST (Rs)
ROOF	Metal corrugated sheet	4700	2	7000	65.8	SQM	100	6580
	Bamboo purlins	7600	12		91.2	METRES	30	2736
	Truss Rafter	4200	2		8.4	METRES	30	252
	Truss Tie	3500	1		3.5	METRES	30	105
	Truss remaining members	3000	1		3	METRES	30	90
	Gusset plate	500	300	5	0.75	SQM	50	37.5
	Nails	LUMPSUM						5000
	Wooden batted	LUMPSUM						5000
	Gutter	7600	2		15.2	METRES	200	3040
	Channel section at ridge	7600	1		7.6	METRES	50	380
WALLS	Bamboo columns	3200	14		44.8	METRES	30	1344
	Split bamboo framework horizontal	3000	39.6		118.8	METRES	25	2970
	Split bamboo framework verticle	19800	6		118.8	METRES	25	2970
	Steel mesh	19800	3000		59.4	METRES	100	5940
	Mud walling	19800	6000	50	5.94	SQM		NOT CONSIDERED
	Cement plaster	19800	6000	50	5.94	CUM	300	1782
	J-bolt for anchorage	LUMPSUM						
	Nails	LUMPSUM						
WINDOW	Wooden frame	4000		3	12	METRES	LUMPSUM	3000
	Top hung shutter	1000	1000	3	3	SQM	LUMPSUM	3000
	Nails	LUMPSUM						
DOOR	Wooden frame	5000		1	5	METRES	LUMPSUM	2000
	Top hung shutter	2000	1000	1	2	METRES	LUMPSUM	2000
	Nails	LUMPSUM						
FLOOR	Brick Flat Soling	6600	3300	75	21.78	SQM	800	6400
	PCC finishing	6600	3300	75	1.6335	SQM	2300	3757.05
	Tiles	6600	3300	75	21.78	CUM	lumpsum	0
	Earth backfill	6600	3300	750	16.335	CUM	1000	16335
FOUNDATION	Concrete strip foundation							
	Excavation	19800	500	1700	16.83	CUM	600	10098
	Brick Flat Soling	19800	1000	75	19.8	SQM	800	6400
	PCC bed(1:3:6)	19800	1000	75	1.485	SQM	2300	3415.5
	Foundation Base (M20 grade concrete)	19800	600	250	2.97	CUM	2500	7425
	Strip Pedestal Brick	19800	1600	500	15.84	CUM	200	3168
	Plinth beam(M20 grade concrete)	19800	500	500	4.95	CUM	2500	12375
	Wooden formwork	39600	1	300	11.88	SQM	500	5940
	Reinforced bars in Foundation							
	MS Reinforced bars main (12 dia tor)	198000		198	176.22	kg	55	9692.1
	MS Rein.bars secondary (8 dia tor)	198000		198	79.2	kg	55	4356
	Reinforced bars in Plinth beam							
	MS Reinforced bars main (12 dia tor)	118800		118.8	105.732	kg	55	5815.26
	MS stirrups (6 dia plain)	2400	100	240	53.28	kg	50	2664
TOTAL								146067.41
								RS 1 LAKH 46 THOUSAND

Table 16 Cost Calculation for Housing Unit

15.2.3.2 TIME

SL NO.	ACTIVITY	CRITICAL PATH DAYS	PARALLEL ACTIVITIES
1	EXCAVATION	3	
2	LAYING OF BRICK FLAT SOLING		
3	PCC CASTING	3	
4	CURING OF PCC	15	
5	BRICK PEDESTAL	22	
6	PLINTH BEAM SHUTTERING	6	
7	PLINTH BEAM CASTING	4	
8	CURING OF PLINTH BEAM	15	
9	BAMBOO COLUMNS CUT TO SIZE		1
10	NAILING OF TRUSSES		3
11	CUTTING OF BAMBOOS INTO HALF		1
12	FLOORING		
13	EARTHFILLING	5	
14	RAMMING OF FILLED EARTH	3	
15	BRICK FLAT SOLING	3	
16	CASTING OF PCC	2	
17	CURING	15	
19	PLACING OF BAMBOO COLUMNS	2	
20	PLACING OF ROOF TOP WOOD	2	
21	PLACING OF TRUSSES	2	
22	PLACING OF PURLINS	1	
23	FIXING OF ROOF	2	
24	FIXING OF RIDGE	1	
25	FIXING OF GUTTERS	2	
26	FIXING OF WALL HORIZONTAL SPLIT	6	
27	FIXING OF WALL VERTICLE SPLIT BAN	6	
28	FIXING OF CHICKEN WIRE MESH	5	
29	PLASTERING INSIDE	5	
30	PLASTERING OUTSIDE	5	
31	FIXING OF DOORS AND WINDOWS		10
	TOTAL TIME OF CONSTRUCTION	135 DAYS	
	ASSUMPTION	MATERIALS, LABOUR FIXTURES ARE PURCHASED AND ARE AVAILABLE NO SHUT DOWN DUE TO SEASONAL HAZARDS FINANCE IS AVAILABLE AS PER PLANNED SEQUENCES.	

Table 17 Time taken for construction of Housing Unit

15.2.3.3 PROCESS

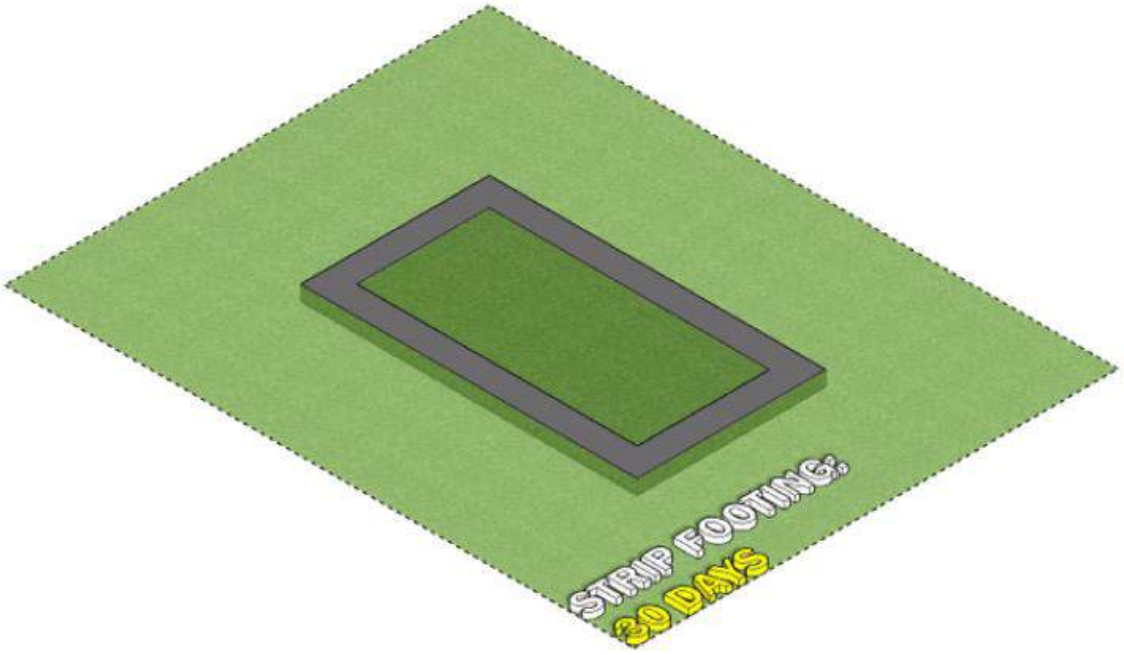


Figure 92 Construction Stage 1 (Source: Author)

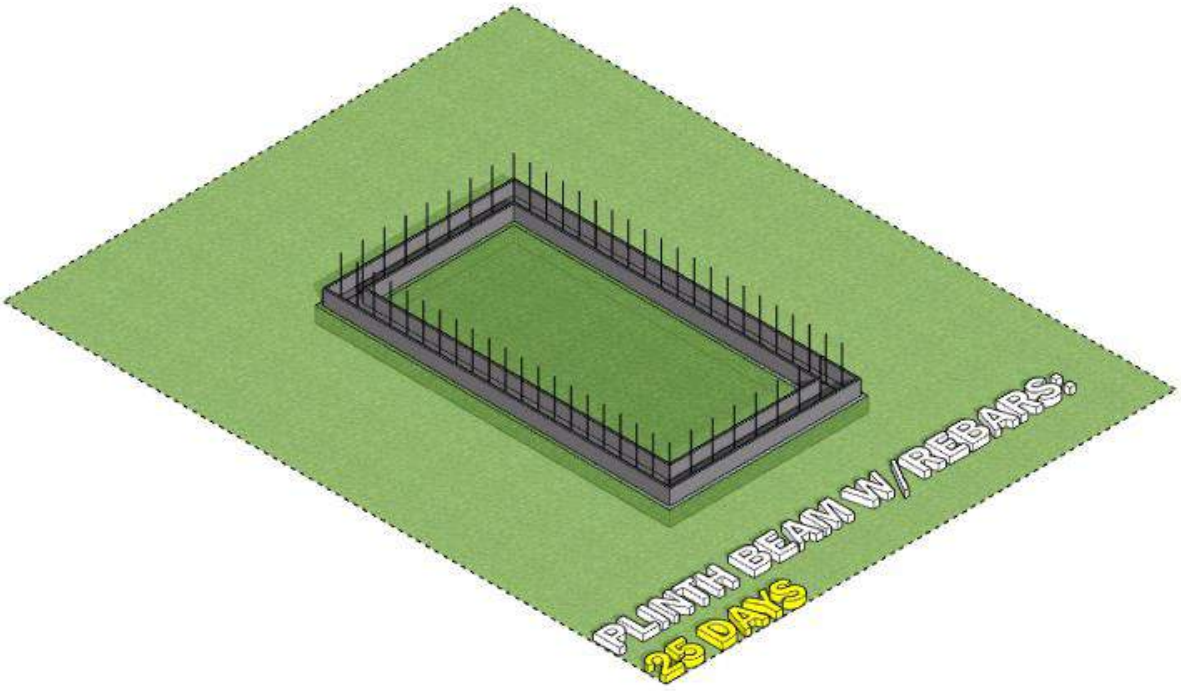


Figure 93 Construction Stage 2 (Source: Author)

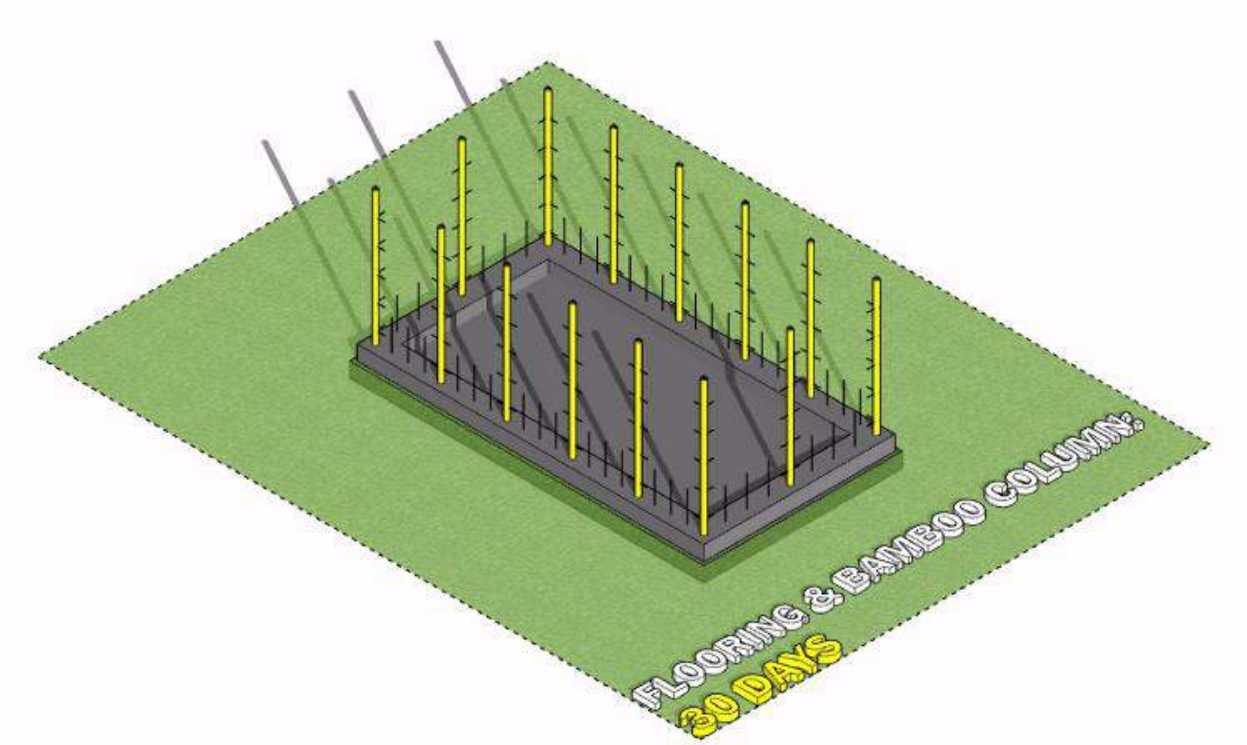


Figure 94 Construction Stage 3 (Source: Author)

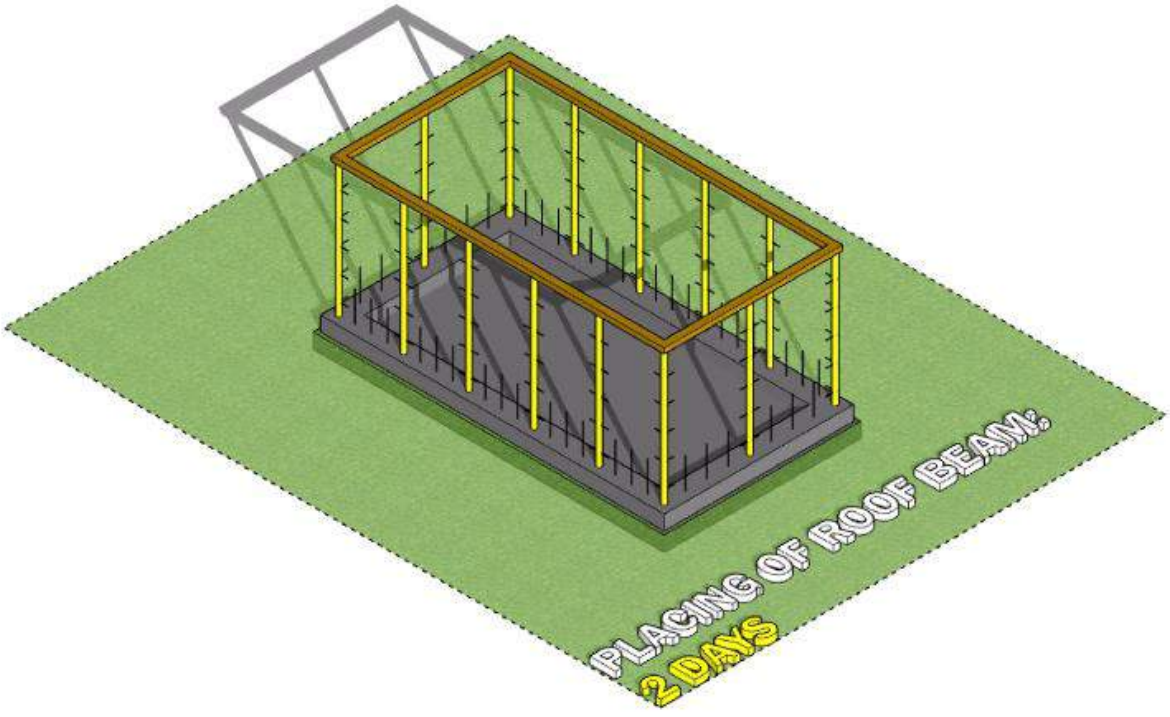


Figure 95 Construction Stage 4 (Source: Author)

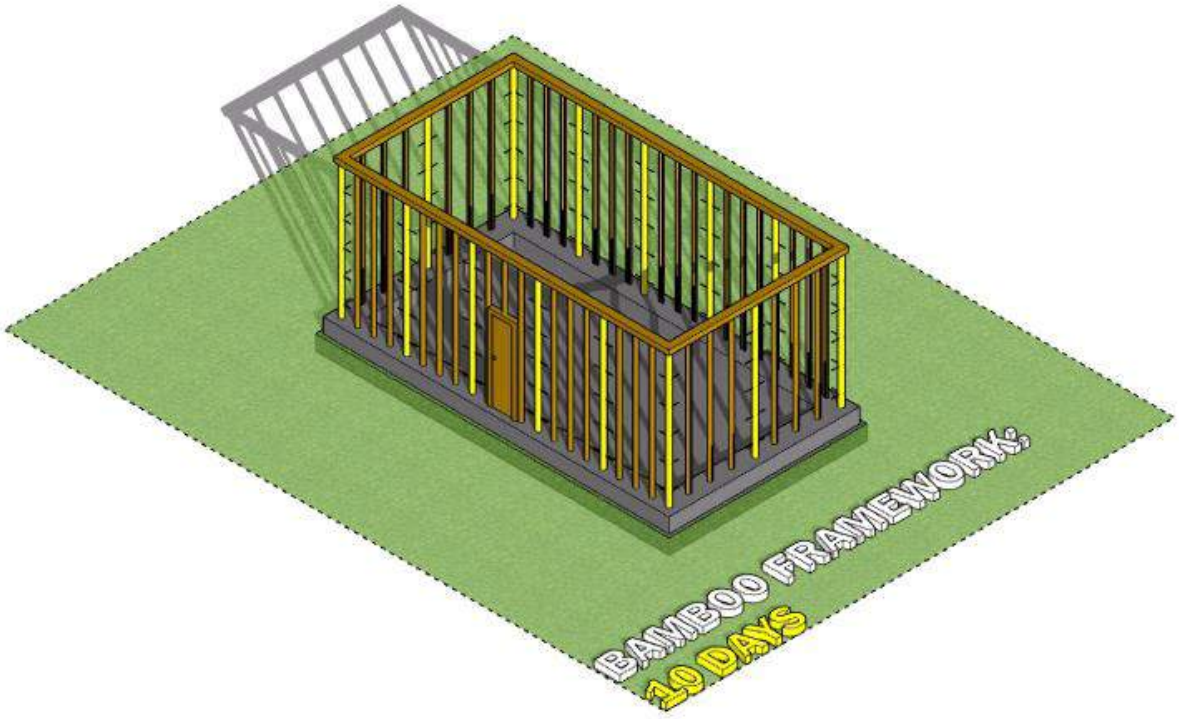


Figure 96 Construction Stage 5 (Source: Author)

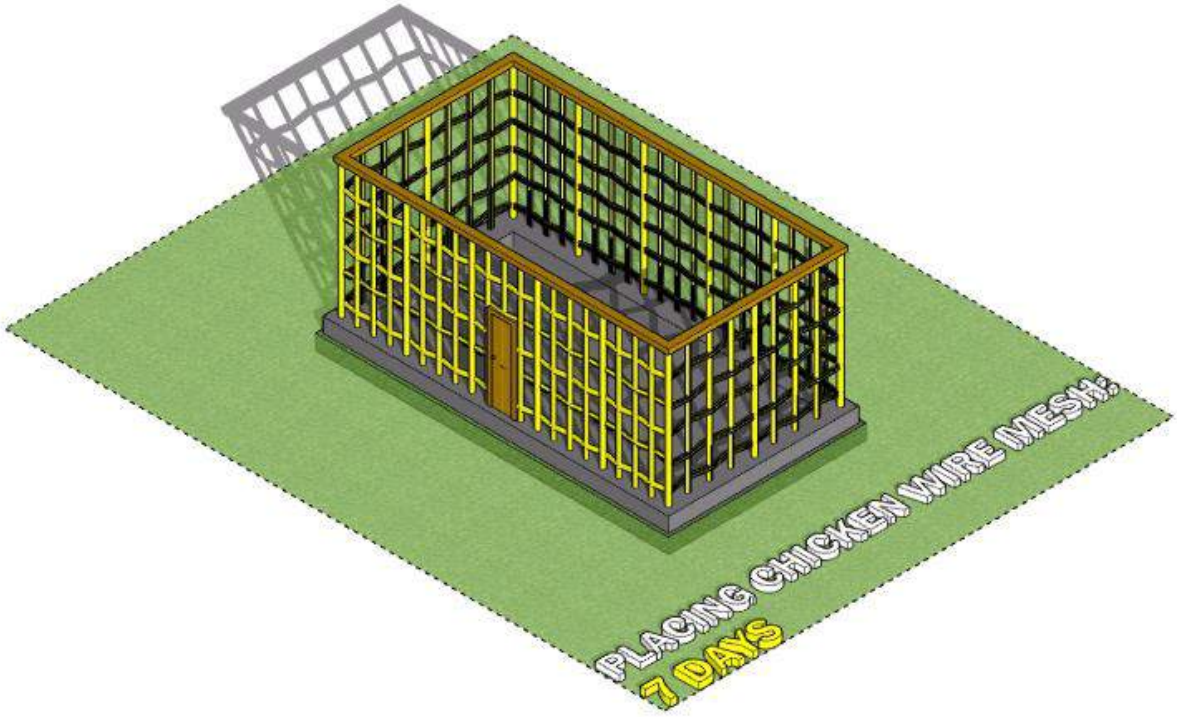


Figure 97 Construction Stage 6 (Source: Author)

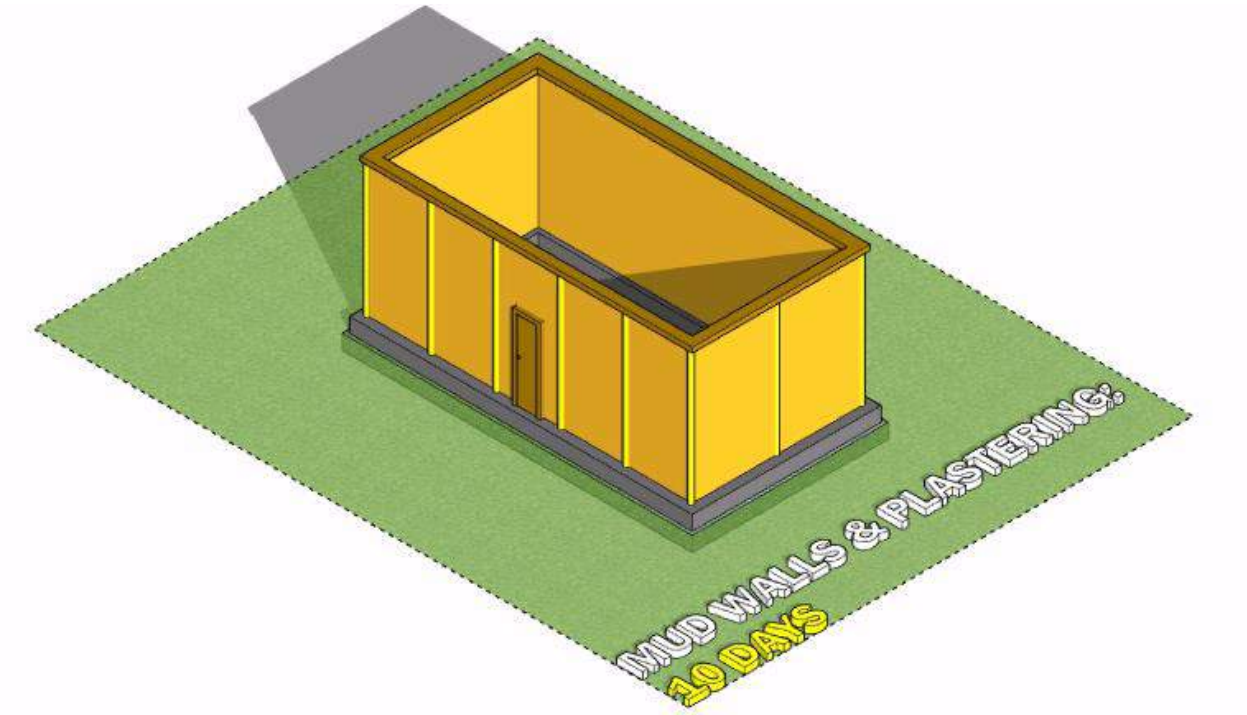


Figure 98 Construction Stage 7 (Source: Author)

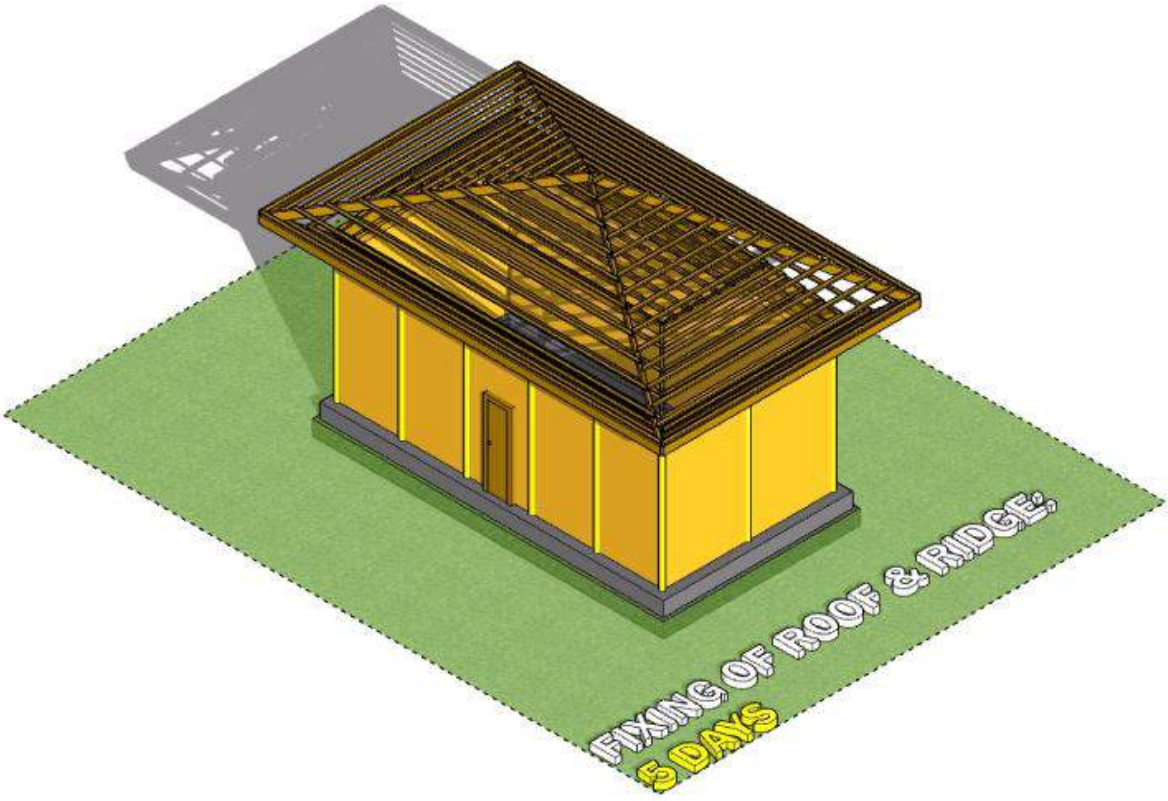


Figure 99 Construction Stage 8 (Source: Author)

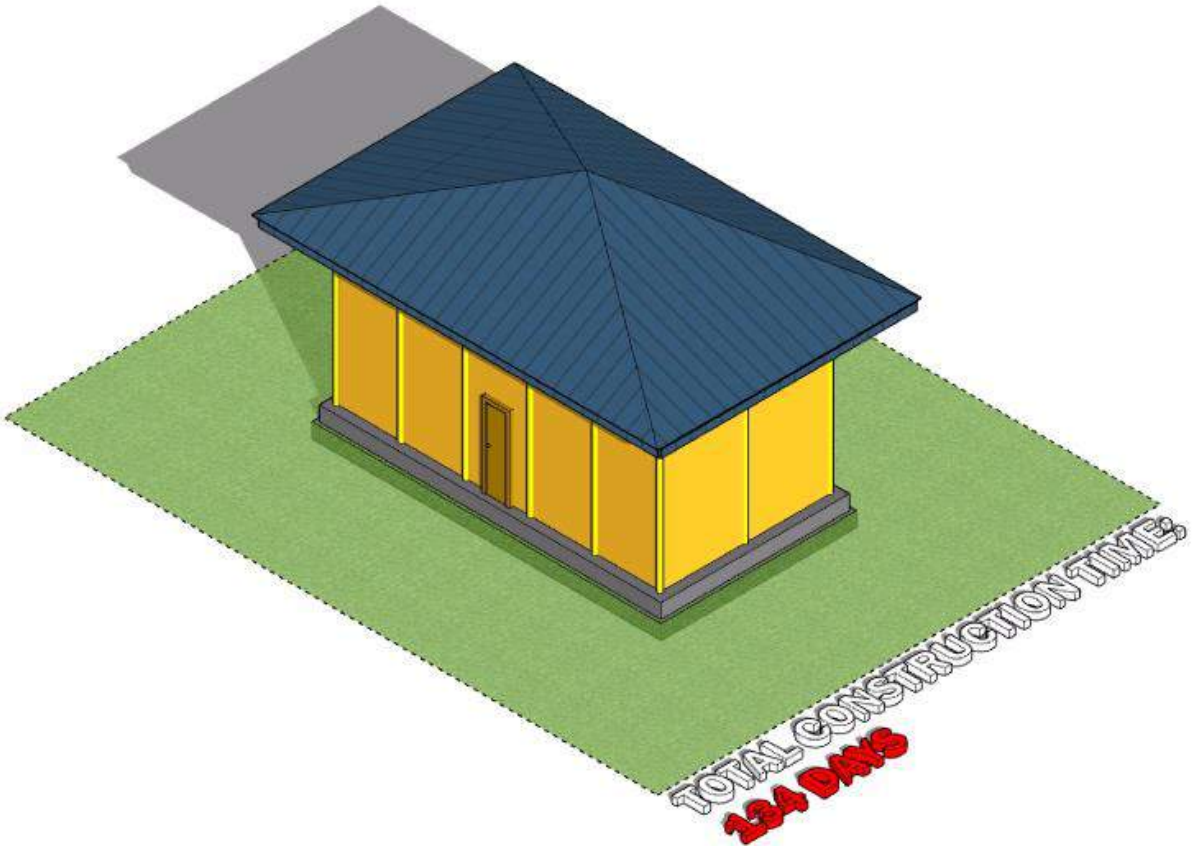


Figure 100 Construction Stage 9 (Source: Author)

Component	Cost	Component	Cost
Roof	23000	Door	4000
Wall	15000	Flooring	26000
Window	6000	Foundation	70000

Total Cost 1 Lakh, 45 thousand

Figure 101 Component-wise cost break up (Source: Author)

15.2.4 **CYCLONE SHELTER - EXISTING**

The existing cyclone shelter in Mandarmani is located in the lowest point of the site – a trough that is regularly subjected to inundations, causing water to stagnate and causing water borne diseases. The building being a stand-alone redundant structure, does not add value to the lives of the villagers, as opposed to its suggested secondary use as a public structure for easier and regular maintenance. The building being constructed of RCC and brick masonry, is not in conformity to the existing architectural characteristic of the site. A one size fits all approach, it adds to the carbon footprint of the site, using technology that is non-sustainable in nature.

Moreover, at the time of the COVID-19, the building was being used as an isolation ward for migrant laborer who had returned to the village. On the issue of an early warning for cyclone, the building was sanitized, and the migrant villagers shifted to temporary shelters. This caused a widespread panic among the villagers, causing a stigma that made them apprehensive about sheltering in the cyclone shelter. The capacity of the cyclone shelter being reduced to 50%, owing the the social distancing protocols, space was deemed to be insufficient. Thus, there was a scramble for temporary shelters, owing to the lack of engineered structures on the site. This exacerbated the already worsening situation, endangering the lives of the villagers. Thus, the design and location of the cyclone shelter needed to be reimagined.

Figure 102 Existing Multipurpose Cyclone Shelter (Source: Author)

15.2.5 CYCLONE SHELTER - PROPOSED

Figure 103 View of Cyclone Shelter (Source: Author)

Figure 104 Cyclone shelter Key Plan (Source: Author)

The proposed cyclone shelter is located on a higher ground, lying in the shadow region of the coastal forest, at a safe distance from the trees, to avoid the damage due to uprooting. The land in front of the cyclone shelter is marked by playgrounds to be used as multifunctional space in cases of emergency. This is a measure to increase redundancy of spaces and allow flexibility for better adaptability.

According to the Disaster Management Handbook, 2018, by the National Disaster Management Authority (NDMA) of India, cyclone shelters may be assigned secondary functions to allow maintenance of the building. Regular usage of a building also increases the familiarity of the structure with the villagers, helping to reduce the trauma associated with cyclone shelters. The trauma is aggravated by the

inevitability of the lives of the villagers falling apart while they seek shelter to save their lives.

Thus, the cyclone shelter is proposed as a community and school building. With minimum furniture inbuilt, flexibility and adaptability of the spatial usage is incorporated into the structure. The outer skin is constructed with steel I-sections and metal corrugated sheets, with shape modified to deviate the wind, minimizing thrust on the structure. The walls on the region of suction is made with wattle and daub panels – locally available materials that increase the dead weight of the structure, increasing the inertia, to resist suction force due to wind drift.

Double heighted spaces incorporated reduce the claustrophobia associated with crowding in a building. The internal partitions are made of split bamboo or woven bamboo partitions – materials that are commonly used by the community for partitioning purposes in their private spaces. They allow multifunctionality as walls and rooms can be modified as per need and usage.

Along with a school building a medical ward is proposed in the cyclone shelter owing to the circumstances where isolation of patients and villagers often necessitate urgent medical attention and supervision. Attached to the school building, schools require medical supervision and awareness programs involving nutrition and child health, on a weekly basis.

Thus, the cyclone shelter is established as a necessary infrastructure for the community - an asset that would help the community progress and serve as identity for the villagers, owing to its form, derived from function, suited to the local context, at the same time, catering to the aspirations for progress in the community.

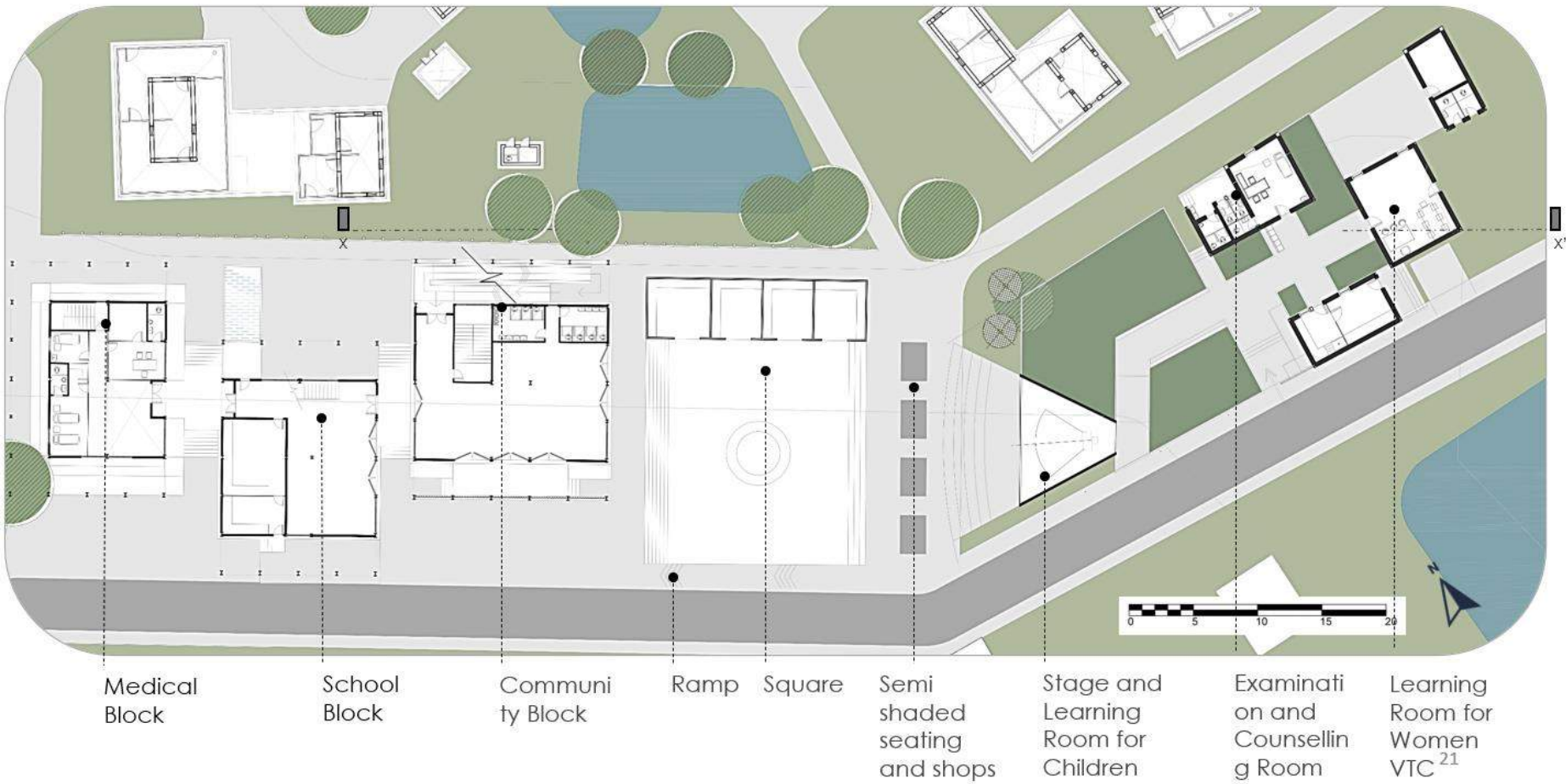


Figure 105 Ground Floor Plan of Village Square

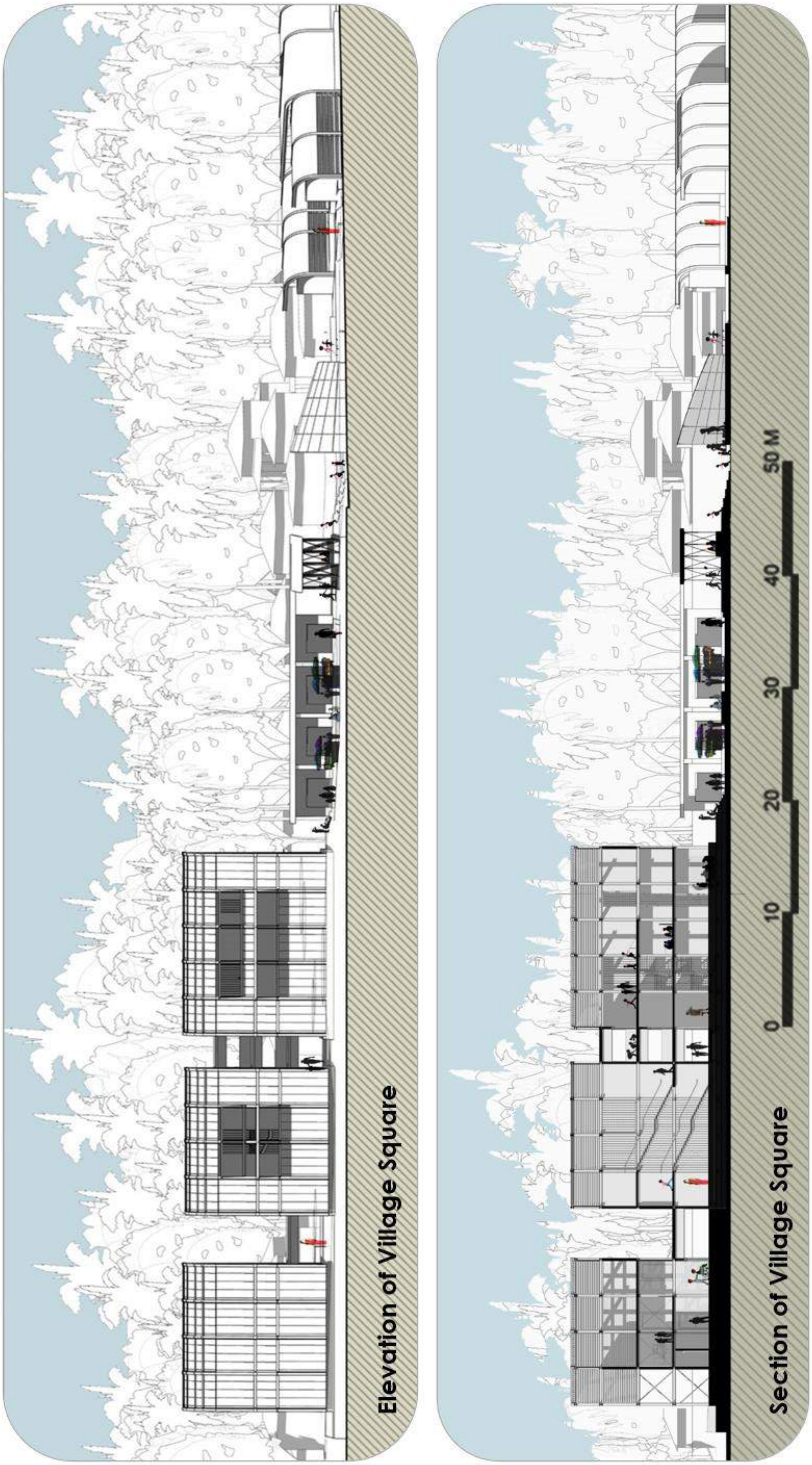


Figure 106 Elevation and Section of Village Square (Source: Author)

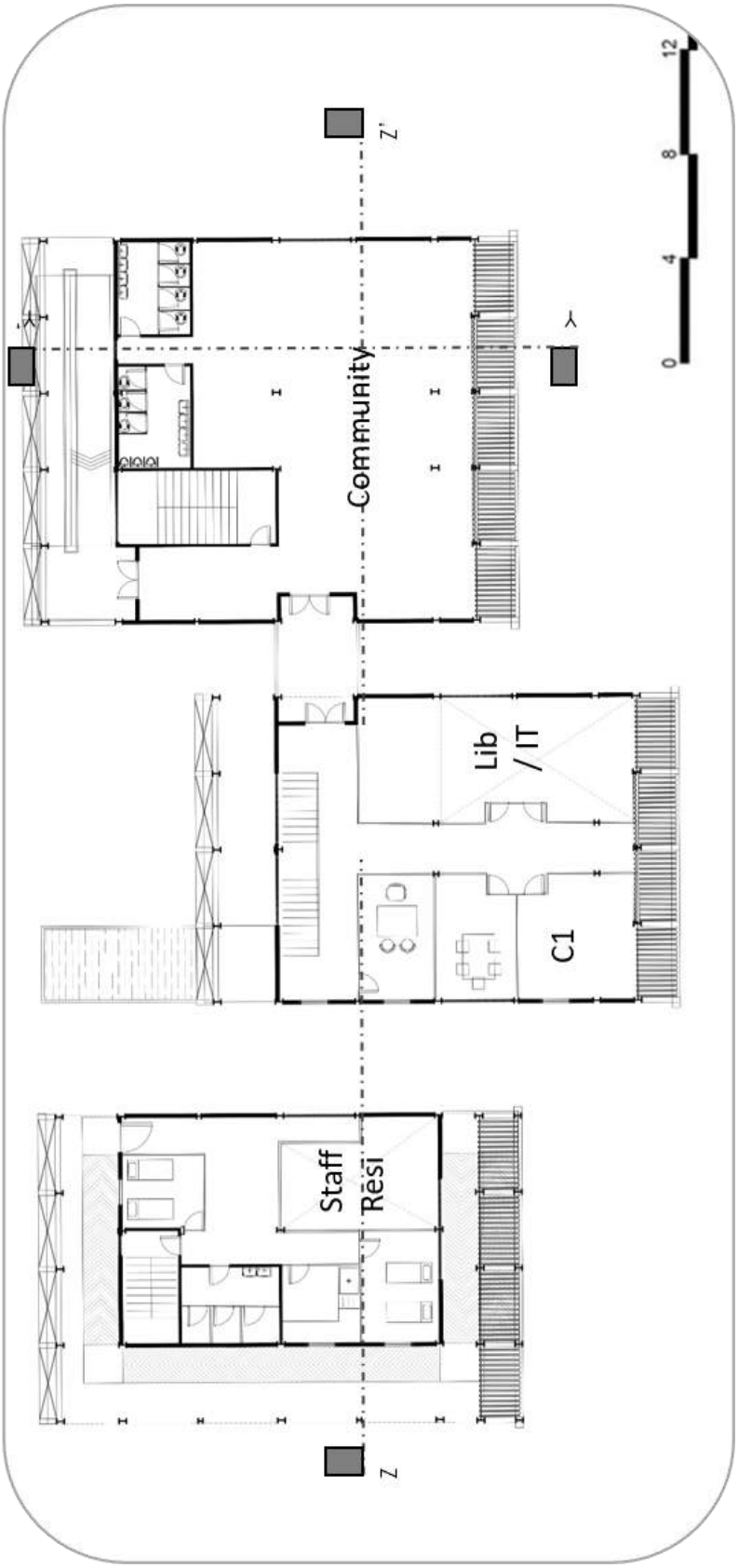


Figure 107 First Floor Plan of Cyclone Shelter (Source: Author)

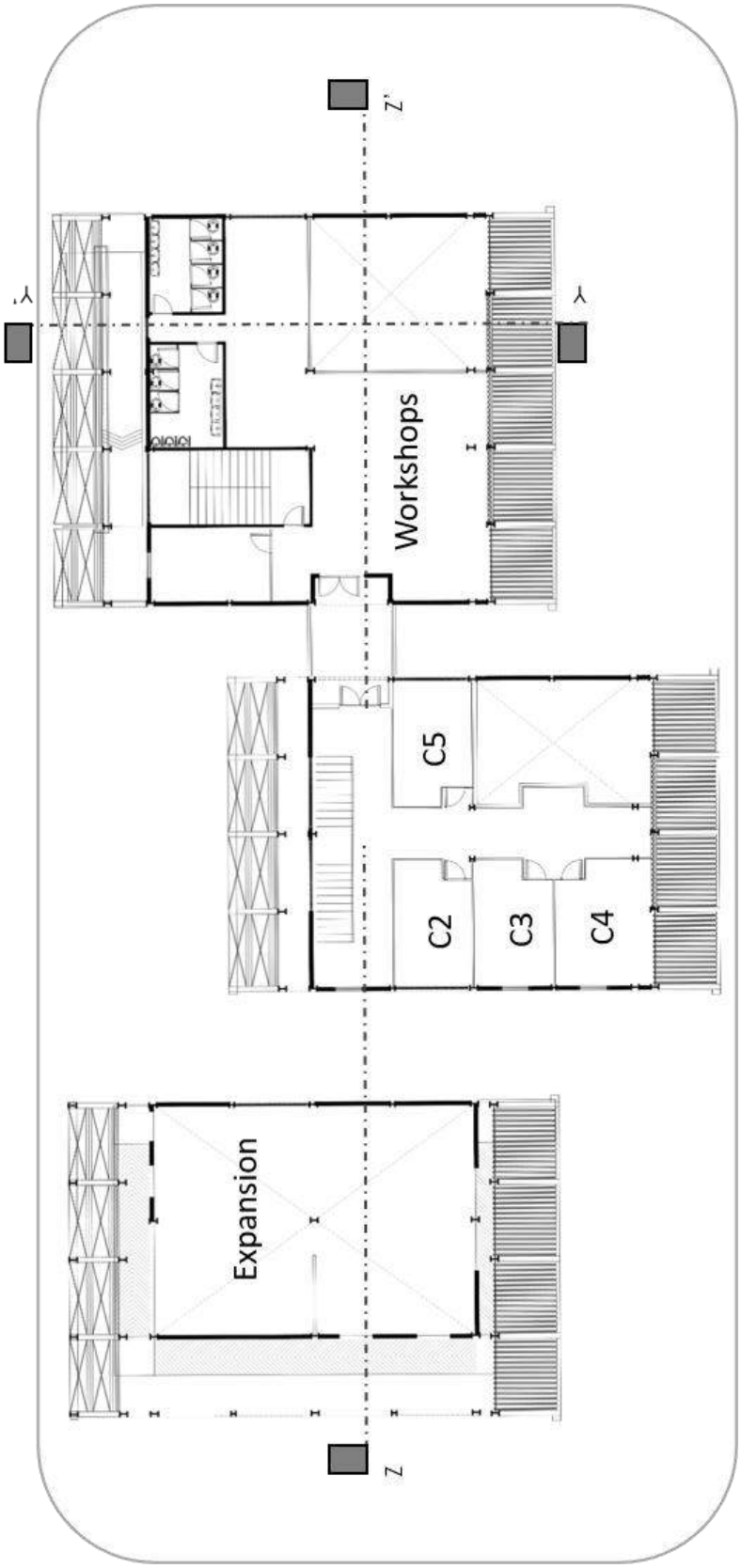


Figure 108 Second Floor Plan of Cyclone Shelter (Source: Author)

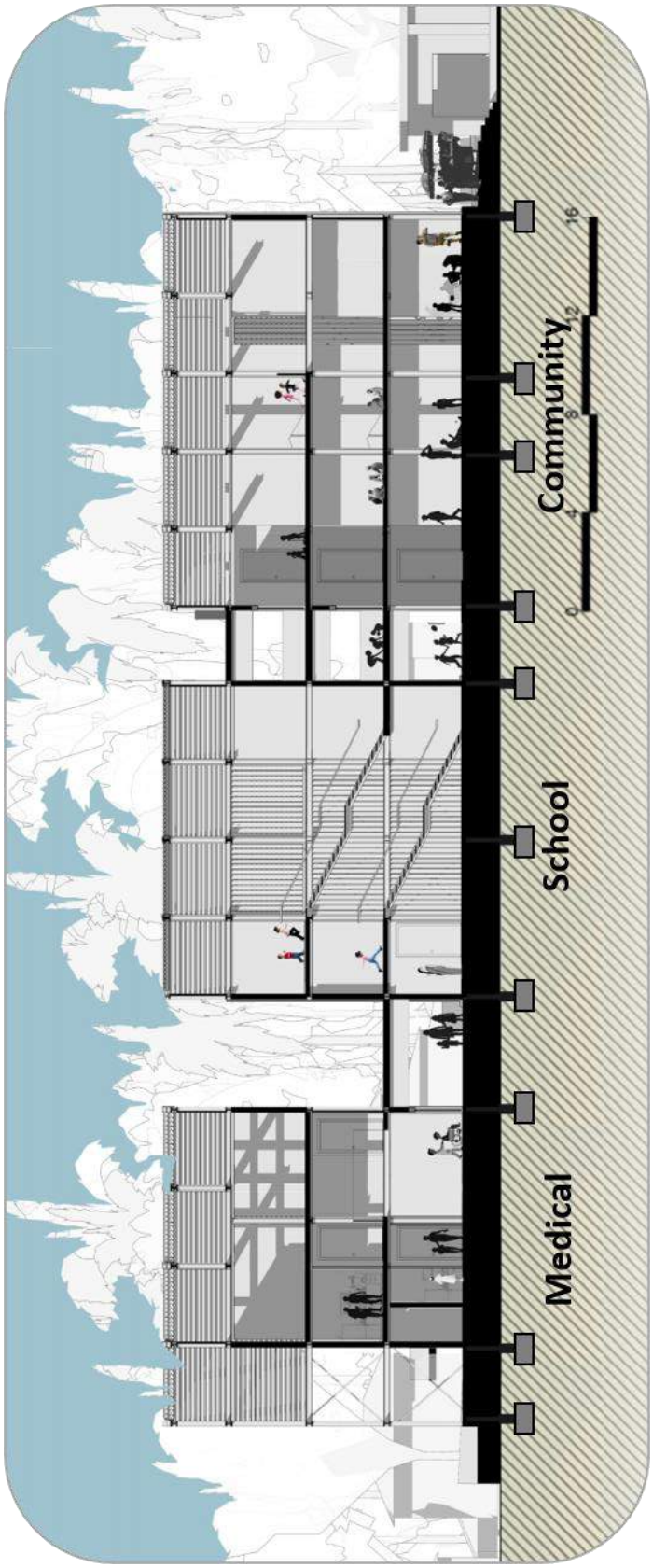


Figure 109 Cyclone Shelter Section XX' During Normal Times (Source: Author)

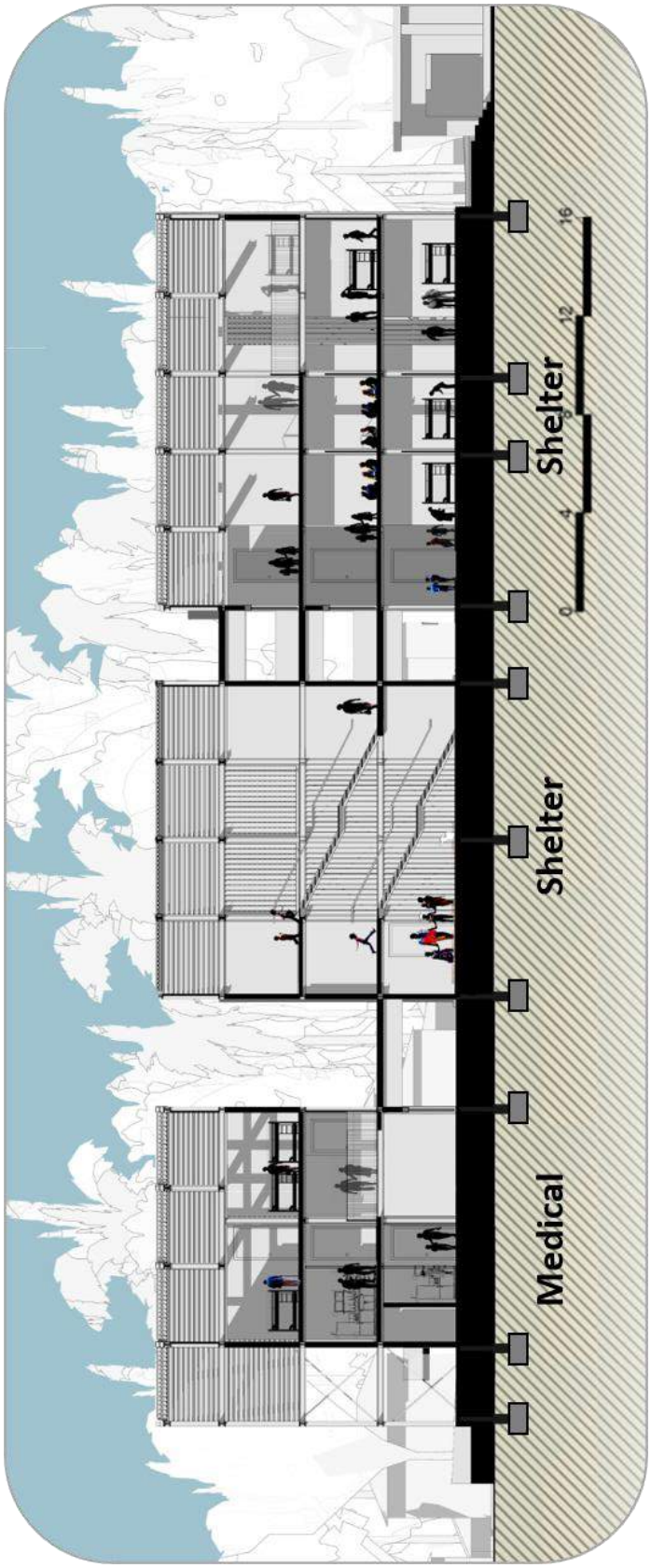


Figure 110Cyclone Shelter Section XX' During Distress (Source: Author)

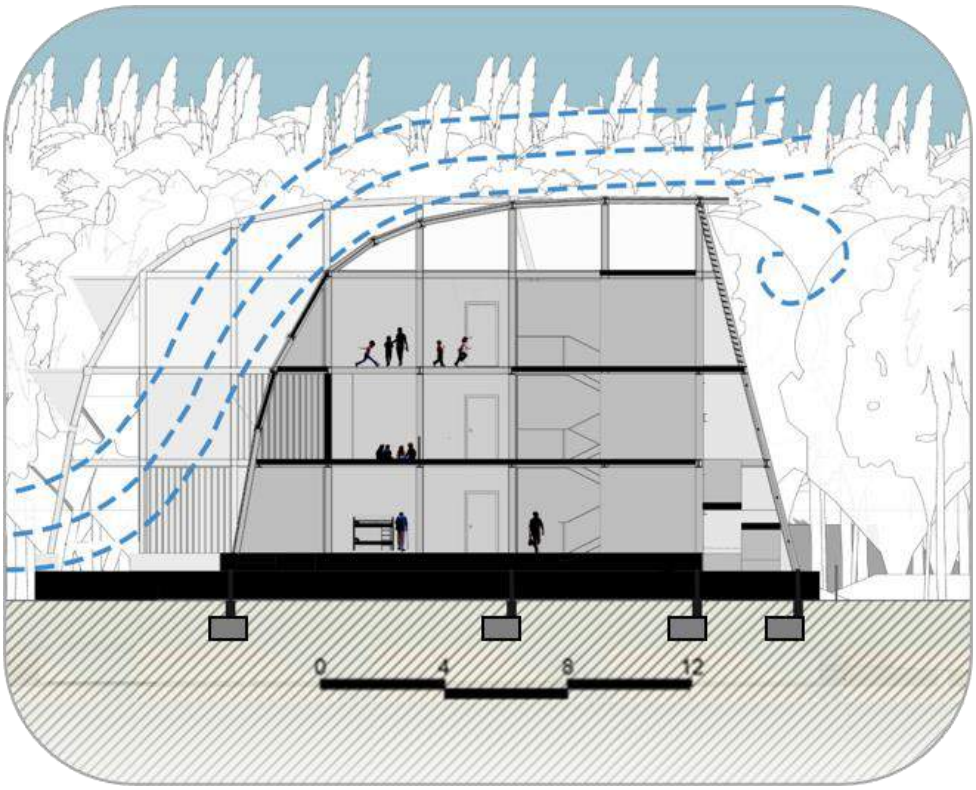


Figure 111 Wind Circulation in Cyclone Shelter During Stress (Source: Author)

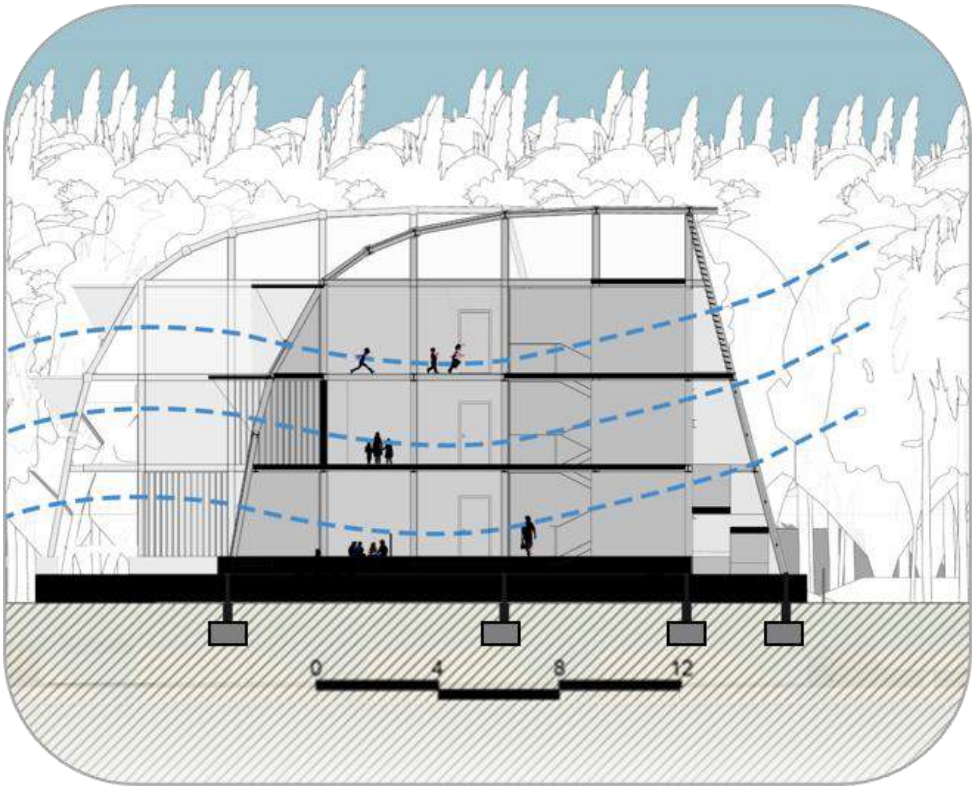


Figure 112 Wind Circulation in Cyclone Shelter During Normal Times (Source: Author)

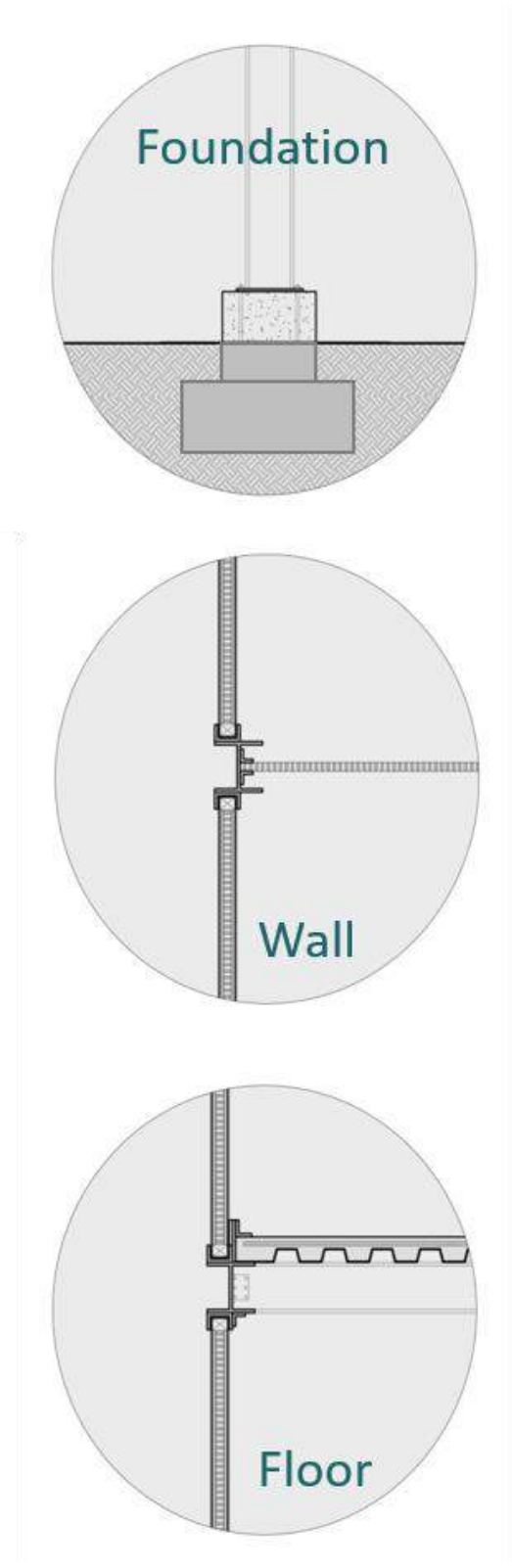


Figure 113 Joinery Details of Cyclone Shelter (Source: Author)

Figure 114 Cyclone Shelter Material Palette (Source: Author)

15.3 PLANNING FOR DISASTER PREPAREDNESS

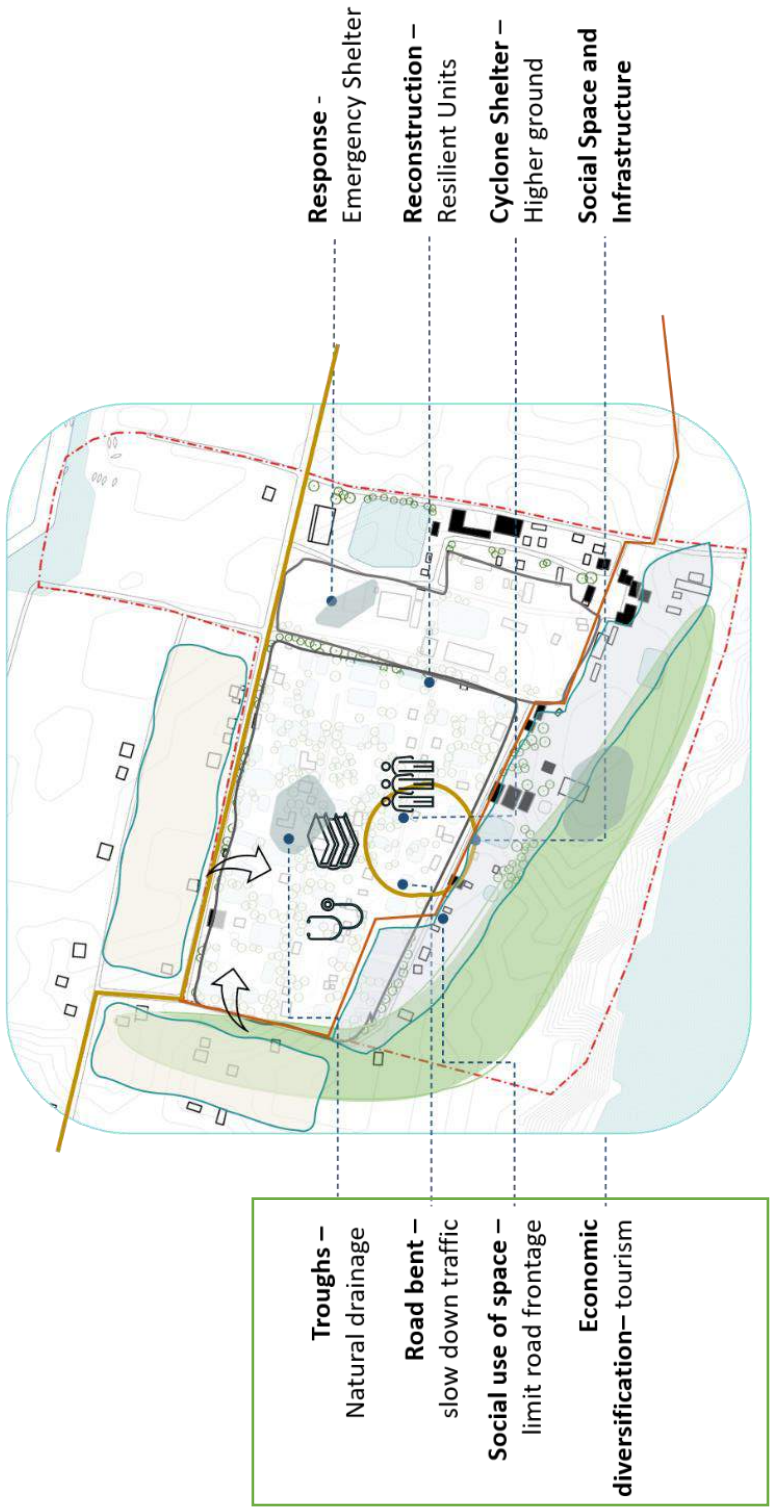


Figure 115 Disaster Preparedness Planning (Source: Author)

After the recovery phase, the preparedness phase sets in, with the transition between the two being indiscrete. The preparedness is dealt with in two layers –

1. The site
2. The architecture

15.3.1 THE SITE

15.3.1.1 THE ROAD LAYOUT AND LINEAR DEVELOPMENT

The social space around the cyclone shelter, being established as a spot with high footfall, the road passing in front of the plot needs to be bent to allow slowing down of the traffic. To prevent expansion of the settlement into the sand dunes and coastal forest can be limited by establishing the use pf the land for community purposes, thus limiting frontage. The social uses established are community fishing, playing grounds for the school attached to the cyclone shelter, temple complex and organic farming – areas for economic diversification.

15.3.1.2 TROUGHS RETAINED FOR NATURAL DRAINAGE

The site is contoured, with a gradual slope from the sand dunes in the couth, towards the tidal creek in the north. In between, there are troughs that get inundated during monsoons and become unusable for a few months. The plots mostly lay vacant. The retention of the troughs as permeable surfaces ensures drainage of the contours into the troughs, without causing the inundation to expand to the surrounding areas. At the same time, the water retained would percolate into the ground water, effectively recharging the water table through rainwater harvesting.

The trough in the community housing area could be used as a green space that interconnects the various clusters existing on the site. Another one has been turned into a man-made pond for prawn aquaculture with water channelized from the tidal creek. The third could be utilized as an extension of the prawn aquaculture set up through conversion into a pond. The rest of the site area could be used for vegetable and organic farming, catering to the resorts and hotels in the area. This would provide an opportunity for economic diversification. Gradually, there could be future expansion into hospitality for increased revenue, owing to the scenic beauty of the place, in proximity to the sea.

15.3.2 THE ARCHITECTURE

The next level of preparedness is through the architecture and built environment. The built environment is further classified into the private and the public – housing and the cyclone shelter.

15.3.2.1 HOUSING

The permeability of the structures is efficient for dealing with cyclones. However, the structures falter at the roof and foundation connections. The former being tied with ropes, is unable to withstand the strong forces of the wind. The foundation consists of a bamboo strut planted into the ground. The soil being a composition of loose sediments with a mixture of alluvial soil and sandy soil, it unbale to hold the bamboo struts under force. Thus, the structure collapses, causing further stress at the roof, causing the roof to fail. Thus, there need to be an upgradation of the structural components.

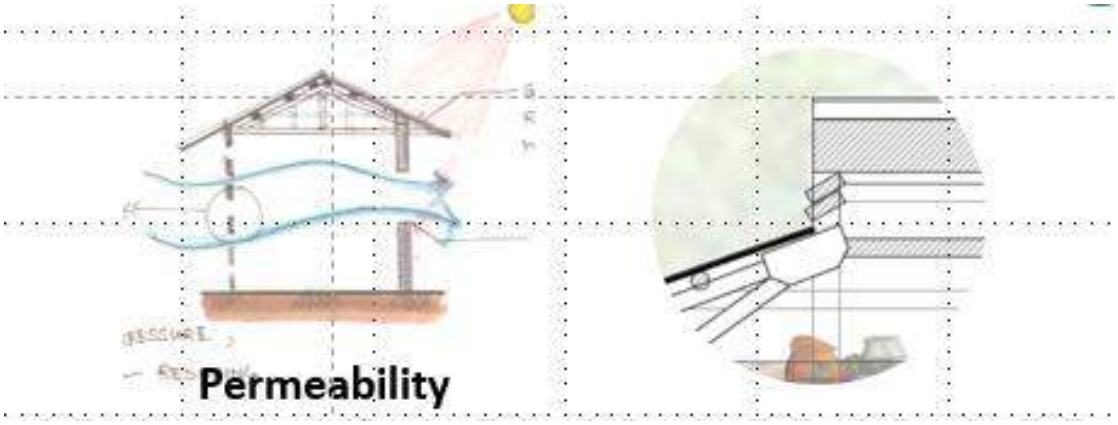


Figure 116 Permeability for Dissipation of Wind Pressure (Source: Author)

The proposed intervention is structural in nature. The permeability is retained using louvres, modified for ventilation. the roof connections are stabilized with the use of anchorage, connecting the roof member to the walls and foundation using j-bolts and u – bolts. At the same time, the shape of the roof has been modified to increase the surface area on which the wind force is incident, to reduce the magnitude of the force experienced at a point. The shape also allows the load to be distributed between he wall and the roof, transmitting it ultimately to the foundation, reducing the stress on the roof connections.

The soil being composed of loose sediments, require and anchorage to hold the walling systems and structural members on application of external stress. Further, the soil requires even distribution of load of the building to the ground to prevent uneven settlement, forming cracks and ultimately making the structure unstable. To counter this issue, strip foundation is proposed that would anchor the structure to the ground and at the same time provide a base for even distribution of load.

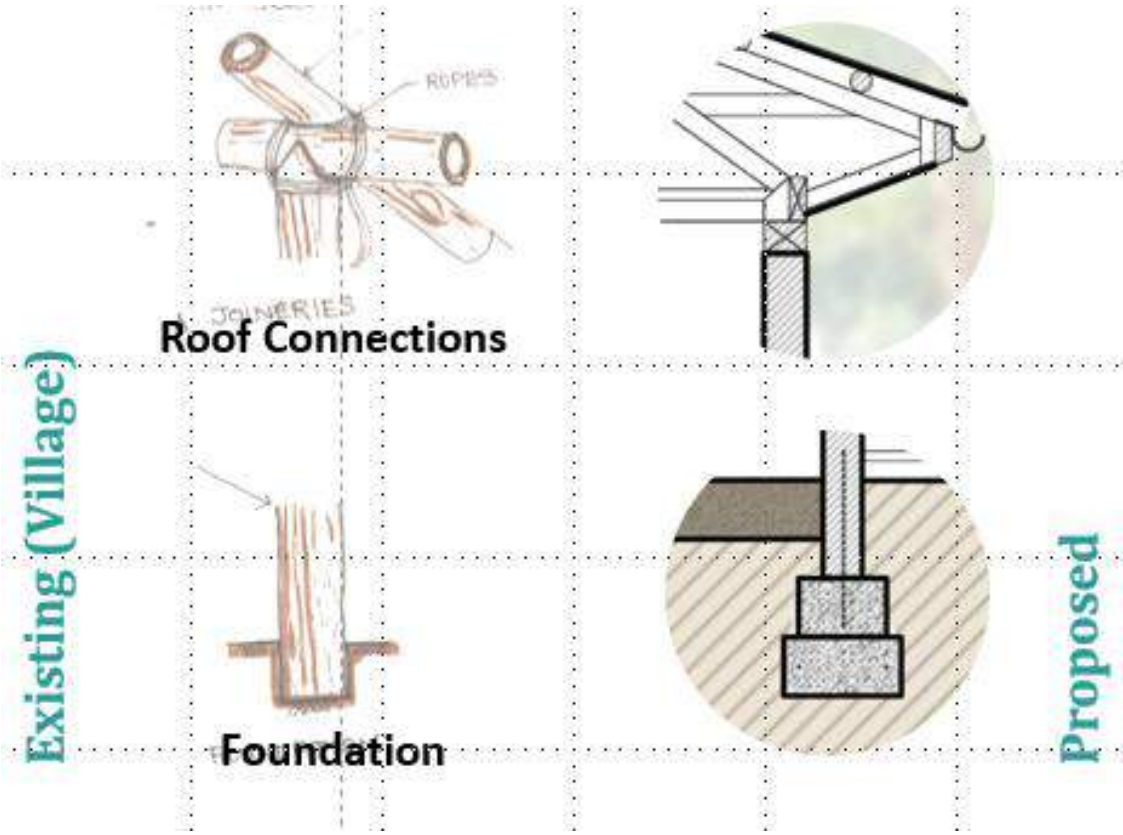


Figure 117 Structural Interventions - Housing (Source: Author)

The roof of the housing, made from corrugated metal sheets, tends to get heated up. Louvres provided allows the hot air to escape, creating a suction, that allows circulation of air through the windows, enabling stack effect and setting up a flow of convection. The mezzanine floor, made from local materials like hay, dried leaves and bamboo, acts as an insulator, keeping the habitable space cool. Cross ventilation is allowed through openings placed opposite to each other in the unit. Thus, the humidity and heat are lowered in the houses, through reinterpretation of technology available on the site.

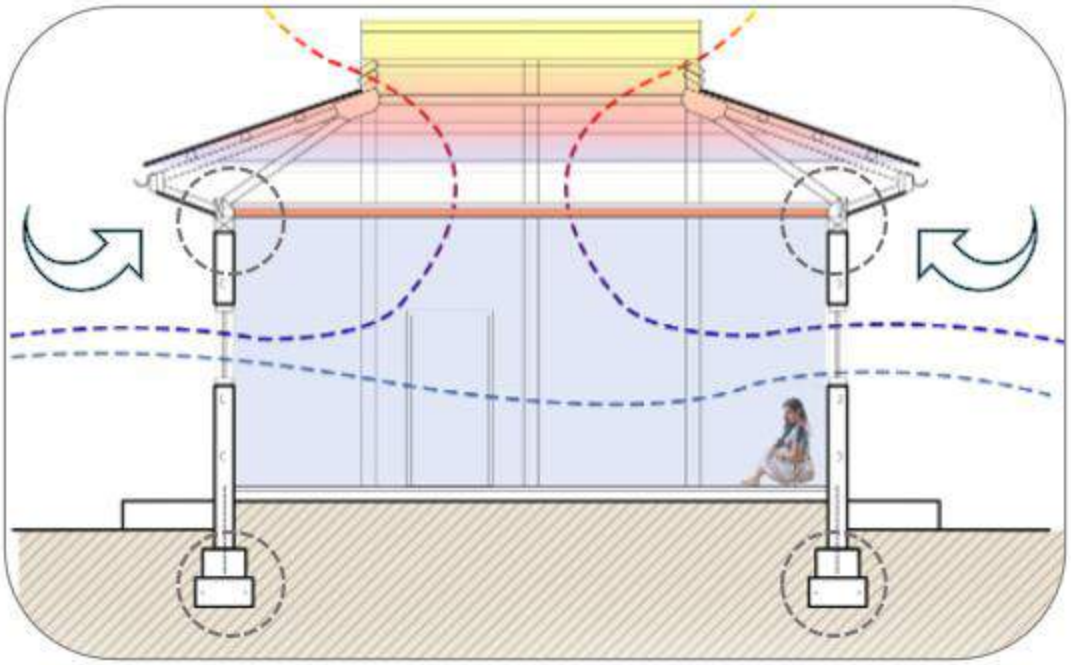


Figure 118 Air Circulation within the Housing Unit (Source: Author)

15.3.2.2 CYCLONE SHELTER

The cyclone shelter by National Disaster Management Authority of India, in its Disaster Management guidelines, suggests a rectangular building, regularly shaped, with rooms for accommodating the villagers. The material specified are RCC and brick masonry. The buildings are standalone structure that are used at the time of the cyclones, creating an issue of maintenance. Thus, at the time of cyclones, the buildings are in poor conditions, often increasing the trauma of the community and reducing the flexibility of the structures.

The proposal makes use of alternative materials and a shape that is more aerodynamic to allow deviation of wind with reduced points of thrust. The interior layout suggested is made from split bamboo and woven bamboo partitions, a local material widely used by the villagers for cheap and quick expansion of their living quarters, to allow the space to be modified as per the needs of the community. The material chosen is brick and steels, with a construction process that is an upgradation to the existing construction process on the site. This would allow easier maintenance of the building by the villagers and make expansion easier.

The use of local materials will allow the villagers to expand the cyclone with ease, as per the needs of the community, without the need for an external intervention. The community will be able to adapt better to the building, while maintaining the integrity of the building. The partitions would allow better fluidity between the various functions of the building.

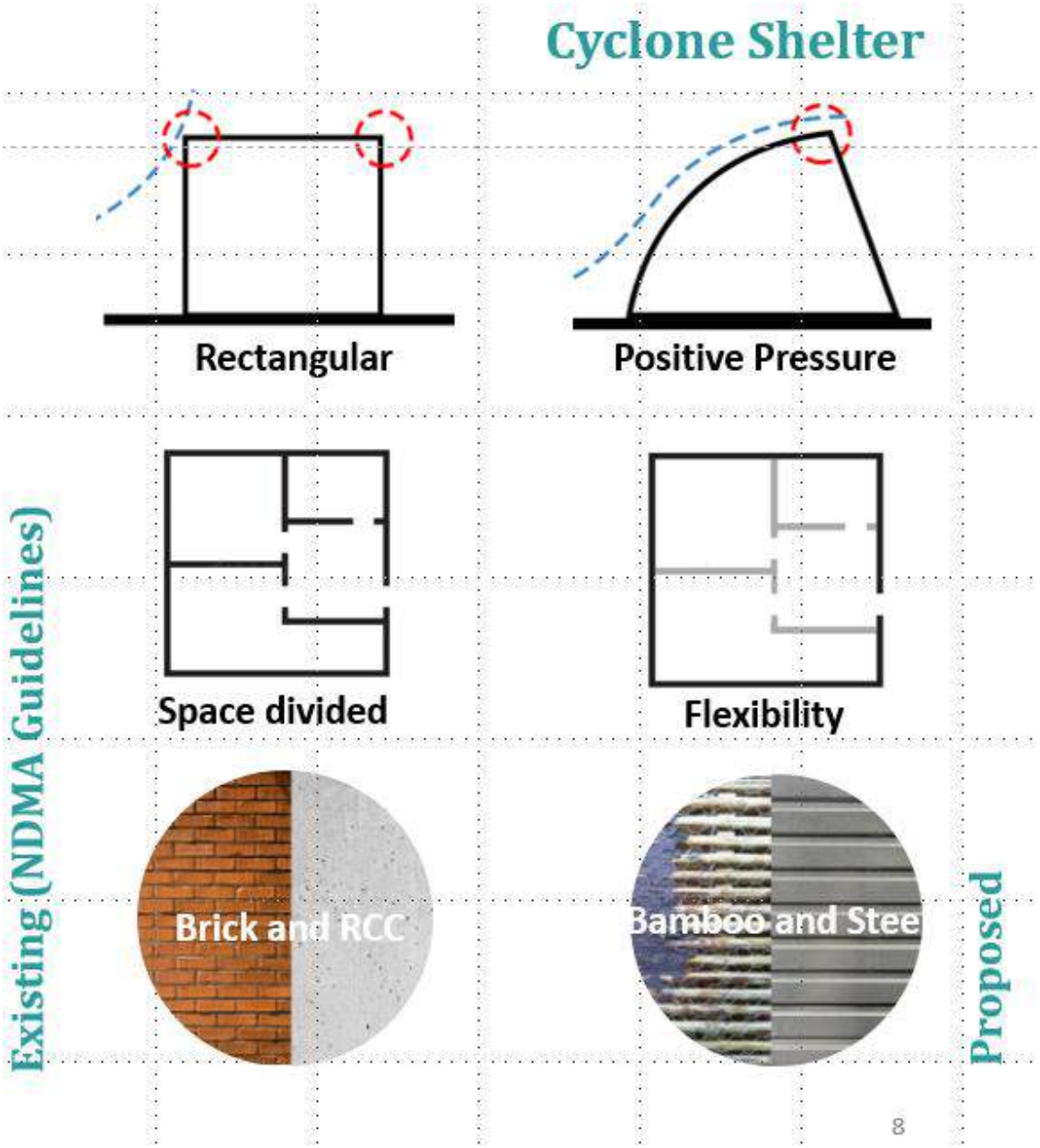


Figure 119 Strategies for Cyclone Shelter (Source: Author)

15.3.2.3 REDUNDANCY – MASS FISHERMEN HOUSING FOR TRANSIENT COMMUNITY

Figure 120 View of Mass Fishermen Housing for Transient Community (Source: Author)

Figure 121 Key Plan

The fishermen housing of the transient village belongs to the *bahardars*, with Benfish as a major stakeholder. The fishermen live in the houses on a rotational basis, where the units are inhabited by a group of fishermen for a day or two, after which they spend the next 12 days on the sea, in the trawlers. Their return is on the 13th day, followed by another 2 days of stay at the units. After that, they return to their own villages, to continue the cycle till the end of the fishing season. The sense of ownership I least in these houses, along with least requirement for storage, owing to the short stay.

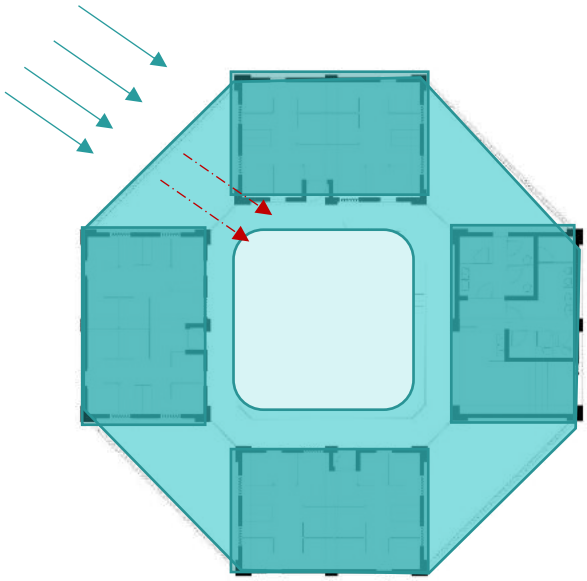


Figure 122 Shape and Open Spaces (Source: Author)

The houses are occupied by the fishermen, where daily chores and activities like net mending are carried out in groups, where a cluster of three to four units participate. Cooking is also a community activity. Thus, in the design, four units are provided with a common area for cooking and storage, with ample access to terraces, open spaces, and semi open spaces, in the form of courtyards, corridors and shaded courts to carry out daily activities and chores.

The permeability of the structures is maintained using louvres. The shaded spaces are protected from overturning by allowing wind movement through louvres, that reduces the wind velocity and reduces upthrust. The hexagonal shape of the structure further reduces the impact of wind by reducing the number of stress points where the wind hits directly, by increasing the angle of incidence, thus, reducing the resultant force in a perpendicular direction.

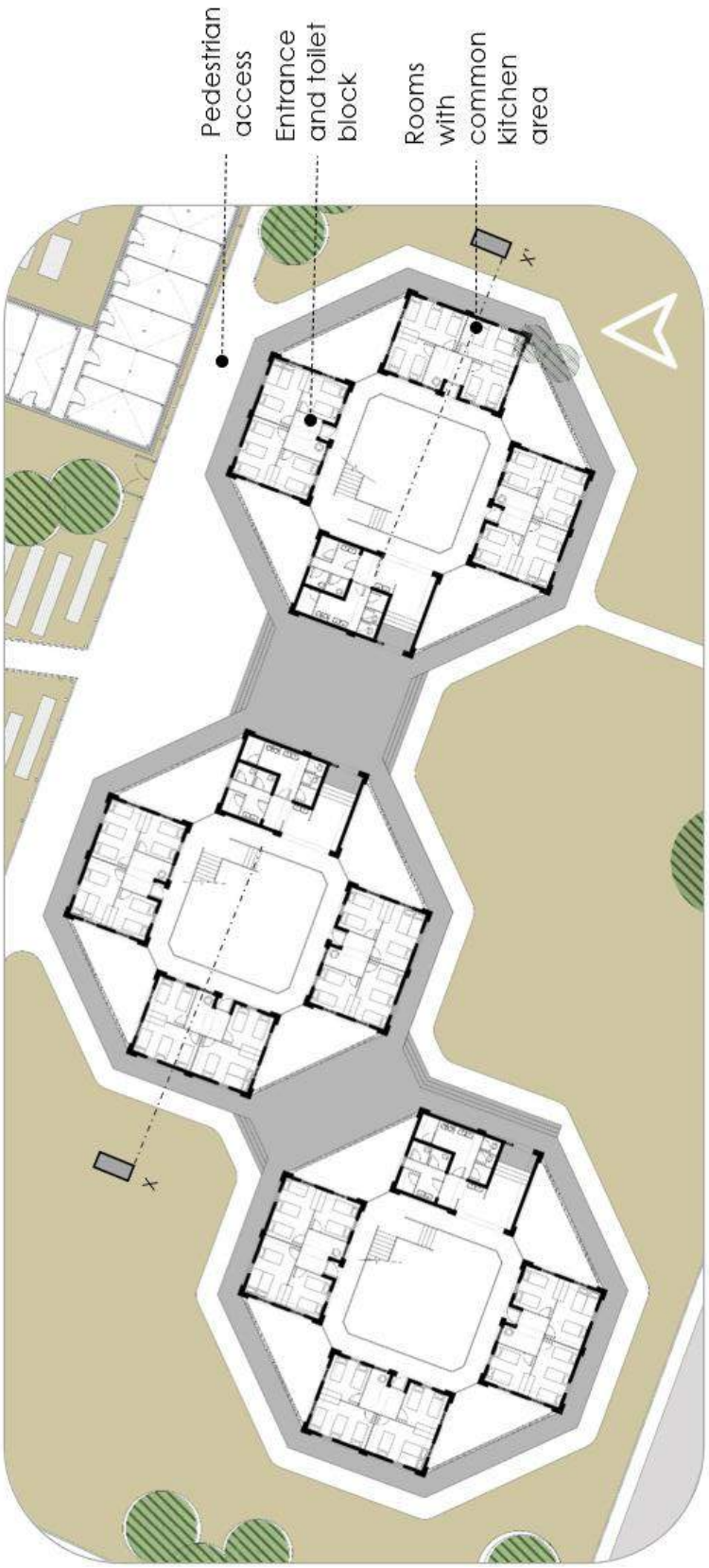


Figure 123 Ground Floor Plan of Mass Housing for Transient Fishermen (Source: Author)

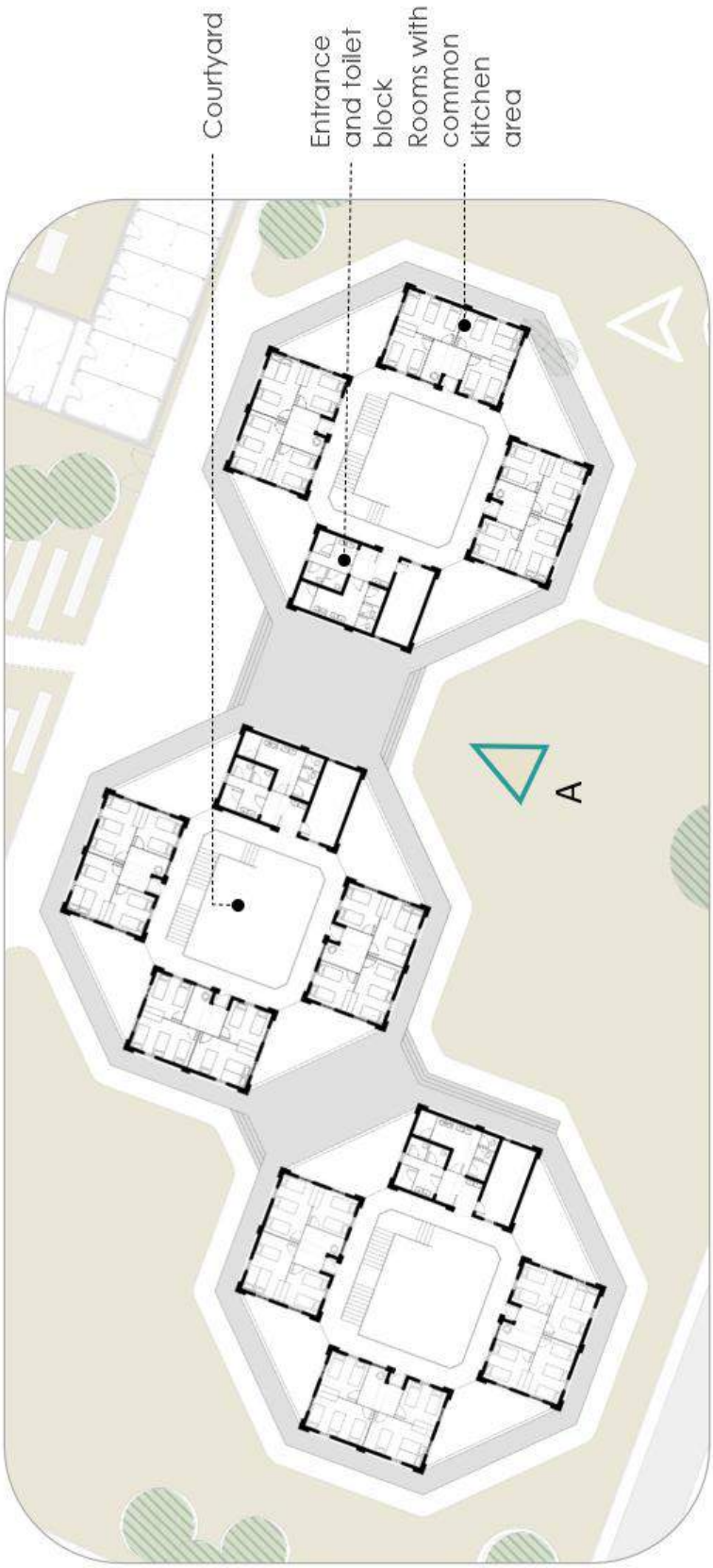


Figure 124 First Floor Plan of Mass Housing for Transient Fishermen (Source: Author)

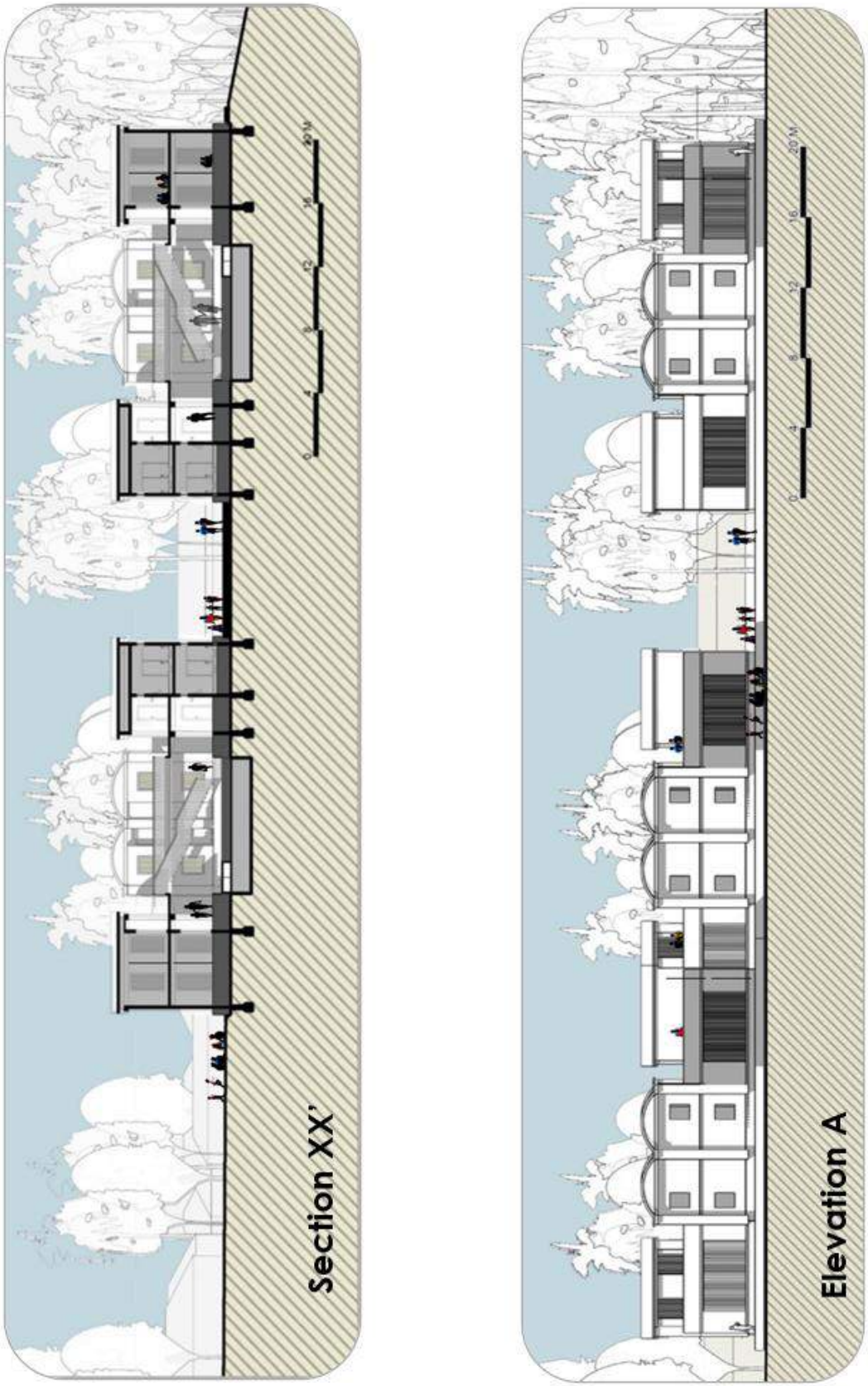


Figure 125 Elevation and Section of Mass Housing for Transient Fishermen (Source: Author)

15.3.2.4 REDUNDANCY – THROUGH ALTERNATE USE DURING STRESS SITUATIONS

Due to the lack of ownership of the residents, there are higher chances of modification of the internal spaces in critical times – COVID coupled with Cyclone Amphan required increased footprint of shelter spaces to allow social distancing within shelters. However, if provided as a standby redundant structure, like the existing cyclone shelter, it would lead to wastage of space and cost, as the usage would be minimum. Hence, building the mass housing facility to accommodate villagers in compartments made out of bamboo mats in times of social distancing, to accommodate families within each as well as provide a room a clear space at other times to accommodate the transient community as well, if need be, as most cyclones strike during the fishing season.

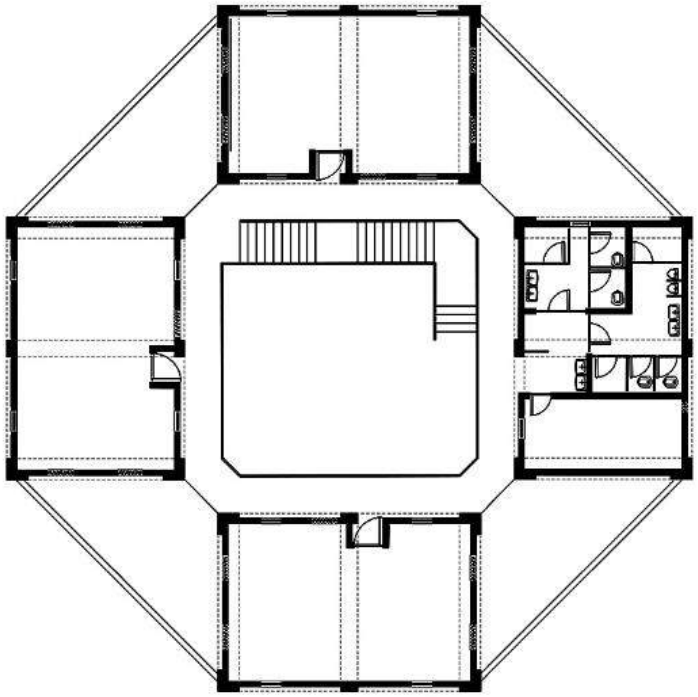


Figure 126 Use as Cyclone Shelter for Transient Community (Source: Author)

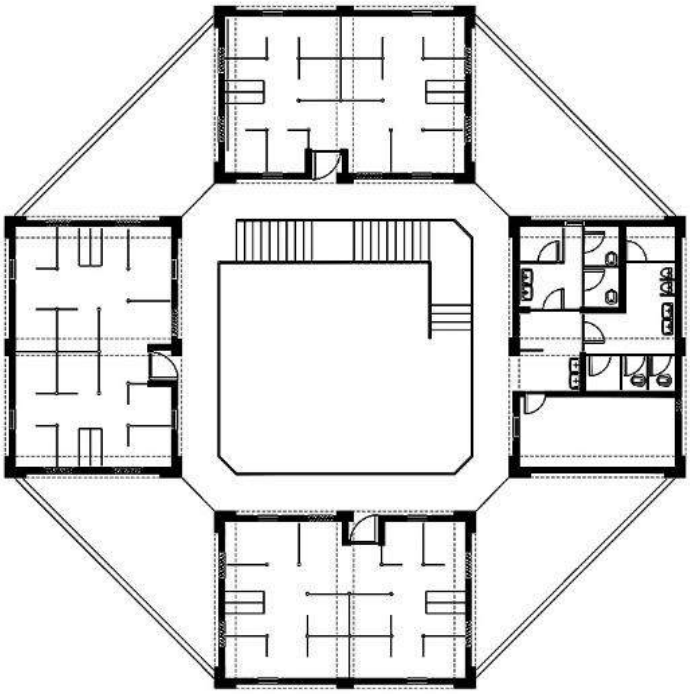


Figure 127 Use as Cyclone Shelter with Compartmentalization for Social Distancing (Source: Author)

16 CONCLUSION – THE WAY FORWARD

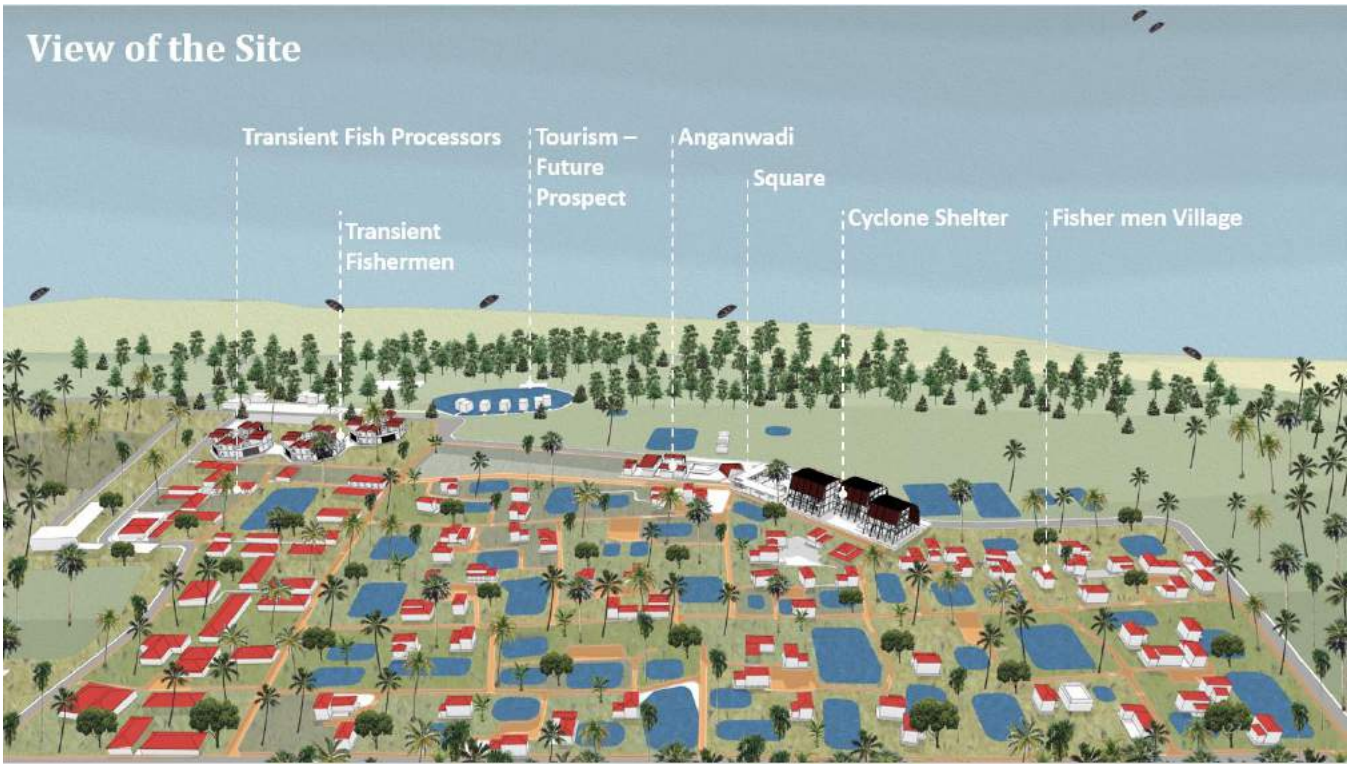


Figure 128 View of the Site

The thesis aimed at improving the live of the fishermen, a community reeling under the effects of climate change, through identification of vulnerabilities. The vulnerabilities are –

- Lack of proper housing
- Lack of community infrastructure
- Lack of access to climate related information
- Dependence on climate sensitive livelihood like fisheries and tourism

Owing to the fall in marine productivity, the increased number of disasters and unpredictability in climatic cycles, the community's ability to recover had been hampered due to the fall in economic capacity, and reduced time frame between subsequent disasters. The adaptive capacities of the community had been affected.

Thus, the community not only proper housing hat would provide a degree of protection against the increased frequency and intensity of cyclones, but also proper access to infrastructure and economic diversification to counter the loss of economic capacity. The inherent traditions and cultures had to be maintained in a design intervention, to allow the community to adapt to the surroundings in a post trauma situation. Flexibility and light weight structures formed the backbone of the built environment of the society, that would allow quick and cheap rebuilding through locally available materials. However, through urban influence, and aspirations, the idea

of a shelter had transformed towards an idea of permanence. This clashed with their inherent nature of resilience and recovery. Thus, a balance needed to be established between permanence and flexibility.

The design proposes housing units that provide a sense of security to the belongings of the fishermen while they may relocate to a cyclone shelter, which is better equipped to deal with their trauma during a cyclone through familiarity and a higher degree of community association. The cyclone shelter at the same time will act as a community asset, providing access to education, awareness and shared workspaces. The social space established around the cyclone shelter would act as an economic generator, attracting the population, with shops and social spaces. An *anganwadi* and women's' vocational training center established at the social space would provide the women with an opportunity for economic diversification through farming, fishing and training for hospitality, to cate to the already established tourism industry surrounding the site. Later on, there could be an expansion of the economic opportunity into tourism, through the establishment of a tourism resort, based on the farming and fishing opportunities, in the back drop of the coastal forest with proximity to the sea.

The site faces the major issues of ground water pollution through seepage of grey and wastewater into the soil. A grey water treatment plant is proposed that would treat the grey water and discharge it into the ponds for aquaculture, which is ultimately connected to the tidal inlet abutting the site. Soak pits for black water would allow the black water to seep into the ground, and later on, the solidified waste could be used as fertilizers on individual vegetable patches and community farming.

The issue of frequent power outages and unreliability of the electricity due to snapping of overhead wires during cyclones is countered by provision of solar panels for individual houses, reducing the energy consumption per capita. The excess [power is fed into a central grid for power back up at the distribution point, to be used by individual houses in case of power failure. This increases the energy reliability in the community.

Thus, the thesis aims to provide the community with a sense of pride and security, while maintaining their inherent quality of having minimum footprint on the environment, which was getting lost due to recent activities. The balance between continuation of identity while making space for progress was a critical consideration.

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18 ANNEXURE I - SITE

SITE – ANALYSIS OF COMMUNITY

Evolution of the Settlement

Mentioned in the Topographical map , 1956, no 730/10, Mandarmani was mainly a Fishing Village. During the past 35 - 40 years, temporary fisherman settlements are set up during the economic season of October to February. These transient features are unique to West Bengal. Fishermen migrate from Orissa, Mednipur (East and West), and South 24 Paragnas for trading activities.

2003
Scale (1:4000)

1. Mandarmani began to develop as an Eco-Tourism hub in 2001, with the establishement of its first resort, Tarangamala.

2. Prior to that, it remained a fishing village, with temporary settlements during the economic season. Otherwise, **Prawn Cultivation** was practiced by the local fishermen, apart from **Marine Fishing.**

3. The village was originally situated beyond the sand dunes, covered with forests of Pandanus and Casuarina acting as a natural barrier to the settlement.

2010
Scale (1:4000)

1. Employment opportunities increased in the area, causing the settlement to expand.

2. Settlements expanded by **clearing forests** and creating ponds for Prawn Cultivation, as a source of livelihood.

3. Benfish under Government of West Bengal dug Pond for Prawn Aquaculture. A **Khoti Office** was established.

4. Ganga and Manasa Temples were established near the Khoti Office. Fishermen pray to the goddesses before sailing every morning and at the end of the fishing season.

2015
Scale (1:4000)

1. Encroachment on the sand dunes in the form of Living quarters of Fish Trawler owners by further clearing out forests.

2. Retail shops and transports flourish during the economic seasons, further promoting economic activites.

3. Expansion of Fish Drying Areas.

4. Plantation of Cashew nuts, Coconut trees and Betel Nut trees as Cash Crops.

2020
Scale (1:4000)

1. Setting up of Cyclone Shelter in 2017 under National Risk Mitigation Project II

2. Setting up of Polyhouse for Controlled fish drying in 2017.

3. Expansion of fish Drying area.

4. Establishment of Prawn Processing Unit, maintained by Mahila samiti, as an alternate income for the Women of the village.

5. Contruction of Public Toilets for Community sanitation.

Built Typology by Material
Scale (1:2000)

Area of the village = 170 Ha

- Kuccha : Fisherman Village
- Pucca : Fisherman Village
- Temporary: Transient Settlement

Spatial Zoning

The Site area can be broadly divided into the foloowing Spatial Zones, each exhibiting a different spatial character whit varied requirements.

- Fisherman Village
- Transient Settlement: Fish Drying
- Transient Settlement: Fishermen
- Fish Drying Area
- Prawn Aquaculture
- Fish Trawler Owners


Commercial Square


Junior School


Khoti Office


Shiv Temple


Polyhouse for Fish Drying


Cyclone Shelter

Mahila Samiti Office

Prawn Processing Unit for Women


Medical Dispensary

Social Spaces
- Congregation
- Women
- Men
- Children

Infrastructure
- Toilets
- Cyclone Shelter
- School
- Medical
- Economic
- Grocery
- Clothes
- Tapri
- Administrative
- Religious

Public Infrastructure and Social Spaces
Scale (1:3000)

Activity Map

Permanent Fishermen Settlement

The resident fishermen practice prawn and other fish species cultivation along with Marine Fishing. They are the original residents of the area.

Landing Centre

Boats bring catch from the sea and the fishes are sorted here

Fishes caught are Shutki, Til Tapra and Prawn. These fishes are dried, processed and transported to markets in Kolkata, Assam and Orissa. They are also sold fresh to local markets.

Fish Drying Area

Demarcated Drying Area for Flat Drying on flat ground and Hung Drying on wooden Frames

Dense Vegetation

Dune Vegetation of Mangrove shrubs and Casuarina Trees

Storage

Demarcated Storage for Fresh Fish (2 days shelf life) and Dried Fish

Dune Vegetation holds the Sand dunes together by Dendritic Soil Binding, thus protecting the Settlement

Cyclone Shelter

Cyclone shelter set up by Department of Disaster Management and Civil Defence Government of West Bengal as a part of NCRMP-II

Prawn Processing Unit

Maintained by Mahila Samiti and Employing the women of the Permanent Fishing Village

Cultural Space

Temple ground acts as a congregation space for cultural and festive activities

Commercial Space

Adjoining the Office and Temple, it houses a grocery shop, chai shop, clothes shop, a toilet and a medical dispensary

Residences of Wealthy Fishermen

The Fish trawler owners are the residents of these houses. These are pucca houses in close proximity to the temple

Prawn Aquaculture (BenFish)

Prawn Aquaculture practiced by Temporary Settlers, in ponds dug by BenFish for WB Fisheries. In the village, the villagers practice aquaculture in ponds dug withing thei properties

Fish Drying Settlers

Fish Drying Settlements are interlinked and intergrated with Fish Drying activities within the same physical space.

Spaces are demarcated for huts of fishermen and fish processors in within the transient settlement. Settlements are clustered in nature. Fish processors have their livelihoods intertwined with their living quarters.

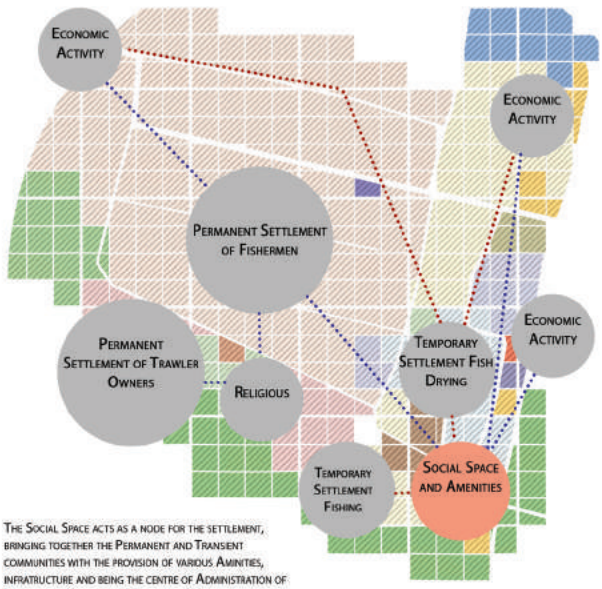
Temporary Fishermen Huts

Huts and trawlers are owned by individuals whi employ the fishermen during the economic season

Administration

Khoti office and Mahila Samiti offices for the Administration of New Jaldha Khoti.

Activity Linkages and Movement patterns



The Social Space acts as a node for the settlement, bringing together the Permanent and Transient communities with the provision of various Aminities, infratructure and being the centre of Administration of New Jaldha Khoyi and Mandarmani Village.

Activities

The main economic activities of the Village and Khoti include Prawn Cultivation and Fishing. Prawn cultivation is practiced by the local fishermen and established by West Bengal Fisheries through aquaculture under controlled conditions. The fishing and fish drying, however, employs majoritiy of the population in the settlement.

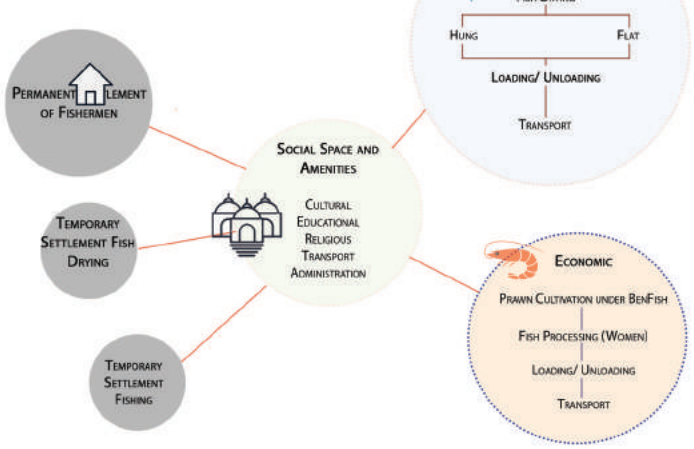
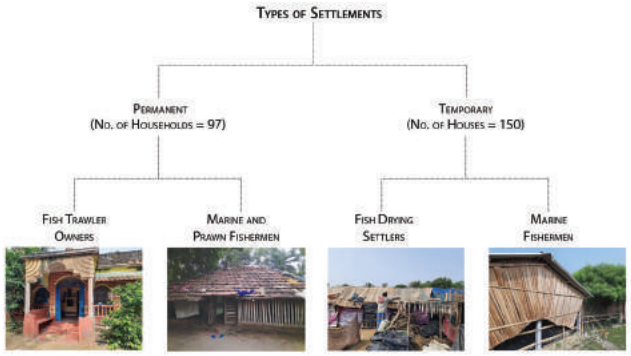


Figure Ground
(scale1:3000)

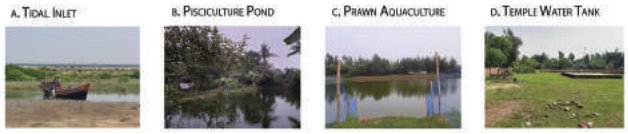
Types of Settlements



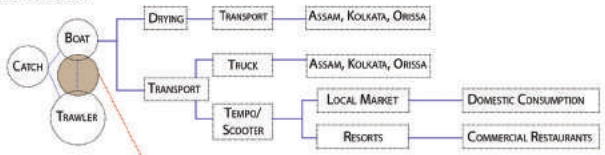
Demarcation of Settlements
(Scale 1:3000)

Water Bodies
(Scale 1:2000)

Types of Water Bodies



Fish Handling

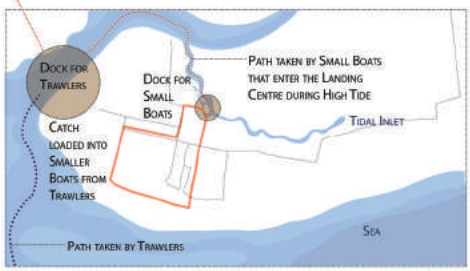


Water Table pre/post monsoon = (11/7) m

Tube Wells 150 m to 250 m depth (Community)

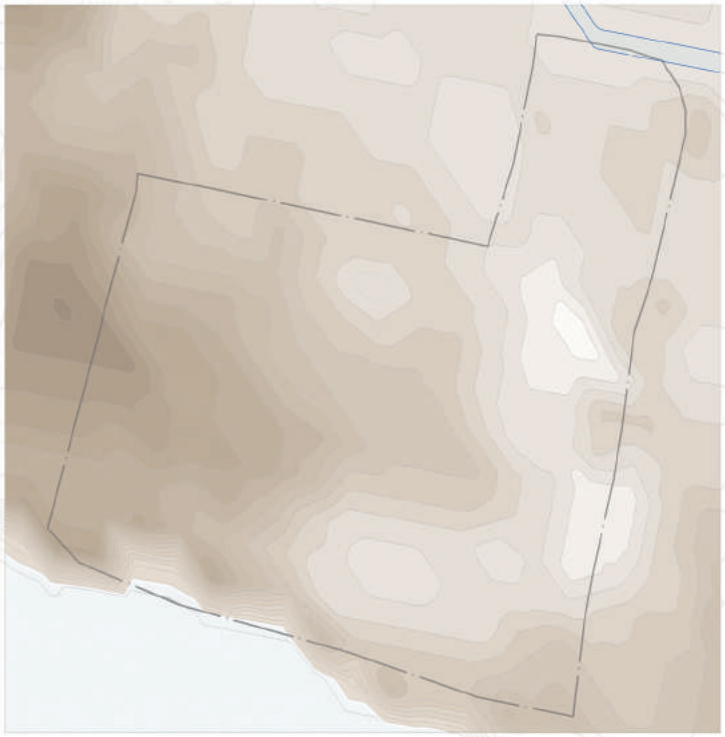
Manmade Pisciculture Ponds

Natural Water Bodies



Site Section
scale (1:1000)

Site Contours



Contour Map
(scale1:2000)

Soil type: Alluvium (Sand + Silt) Ancient Estuarine Deposit (early to Late Holocene)

Presumptive Bearing Capacity = 150 KN/ sq. m.

Aquifer Material: Loose sediments

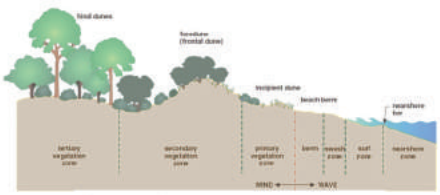
- level + 12.0 m
- level + 12.0 m
- level + 10.0 m
- level + 8.0 m
- level + 6.0 m
- level + 4.0 m
- level + 2.0 m
- Sea Level 0.0 m

Dune Landscapes

Frontal Zone (Fore dune) and Back Dune Zone (Hind Dune) Vegetation are crucial for the evolution of dune landscapes. The Frontal Zone is usually covered with grass and vines. In the Back Dune Zone, there are shrubs and herbaceous plants. This eventually gives way to coastal forest zones.

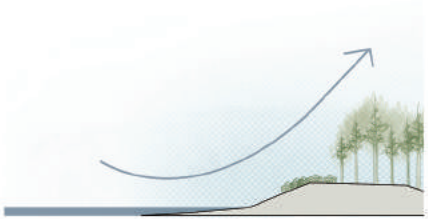
Wind velocity is reduced by plant cover, encouraging trapping and deposition of wind borne sand.

Typical Section of a Sand Dune



Source: Digha Shankarpur Developement Authority

Deflection and Trapping of Sand Borne



Natural Vegetation

Vegatation Map
(scale1:2000)

Bioshield (Predomnant Features):

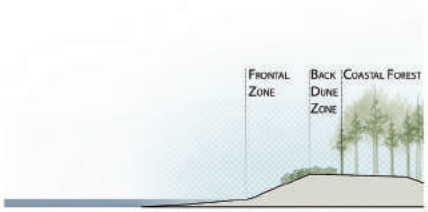
A. Casuarina equisotifolia

A Plantation tree, planted through Social Forestry.

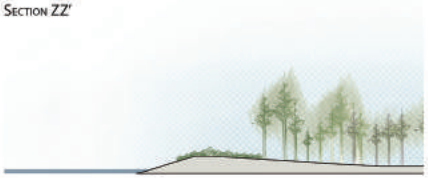
B. Pandanus

- Trees (Cash Crops)
- Roads
- Dense Vegetation
- Water Bodies

Sand Dunes and Natural Vegetation found in Mandarmani



Section ZZ'



Section XX'

Cash Crops/ Plantation Crops

Areca catechu (Beetel Nut)

Cocos nucifera (Coconut Tree)

Anacardium occidentale (Cashew Nut)

Acacia auriculoformis

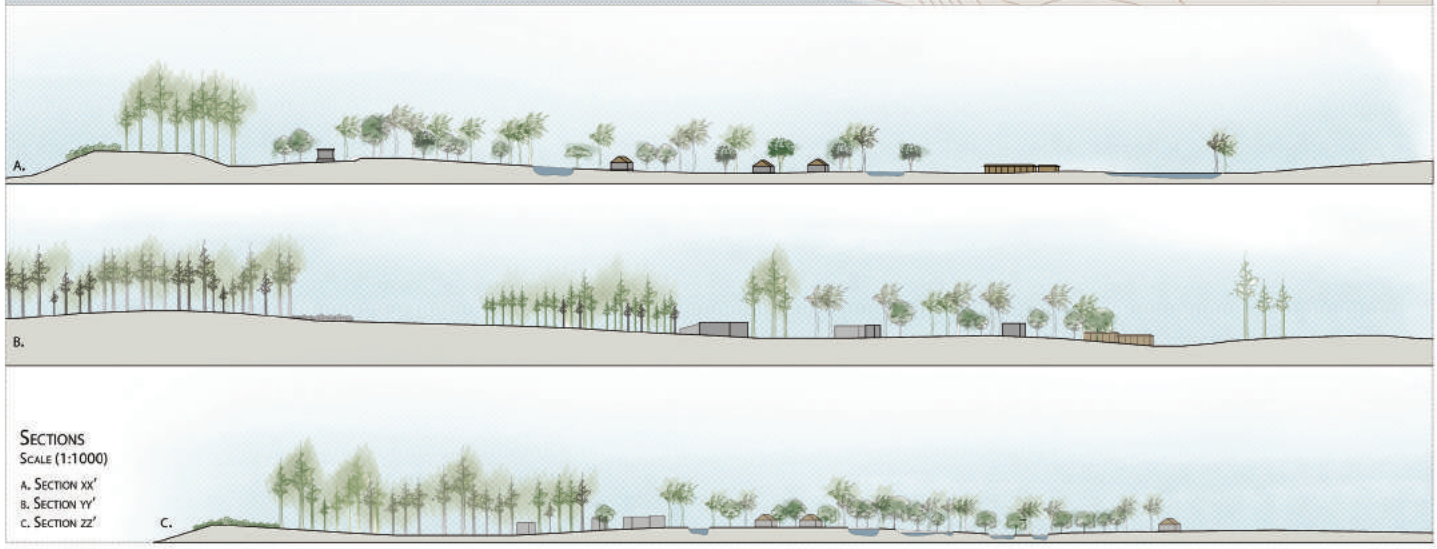
Site Section
scale (1:1000)

Designing for Resilience: Housing for Fisherman Community at Mandarmani, WB

Debeshi Ghosh
2015BARC026

Stage I : Introduction and Site Analysis
Contour and Natural Vegetation

Site Plan
Scale (1:1000)



Sections
Scale (1:1000)

A. Section XX'
B. Section YY'
C. Section ZZ'

Designing for Resilience: Housing for Fisherman Community at Mandarmani, WB

Debeshi Ghosh
2015BARC026

Stage I : Introduction and Site Analysis
The Site

EXISTNG UNITS (1:100)

A. FISHERMEN (PERMANENT)

B. FISHERMEN (TEMPORARY)

C. FISH DRYING SETTLEMENT

EXISTING UNITS

DEBESHI GHOSH
2015BARC026

TYPES OF BUILDINGS

NON ENGINEERED BUILDINGS :

- CONSTRUCTED FROM NON-STANDARD MATERIALS —
  - AGRI WASTE
  - LOCAL CONSTRUCTION PRACTICES

HIGH VULNERABILITY TO CYCLONES

SEMI ENGINEERED BUILDINGS :

- BUILDINGS MADE INTUITIVELY FROM STRUCTURAL MATERIALS —
  - BURNT BRICKS
  - LAID IN CEMENT OR LIME
  - RCC SLABS / ROOFS

GOOD RESISTANCE TO CYCLONES

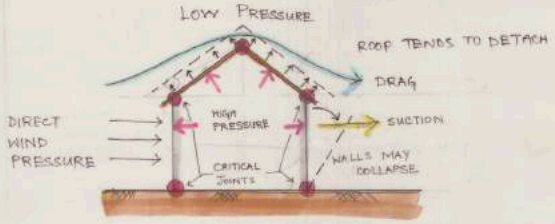
ENGINEERED BUILDINGS :

- DESIGNED AS PER RELEVANT INDIAN STANDARDS ;
- INCIDENTAL LOADS CONSIDERED

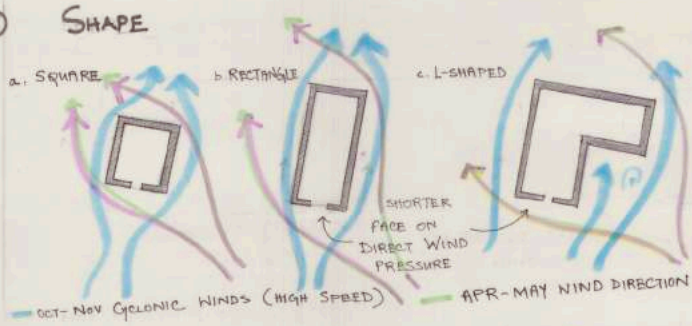
CYCLONE RESISTANT

CYCLONE RESISTANCE : TRADITIONAL HUTS

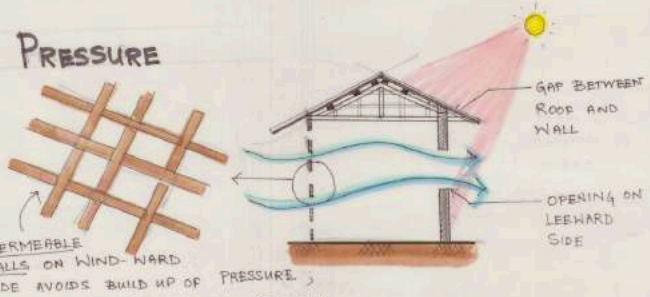
DESTRUCTION DUE TO PRESSURE BUILD UP/ DIFFERENCE BETWEEN TWO SIDES OF A SURFACE, CAUSING SUCTION.



1) SHAPE

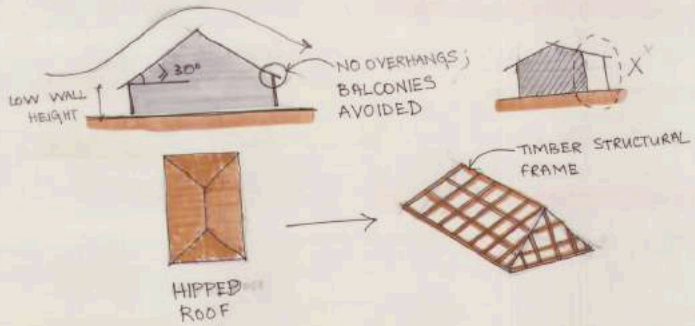


2) PRESSURE

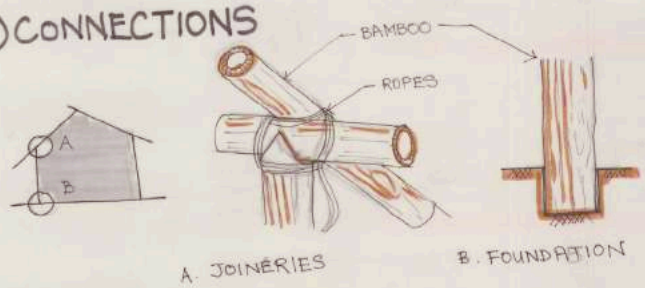


- PERMEABLE WALLS ON WIND-WARD SIDE AVOIDS BUILD UP OF PRESSURE ; ENSURES AIR CIRCULATION - REDUCING HUMIDITY

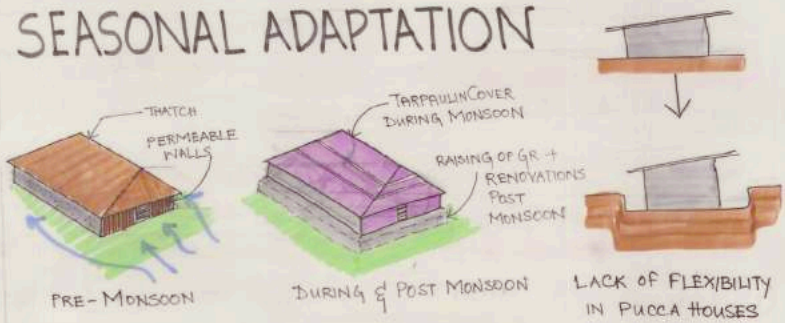
3) ROOF



4) CONNECTIONS

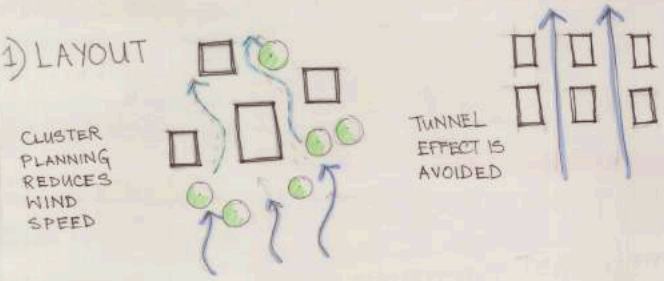


SEASONAL ADAPTATION

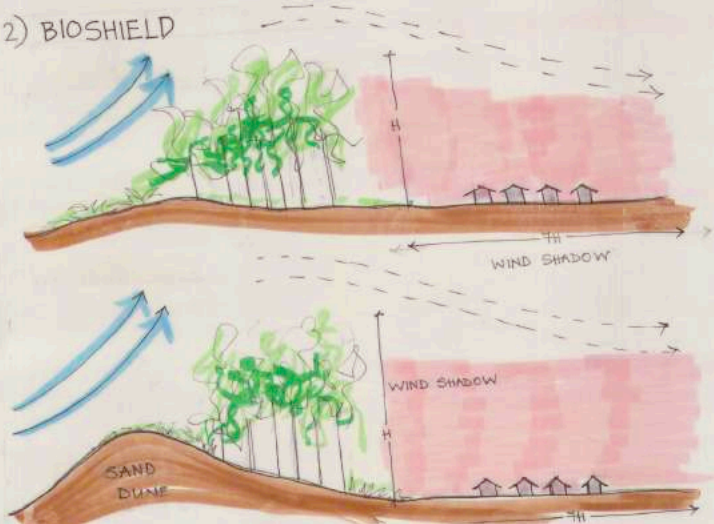


SITE PLANNING

1) LAYOUT



2) BIOSHIELD

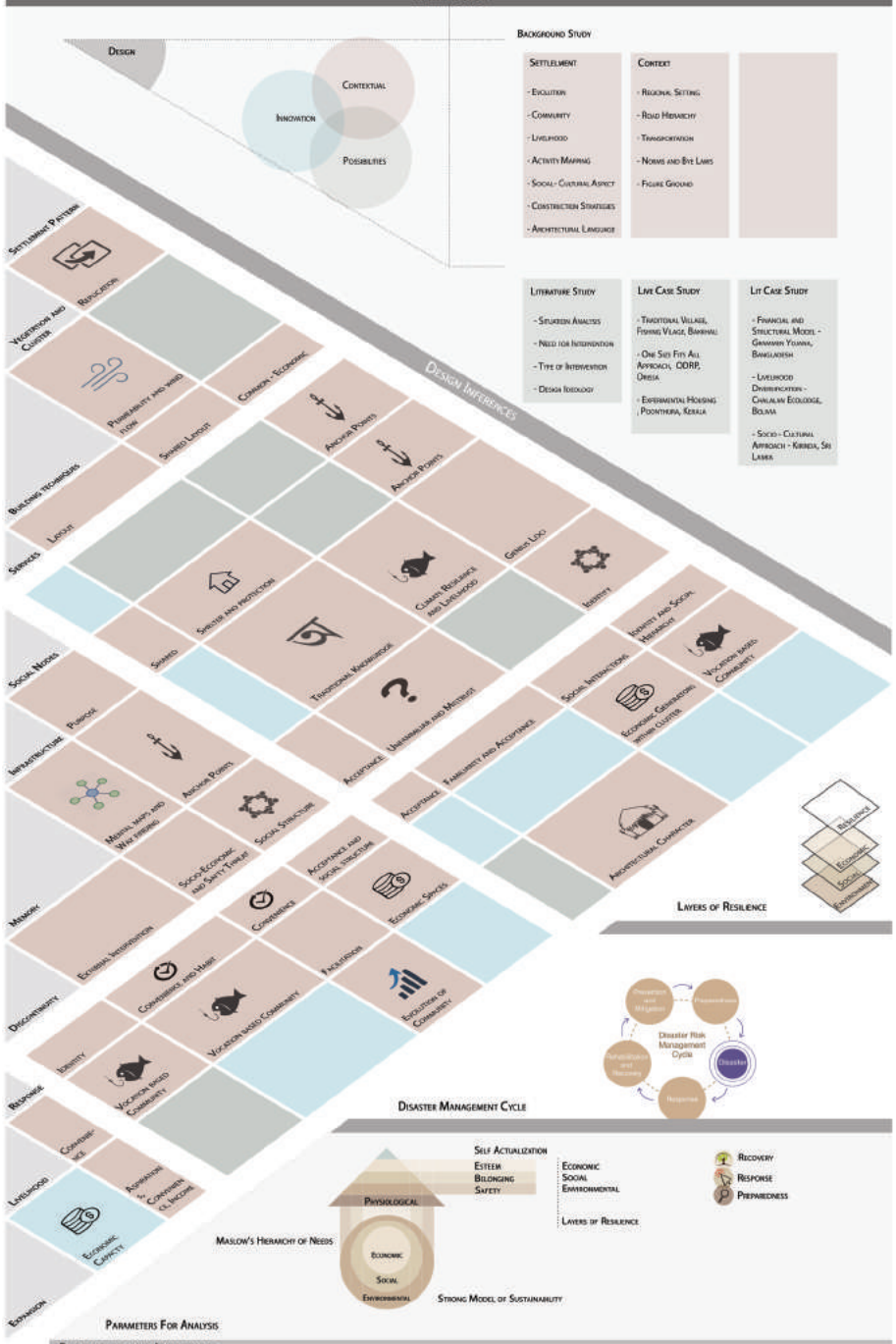


18 ANNEXURE II – CASE STUDIES

CASE STUDIES – COMPARISON AND INFERENCES

Case Study	Bakkhali	Poonthura, Kerala	ODRP, Orissa	Bangladesh	Kirinda, Sri Lanka	Inferences
Relevance	1. Local Context 2. Climate Adaptation 3. Cyclone Resistance	1. Vocational Need Incorporation in Housing 2. Cyclone Resilience 3. Factors of Expansion	1. Impact of Rehabilitation on the social and cultural dimensions of a community	1. Structure of Houses 2. DRR through Economic and Habitat Security	1. Materials and Technology 2. Revitalize social and cultural aspects of a Society	
Project Typology	Traditional Village	Community Housing Redevelopment	Community Housing Reconstruction	Structural Design	Post Disaster Redevelopement	
Disaster	Cyclone, Storm Surges, Coastal Erosion	Cyclone, Receding Sea Shore	Cyclones	Cyclones, Flood, Tropical Storms	Tsunami, Cyclones, Storm Surges	
Environmental | Safety | Preparedness						
Settlement Pattern	Linear Pattern Predominant  Linear pattern along the road, Scattered settlements in the interior	Staggered Rows 	Linear Pattern 		Linear Pattern Predominant  Linear pattern along the road, Scattered settlements in the interior	Tendency of settlements to develop linearly along abutting road and organically inwards
Vegetation and Cluster Planning	Wind Breaks  Trees acting as wind breaks, preventing funnel effect	Funnel Effect  In the absence of vegetation, cluster planned to allow wind to pass without hindrance			Bio-shield  150 m buffer vegetation and strategic plantation of trees as Bio-shield	Vegetation used to channelize or block wind flow as a measure of cyclone resilience
Building Techniques	a. Permiable Walls b. Regular Shapes, No Overhangs 	Continuous lattice work to let winds pass without hindrance Open walls: to dispel the force of wind 	a. RCC Columns b. Masonry Walls for structural stability against cyclones 	a. CI Roof Sheet b. Concrete Columns c. Plinth 	Local Materials  Clay Tile Roof Timber CSEB Timber Timber	1. Techniques and Materials familiar to community are better accepted and implemented 2. Structural stability through securing corners of a regular shaped plan
Services	Water Supply: Community Tube Wells	Water Supply: Piped Water Supply Drainage: Covered Drains to river, causing Clogging of the River	Water Supply: Piped Water Supply from OHT Drainage: Covered Drains to Chilika		Drainage: Drainage Rearranged according to topography	Water Supply and Drainage of primary importance while settlement planning. Presence of electricity in all.
Social | Belongingness | Response						
Social Nodes	Religious: Fishing Activities: Market 	a. Markets Places for Community; b. Religious structures like Church 	a. Women: Plinths of houses; b. Men: Shops and Tapris 		a. Women: Courtyards of Houses; b. Men: Mosque and Market 	Economic spaces, Religious spaces, Infrastructure and spaces for collection of water serve as primary Social Spaces
Infrastructure	a. School b. Cyclone Shelter 	a. Community Hall b. School c. Health Faciliy d. Anganwadi 	a. Community Centre b. School in the vicinity 	Funding and Construction of Educational Pre Schools		Infrastructure acts as anchor points for settlement development and help in acceptance of rehabilitation housings
Memory	Traditional House Layouts  Plan Elev A; Section XX'	a. Built open relationship - open space used for storage and mending of nets and catch b. Living in close proximity to the Sea - Interlinking of vocation with housing 	a. Joint family system b. Markets as social and economic anchors c. Festivals and Culture 	a. Clustered pattern b. Thatched Houses with Mud or straw walls c. Close proximity to ponds and agricultural fields as economic generators 	a. Thatched Houses with Mud or straw walls b. Proximity to religious nodes c. Vegetation of consisting of Coconut trees 	The enrichment of memory within a housing project determines the degree of acceptance and user changes.
Discontinuity		Rehabilitation Plan 	Rehabilitation Plan 	Not Apparent. Continuity maintained through materiality, function and spatial morphology. 	Rehabilitation Plan 	Allowing sufficient space for user changes, expansion, embodiment of memory and livelihood within housing.
Economic | Esteem | Recovery						
Repurcussions and Response	Greater intensity and frequency of cyclones causing widespread destruction, demanding better resilience.	Initial reluction of Housing Redevelopment provided due to lack of community infrastructure	Rehabilitation posing threat to safety and loss of livelihood due to its location, Socio-cultural disruption.	Rehabilitation exhibiting a positive impact on society with respect to disaster resilience and economic conditions.	Immediate relief in post disaster scenario. Issues related privacy and leading to blocking of courtyard and poor ventilation.	Presence of amenities, degree of commitment, mental maps and safety decide acceptance of a rehabilitation
Predominant Livelihood Patterns	Fishing and related activities a. Fishing b. Fish Drying 	Fishing and related activities a. Ice Plant b. Fishing boats 	a. Fishing b. Boat Making 	Miscellaneous	Fishing and related activities	Fisherman communities, having a resourceful lifestyle exhibit high linkage between social, economic and housing spaces.
Expansion	Horizontal single storeyed expansion predominant in the form of standalone additions forming clusters 	a. Vertical b. Horizontal 	Horizontal expansion in the form of confinement of open spaces for utilitarian purposes 			Horizontal expansion prevalent, with a pattern of temporary confinement followed by permanent extension
Qualitative Comparison : Resilient Housing						

Methodology



Parameters and Inferences

Case Study — Quantitative and Qualitative Comparison, Inferences.

Debeshi Ghosh
2015BARC026

19 ANNEXURE III - DESIGN

DESIGN PROPOSAL - PRESENTATION

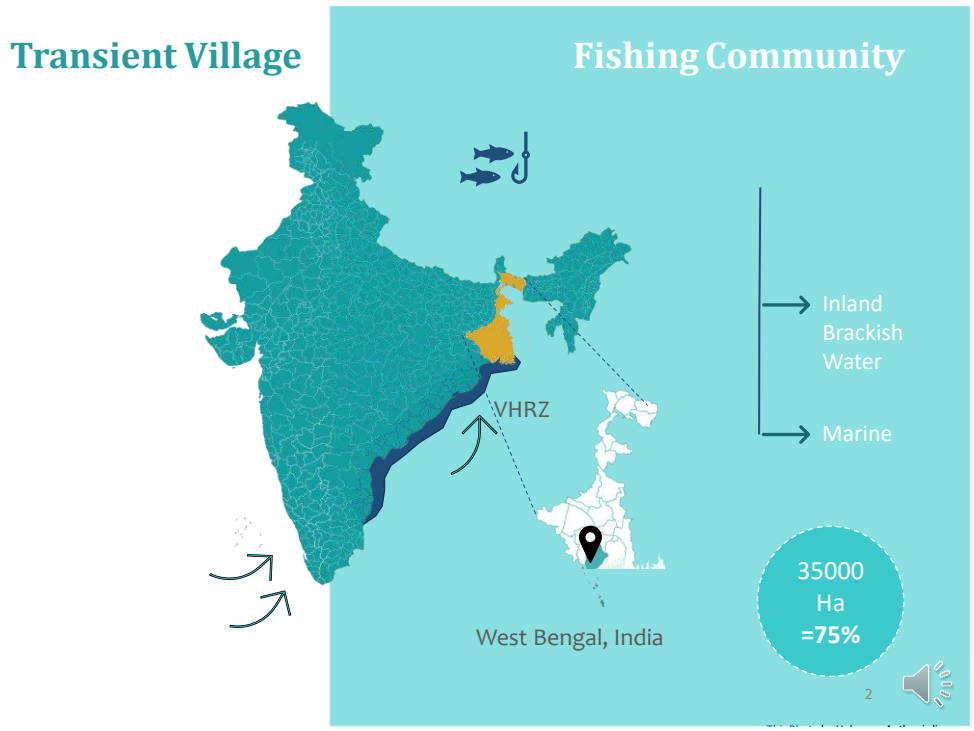

Designing for Resilience
Housing for Fisherman Community at Mandarmani, West Bengal
1

1


Fish Drying

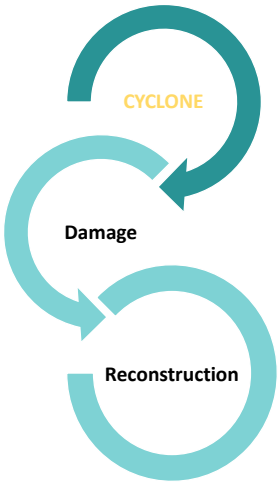

Fish Processing


Community


Transient Village
Fishing Community
VHRZ
Inland
Brackish
Water
Marine
West Bengal, India
35000
Ha
=75%
2

2

Repetitive Cycle



Fishing Community

Inland
Brackish
Water

Marine

35000
Ha
=75%

3

3

Tourism

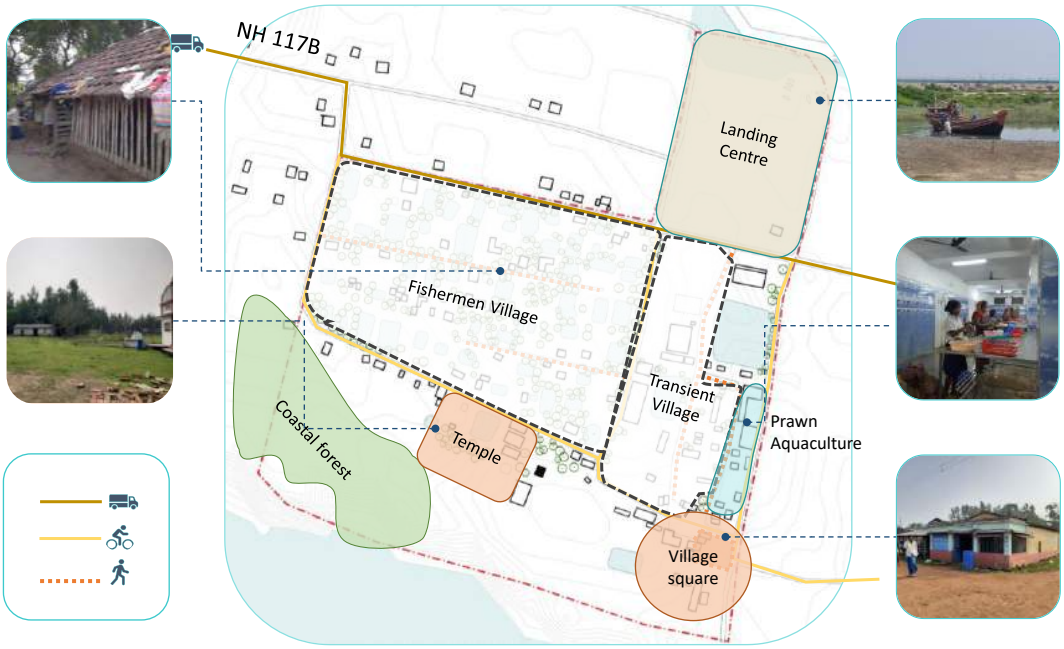
Viceroy Hotel

Marino Resort

4

4

Existing Site

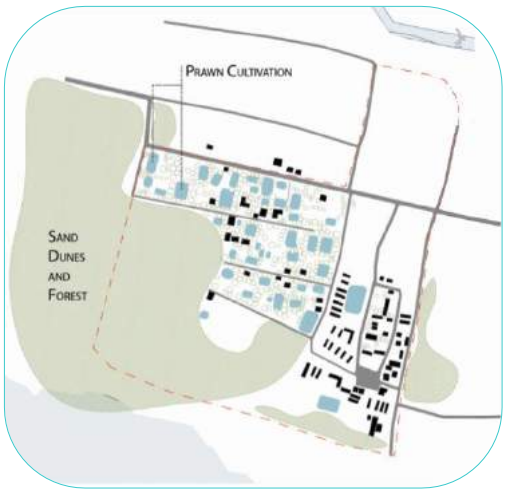


5

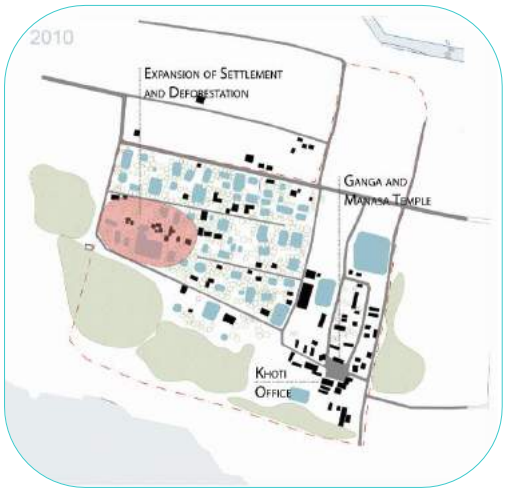
5

Evolution

2003



2010



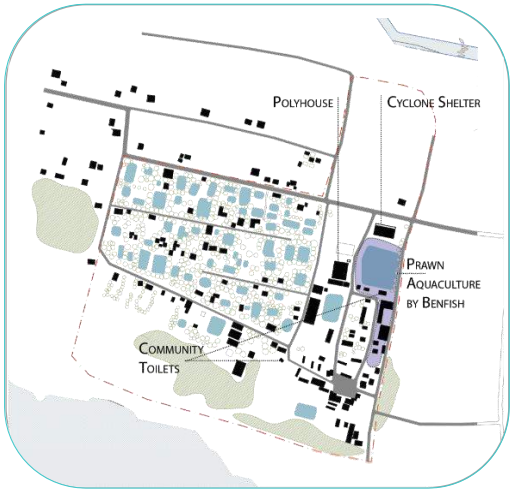
6

6

Evolution

Cyclone Amphan

2020



'Covid-19 took my job, Amphan the rest': Cyclone devastates Bengal

Half a dozen districts, including large parts of Kolkata, wore a battered look as lakhs of people were homeless and low-lying areas swamped by the cyclone that slammed the Digha coast of West Bengal

Topics
Cyclone | West Bengal | Lockdown

Press Trust of India | Kolkata
Last Updated at May 21, 2020 20:33 IST

Estimated Causes

- Deforested Coast
- Structural Failure
- Social Distancing

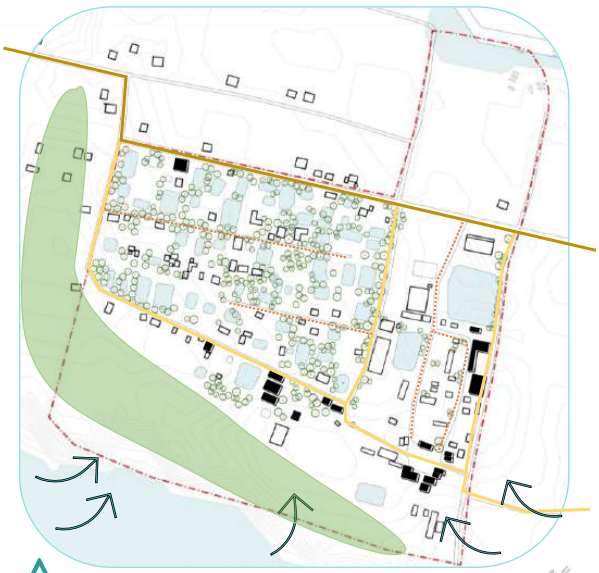
7

7

DISASTER
Response
Recovery
Reconstruction
Preparedness

Roof and Foundation – Critical Points

Effect of Disaster on Site



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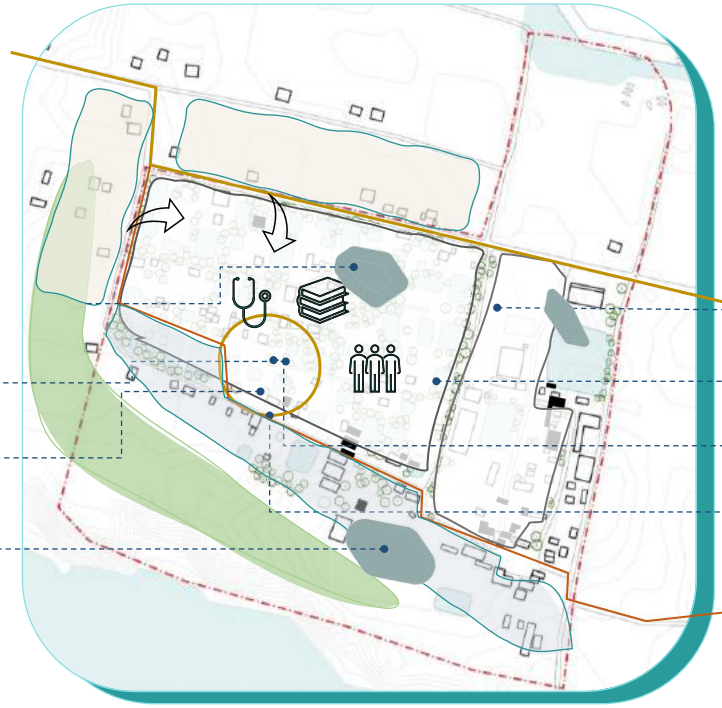
Preparedness



Troughs – Natural drainage

Road bent – slow down traffic

Social use of space – limit road frontage

Economic diversification– tourism

Response - Emergency Shelter

Reconstruction – Resilient Units

Cyclone Shelter – Higher ground

Social Space and Infrastructure

Recovery

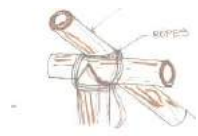
9

9

Preparedness through Architecture

Existing (Village)

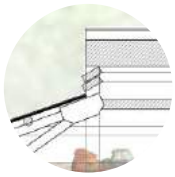
Permeability

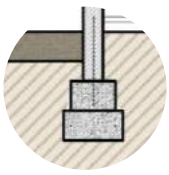


Roof Connections

Foundation

Housing

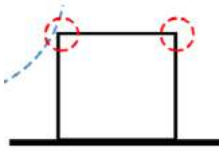




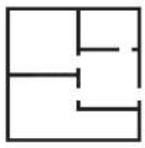
Proposed

Existing (NDMA Guidelines)

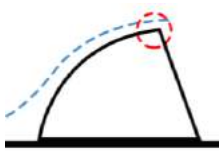
Cyclone Shelter



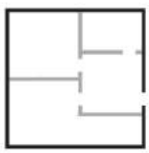
Rectangular



Space divided



Positive Pressure



Flexibility

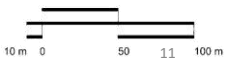
Proposed

10

10

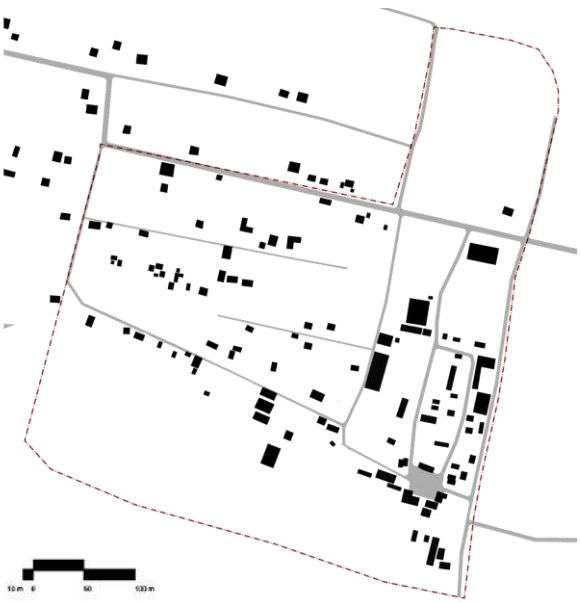
Legend

1. Existing Landing Centre
2. Transient Processing Community
3. Transient Fishermen Community
4. Fishermen Village
5. Cyclone Shelter
6. Anganwadi
7. Village Square
8. Existing Temple Ground
9. Revived Coastal Forest
10. Tourism Resort – future expansion



11

Existing Figure Ground



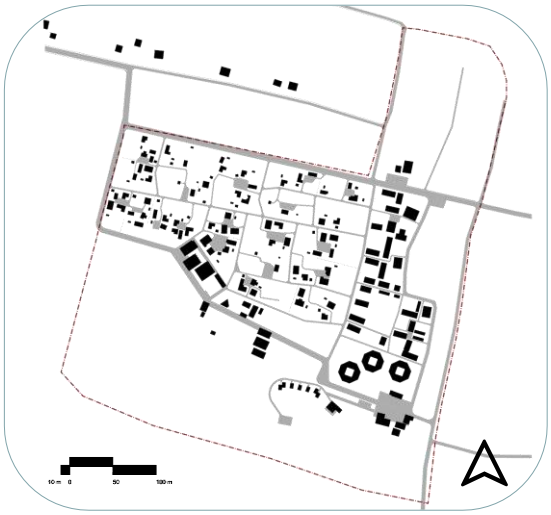
Proposed Figure Ground

12

Area Statement

Plot Area = 165000 sq. m.
Total Built Up Area = 10500 sq. m
Area on Ground = 8600 sq. m
Ground Coverage = 5%
Maximum height for Residential (CRZ) = 6.5 m

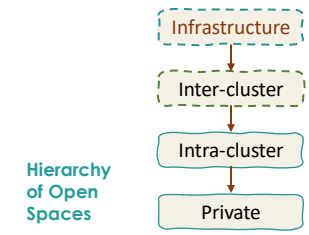
Component	Area (sq. m.) Details
Fishermen Village Housing	3440 23 sq. m for resilient units
Outdoor Spaces	360
Transient Community – fish processors	2700
Transient Community – fishermen	2300
Cyclone Shelter - Medical	290
Cyclone Shelter - School	410
Cyclone Shelter – Community Building	540
Anganwadi	300
Shops	135



13

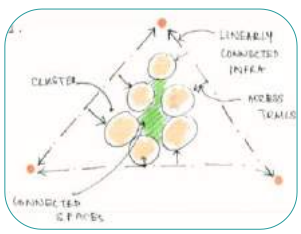
13

Spatial Linkage



Hierarchy of Open Spaces

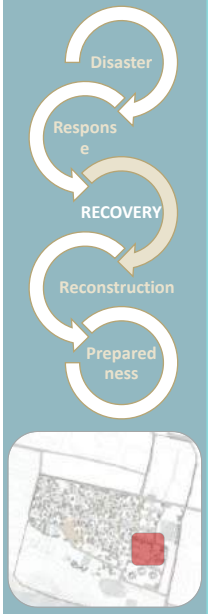
Spatial Logic

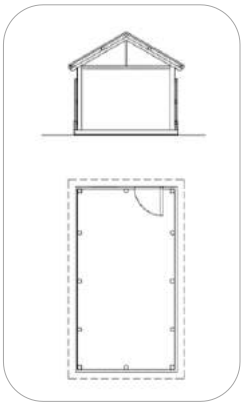


14

14

Transient Village





Unit Plan and Section of Emergency Shelter

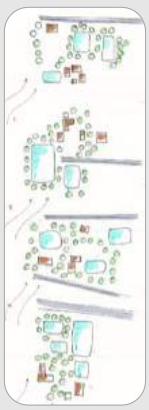
15

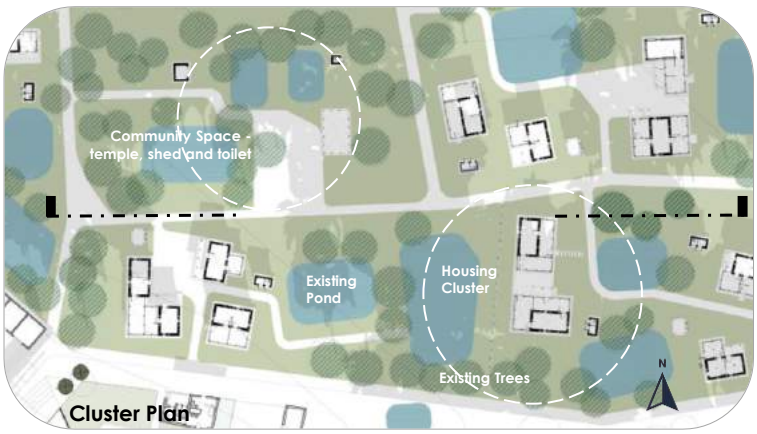
15

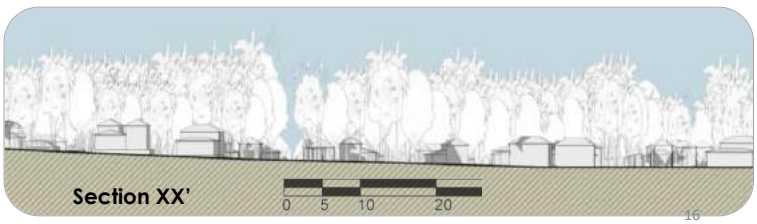
Village Cluster Housing

Spatial Logic

Existing Clusters



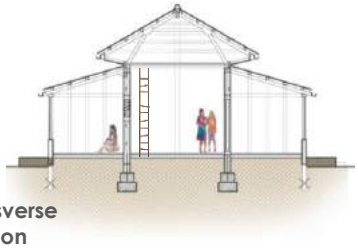




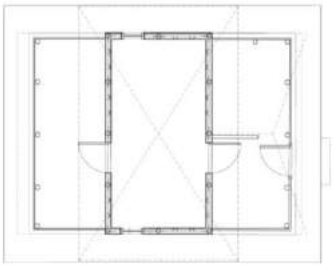
16

16

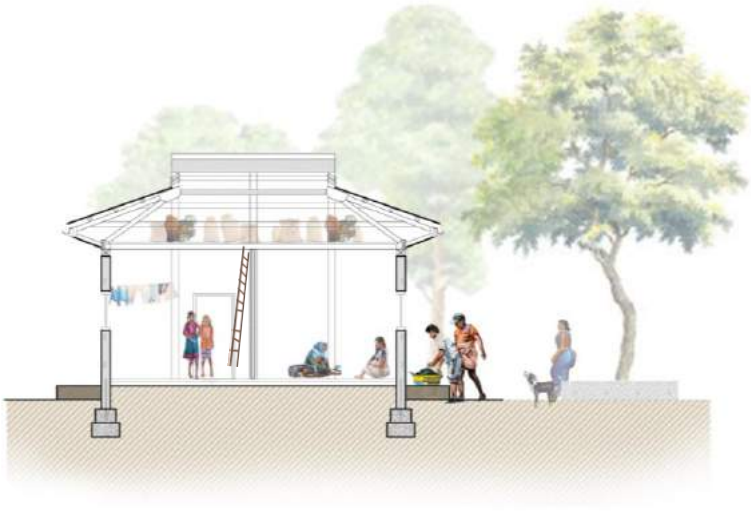
Housing Unit Prototype



Transverse Section



Unit Plan

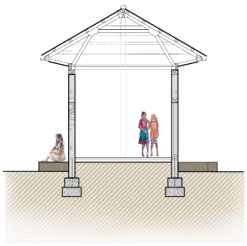


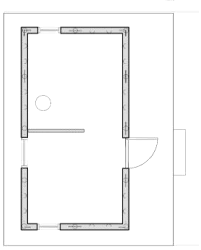
Longitudinal Section

17

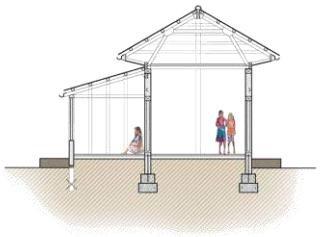
17

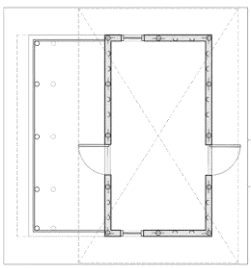
Incremental Expansion



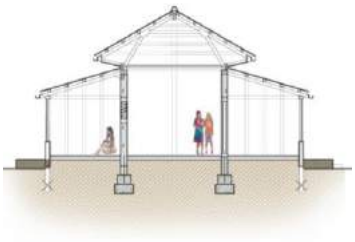


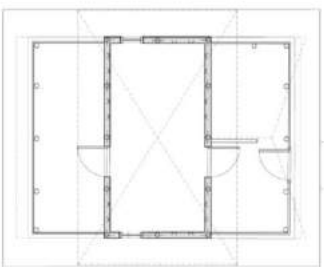
Stage 1





Stage 2

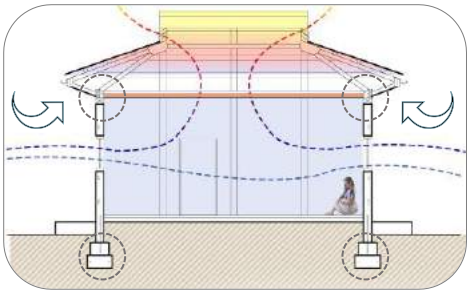




Stage 3

18

Housing Unit Prototype



Air Circulation

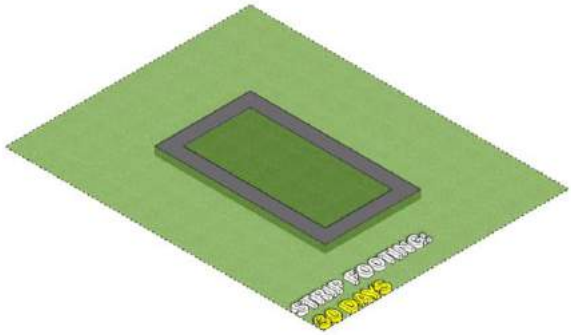
Component	Cost	Component	Cost
Roof	23000	Door	4000
Wall	15000	Flooring	26000
Window	6000	Foundation	70000

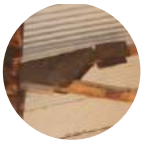
Total Cost 1 Lakh, 45 thousand

Cost Analysis

Details

Construction Process



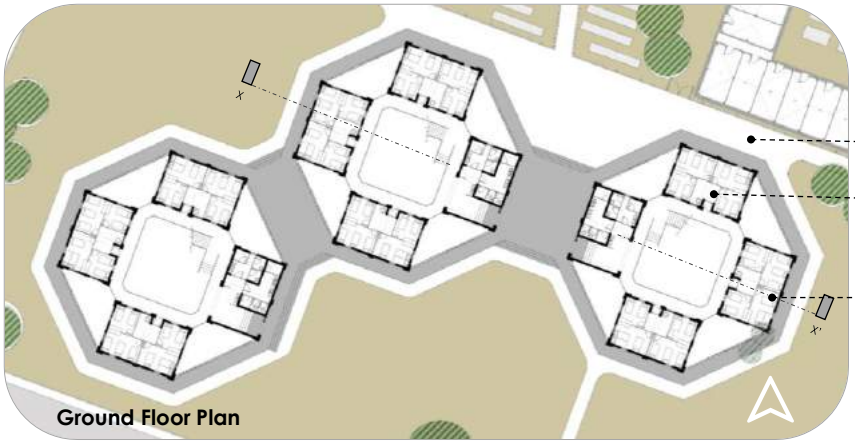

Technology and Material

19

19

20

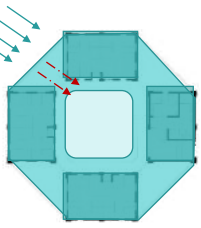
Housing for Temporary Community



Pedestrian access

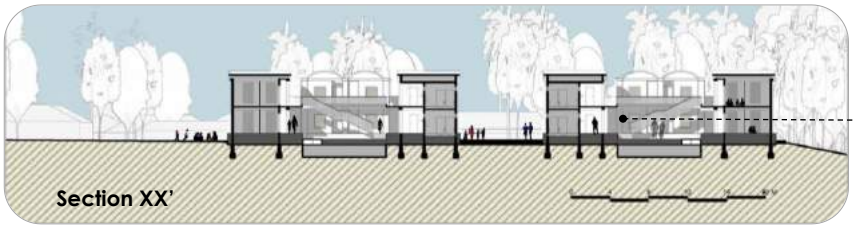
Entrance and toilet block

Rooms with common kitchen area



Shape

Key Plan



Courtyard for daily activities

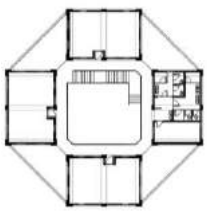
21

Housing for Temporary Community

Courtyard

Entrance and toilet block

Rooms with common kitchen area



Use as Cyclone Shelter

Alternative Usage

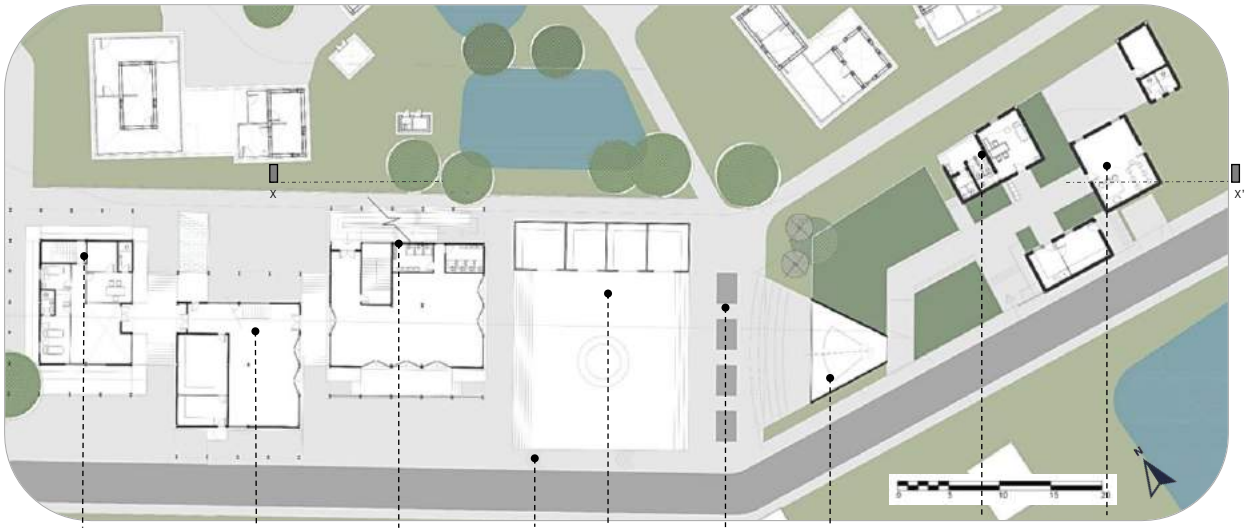
Compartmentalization for Social Distancing

22

22

23

Village Square – Ground Floor Plan



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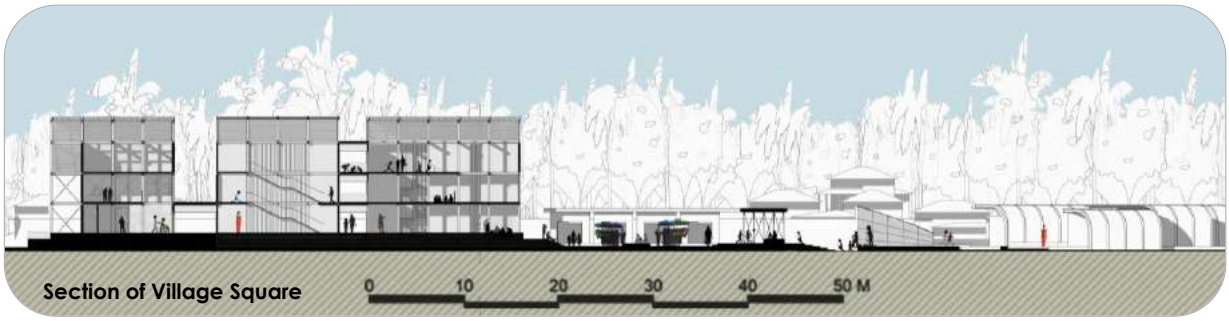

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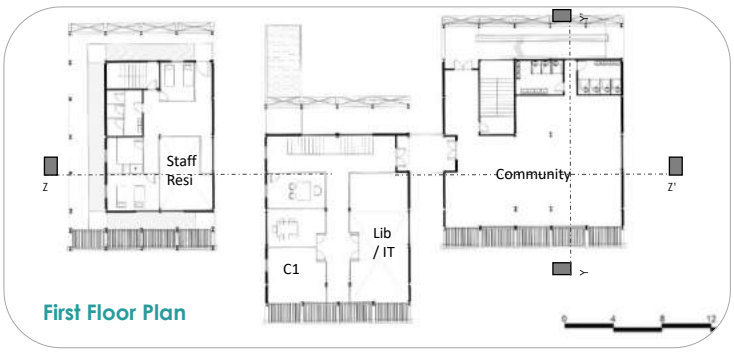
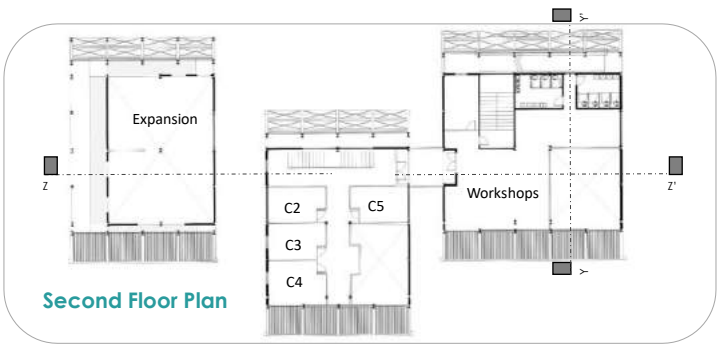
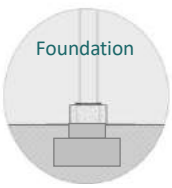
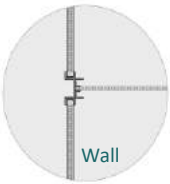
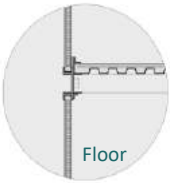




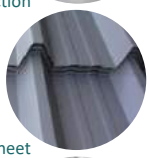
Cyclone Shelter



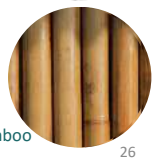





MS I-section


Profile Sheet

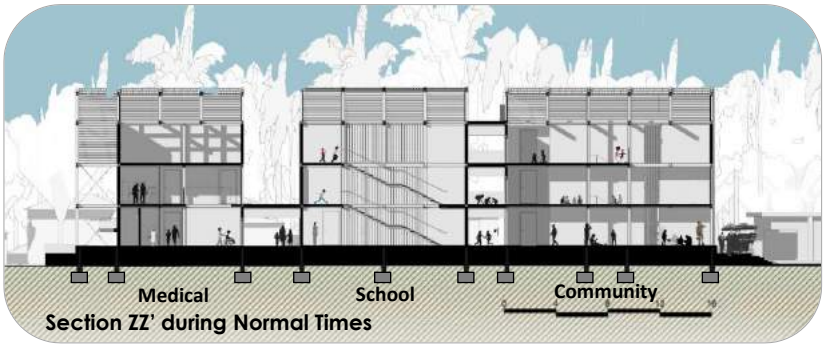

nent Plaster

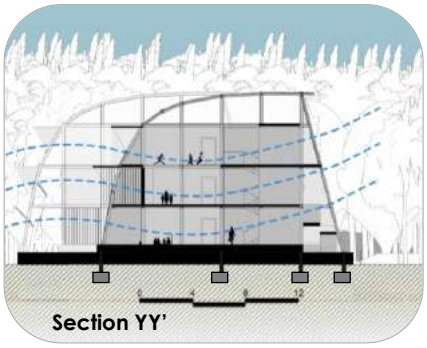

Bamboo

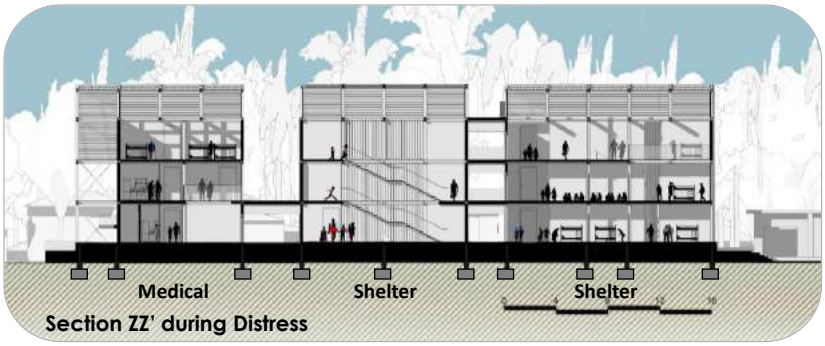
Materials and Joineries

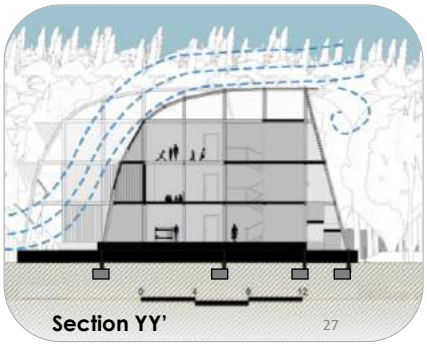
26

26


Medical
School
Community
Section ZZ' during Normal Times


Section YY'


Medical
Shelter
Shelter
Section ZZ' during Distress


Section YY'
27

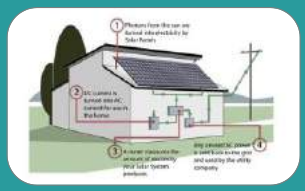
27


View
28

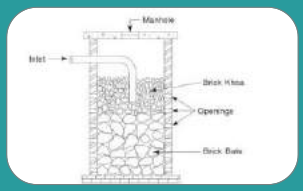
28

Electricity and Wastewater

Solar Power



Soak Pit for Black water



Water Treatment for Grey water

Service Layout

Distribution Point for Electricity

Wastewater Treatment Plant

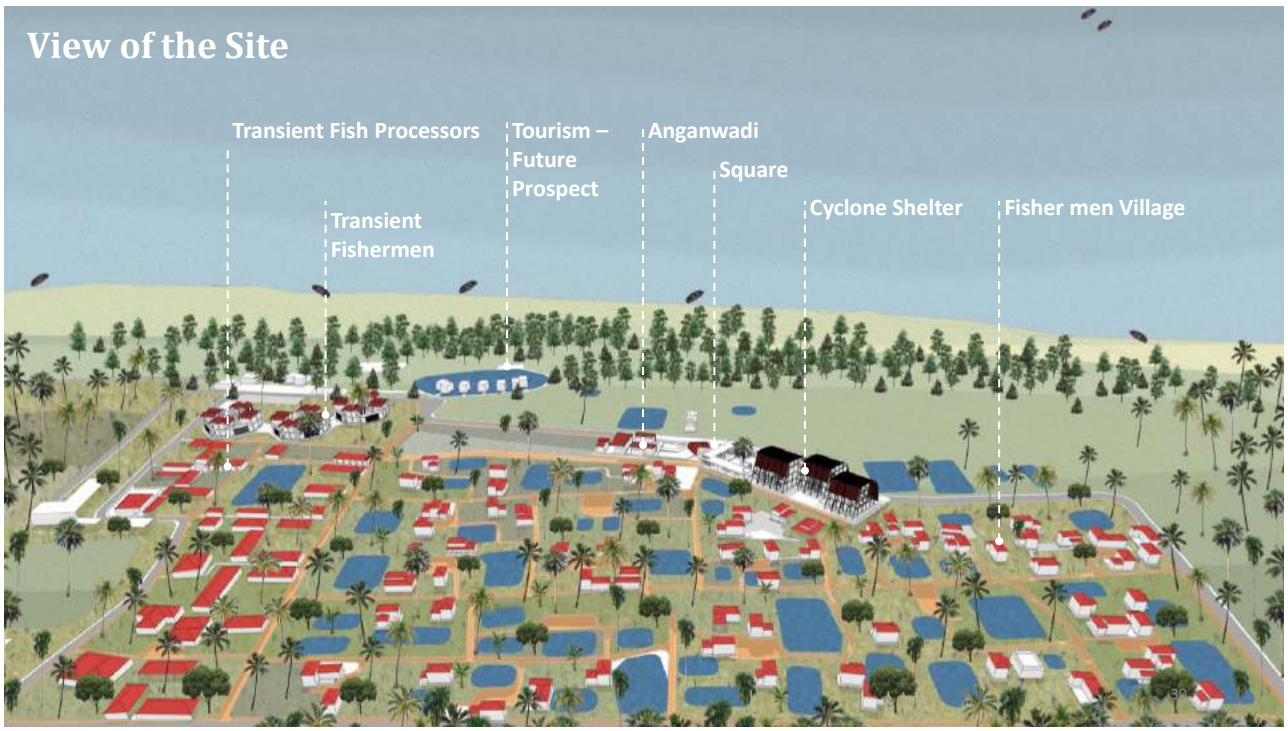
Legend

- Wastewater
- Electrical Trenches
- Plot Boundary

29

29

View of the Site



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20 ANNEXURE IV - COMMENTS

20.1 REVIEW 1 – SITE ANALYSIS

1. To incorporate economic diversification within the project to enhance feasibility and economic capacity.
2. To consider tourism as an economic opportunity, given the established tourism industry existing on the site.

20.2 REVIEW 2 – CASE STUDIES

3. Improving the quantitative analysis with respect to the proximity of function from housing
4. Questioning the viability of tourism in the setting of a fisherman village community
5. Increasing the scope of design

20.3 REVIEW 3 – CONCEPT

6. To incorporate tourism trails that would show case the daily lives of the fishermen and give the tourists a closer experience of the village.

Note: Due to the occurrence of Cyclone Amphan and the corona virus disease, the viability of tourism as an immediate development was dissolved. Tourism was hence incorporated as a future expansion in the design process, with the design intent focusing on reconstruction and infrastructure in the community.

20.4 REVIEW 4 – DESIGN PROPOSAL

7. To mention the major stakeholders in the project, for the viability of the finance and cost of construction
8. To consider how the community could be convinced to opt for a hybrid construction instead of the “pucca houses”