BUILDING RESILIENT COMMUNITIES THROUGH ARCHITECTURAL INTERVENTIONS: TOWARDS A SUSTAINABLE FUTURE

A Dissertation for the Degree of Master in Disaster Management

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ABSTRACT

The global context and the climate is changing rapidly and this poses a major threat to the population and their habitat to cope with the changing dynamics of the surroundings. Hence, the habitat that house entire communities that in turn build entire nations need to be structured in a safe and robust manner that can easily adapt to adversity. These solutions can be achieved through architectural designs that are affordable, safe, socially /environmentally conscious, socio-culturally appropriate. This paper hence, highlights the architects as professionals who are not only the namesake for mainstream designs but are most vital components in the preparedness and reconstruction phases of the DM cycle capable of achieving sustainability and resilience through interventions.

The concept of architects and architectural interventions is seldom highlighted or appreciated in the disaster management cycle. Therefore, the thesis in its first chapter gradually unveils the concept of the disaster management cycle and its link to approaches that focuses mainly on interventions/solutions that are architecturally related to achieve sustainability.

The subsequent chapter clarifies the link between DM and architecture even further by show-casing examples of countries from all over the world that have been affected by destructive natural calamities and have benefitted through innovative designs. The case-studies were seen through the lens of an architect and the process of reconstruction of each example was outlined for different types of hazard. In doing so, the process revealed the different kinds of architectural interventions or creative solutions in detail that carry the potential of becoming catalysts for a sustainable future.

In the concluding chapter, the process was further analyzed for pros and cons and in this way ideas were presented as to how the projects or solutions can work more effectively and how it can be further improved. The essence of the thesis is to carry forward the concept of architectural innovations and its effectiveness in the DM system so that is can be adopted sooner to see a much more improved and “built back better” world in the approaching times of impending disasters.

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INTRODUCTION

1.1. BACKGROUND

Disaster is an irrevocable phenomenon that brings with it a string of destruction. It affects the human population, their property and their economical status. In other words, the destruction ravages through people, property and their positions costing their lives, homes and their morals. Nature- a pure architecture of the Almighty can never be tamed. It unleashes itself with unfathomable might and is unmatched. This rebellion of nature arises due to the constant impact it receives from mankind and their activities in the form of unplanned settlement and growing urbanization of cities; population growth in magnanimous proportion and aging infrastructure along with other debatable issues such as climate change and global warming. Disasters combine two elements: events and vulnerable people. (IFRC, 1993). Like they say- **“without people there is no disaster”**(O’Keefe, Westgate & Wisner, 1976) and hence this climb in vulnerability of the human population is to a large extent due to the changes in the ecosystem and environment by men themselves. The rest is just because nature works in mysterious ways. Hence, should a hazard turn disastrous, it is very necessary to take appropriate steps by multi-disciplinary professionals towards sustainable goals.

Hazards can easily take shape of a disastrous situation and cannot be contained but it can be made bearable to the victims during its onset and long after it strikes. This can be done by increasing the adaptive capacity of individuals and the community through innovative and coping strategies and solutions. These solutions can be hence engineered in a more comprehensive and faster manner by architects and designers notably during **preparedness** and the **reconstruction phase** for a better and resilient tomorrow.

Yes, the two words “disaster” and “architecture” appear to be unrelated, history shows the connections. Marcus Vitruvius Pollio, a Roman architect in the 1st century BC, asserted that a structure must exhibit the **three qualities** of **strength, usefulness, and beauty** in his only surviving work *De Architectura*.(Murao, 2008). Architecture means “construction” or “evolution” of an idea or concept that can be implemented whereas ‘disaster” denotes “destruction” and “demolition” of matter or objects. One is useless, weak and unsightly without the other really. Just like the ying and yang – architecture plays a vital role in balancing out the destruction in the different phases of DM cycle and helps in establishing harmony within the chaos. This restoring of balance and harmony is sustainability and resilience and can be achieved through architectural interventions.

Even though, “Architecture “and “Disaster Management” is often viewed as separate disciplines belonging to different school of thoughts; these fields are actually branches of the same tree where the raw materials needed for its growth is the same. Architecture does not only mean practicing mainstream design concepts but its root lies in shaping up a community through design measures. Mainstream architecture maybe so called “trending” in the eyes of the regular mass but the fact that it can have a new meaning and style also cannot be undermined. Just like there are different styles in architecture in the likes of modern, traditional, deconstruction and so on-another interdisciplinary style may exist that is the blend of architecture and disaster management (Murao,2008). The literature on natural hazard mitigation directed toward the architectural profession is scarce in spite of the fact that architects can make a significant contribution to hazard risk reduction” *(FEMA, A Manual for Architects, 2006).* Even though, this topic is seldom discussed in literature-this particular paper advocates putting forth the relationship between architecture and disaster management and also explores how the former fits into each stages of the disaster management cycle.

Designers can play an important role in enriching users’ lives by drawing on and respectfully using local cultural wisdom; making meaningful products through culturally appropriate design; facilitating cultural experiences (e.g., spaces for contemplation, peace, tranquility);incorporating and specifying local arts and crafts and local materials, products, and labor; and through socio-culturally inspirational design that becomes a pride of the community. Additionally, whether required or not, they can address intractable problems, and provide “socially **conscious” elegant, affordable, culturally appropriate, imaginative, eco-sensitive, healthy, and safe solutions** that make the project suitable for persons with disabilities, children, and the elderly, powerless, and poor.*(Oliver 2003).* Design professionals and the construction industry have a significant role in the health and safety of the environment and in disaster management .Their role includes a range of activities designed to maintain control over emergency situations, providing a framework for helping those who are at risk to avoid or recover from the impact of the disaster (*Kelly, Limitations to the Use of Military Resources for Foreign Disaster Assistance, 1996).*

Through architectural interventions- new, contextual and innovative models and concepts can emerge that may help to reduce future risk. Models can be designed in the manner so that it is flexible enough to be replicated or manipulated elsewhere with the same effectiveness. Generally, the plans prepared in the institutions do not take into account the users' needs and this is exactly where an architect and his work come in. It is important to bridge this gap between the different stakeholders and users and know who does what and who best fits into what stage of the DM cycle. The implementation of innovative solutions and concepts before (preparedness) and after (reconstruction) a disaster ensure that the user and its surrounding are resilient and can sustain their lives through adversity. This paper advocates the idea that through resourceful and inventive design concepts an architect can make significant contributions to humanity and the built environment. This constant evolution of ideas with the ever-changing adversities will pave the way towards a robust and healthier future because rebuilding every time from scratch not only amplifies the pain and suffering but also increase their vulnerability of individuals and communities with no hope for the future. It so may be believed that humanitarian / sustainable architecture is the way ahead for a resilient future.

1.2. STATEMENT OF THE PROBLEM

Since, architecture and disaster management are seldom linked in literature or in practice- the scope of the former in the latter is often overlooked. This is due to the fact that DM is a broad field and architecture may be a mere component. Nonetheless, if the stages were dealt with further scrutiny it can be asserted that it is the architect's capacity only to work within a "process" to come up with a sustainable solution rather than only a "product" during certain stages of the DM cycle (pre-disaster preparedness and post disaster recovery and reconstruction phases). In order to shed more light on an architect's scope of work during a disaster-this paper inspects the "how"(intervention techniques) and "why"(justification of intervention techniques) aspects and for "whom" (people-centered & aimed at future generation)to achieve "what"? (resilience/sustainability).

1.3. OBJECTIVE

1. An interdisciplinary field between architecture and DM is explored and that architects are one of the key contributors during a crisis is analyzed.

2. To explore how designers can lead the way of seeing every project as a window of opportunity for future interventions.

3. To investigate the relationship of the physical or built environment in the apt stages of the disaster management cycle.

4. To investigate how socio-cultural inspirational design concepts (structural-non-structural) can facilitate efforts for a community to become truly **“resilient”** and “socially conscious” to become sustainable from future disasters.

1.4. RESEARCH QUESTIONS

1. How and in what capacity can architects intervene to help build resilience and sustainability in the face of disasters?

2. What kinds of architectural interventions can shape communities to become resilient and sustainable through creative solutions in both micro (individual household/structures) and macro levels (infrastructure and land-use or urban planning)?

3. How can the refurbishment of policies by incorporating architect’s and the role of architecture be instrumental in designing concepts and solutions for a more concrete-resilient future?

4. How can mainstreaming the concept of “architects” and “architecture” in the form of education, awareness and participation prove to be an instrumental component in the DRMC to minimize risk in both the structural and non-structural issues?

1.5. METHODOLOGY

In this paper, examples of different countries that have been exposed to the pros and cons because of the policies or steps taken by architects during and after a disaster in accordance with the locals and the government will be explored. Examples around the world showing the relation of the physical environment with disaster management will be analyzed to form the basis of the paper. Interviews with architects involved in disaster management may prove to be a huge asset for the paper as sharing of real-time experiences will help to formulate better solutions. Communities that have been affected by a disaster and also been benefitted through intervention techniques through new design concepts introduced by architects shall be explored in theory. After collection of information about the relationship of DM with architecture all over the world and locally-the paper will be presented to show how activities can be classified into the different stages of the DM cycle- being mitigation, **preparedness**, response and recovery and **reconstruction** and what stages fits the role of an architect at best.

1.6. POSSIBLE OUTCOME

The outcome of the paper will help to justify a new trend or concept in DM through the lens of architects and architecture. To **"Build back better"** is one of the main components of the DM cycle and so is a sworn motto for architects while designing ideas for implementation. Hence, the merging of the two disciplines may result in a more comprehensive approach for "rebuilding homes to rebuild lives".

1.7. LIMITATIONS AND SCOPES

The conceptual nature of the thesis prompted the research to be secondary sources and expert advice based. Field survey was not possible as case studies were picked from all over the world.

Adequate research materials about architecture and disaster management are not available or are inaccessible at times. Also, the reviewing of journals and articles from different sources (mostly secondary) was difficult to highlight and pin-point accurately under the apt chapter headings.

CHAPTER 02

SCRUTINIZING DISASTER

2.0. SCRUTINIZING DISASTER

2.1. What is Disaster?

A disaster is an event, natural or man made, sudden or progressive, that seriously disrupts the functioning of a society, **causing human, material or environmental losses** of such severity that the affected community has to respond by taking exceptional measures. *(adpc).*

Disasters combine two elements: events and vulnerable people. A disaster occurs when a disaster agent (the event) exposes the vulnerability of individuals and communities in such a way that their lives are directly threatened or suffiecient harm has been done to their community's economic and social structures to undermine their ability to survive. It is an extreme but not necessarily abnormal state of everyday life in which the continuity of community structures and processes temporarily fails. *(IFRC,1993)*.

2.1.1. Hazard

Hazard is any substance, phenomenon or situation which has the potential to cause disruption, or damage to people, their property, their services and their environment.

In broader sense, according to *(UN/ISDR,2004,)*

A potentially damaging physical event, phenomenon or human activity that may cause the loss of life or injury, property damage, social and economic disruption or environmental degradation. Hazards can include latent conditions that may represent future threats and can have different origins: natural (geological, hydro -meteorological and biological) or induced by human processes (environmental degradation or technological hazards). Hazards can be single, sequential or combined in their origin and effects. Each hazard is characterized by its location, intensity, frequency and probability.

Hazard classification

HAZARD

A potentially damaging physical event, phenomenon or human activity, which may cause the loss of life or injury, property damage, social and economic disruption or environmental degradation.

NATURAL HAZARDS

Natural processes or phenomena occurring in the biosphere that may constitute a damaging event. Natural hazards can be classified according to their geological, hydrometeorological or biological origins.

ORIGIN	PHENOMENA / EXAMPLES
Hydrometeorological hazards Natural processes or phenomena of atmospheric, hydrological or oceanographic nature.	• Floods, debris and mudflows • Tropical cyclones, storm surges, wind, rain and other severe storms, blizzards, lightning • Drought, desertification, wildland fires, temperature extremes, sand or dust storms • Permafrost, snow avalanches
Geological hazards Natural earth processes or phenomena that include processes of endogenous origin or tectonic or exogenous origin, such as mass movements.	• Earthquakes, tsunamis • Volcanic activity and emissions • Mass movements, landslides, rockslides, liquefaction, sub-marine slides • Surface collapse, geological fault activity
Biological hazards Processes of organic origin or those conveyed by biological vectors, including exposure to pathogenic micro-organisms, toxins and bioactive substances.	• Outbreaks of epidemic diseases, plant or animal contagion and extensive infestations

TECHNOLOGICAL HAZARDS

Danger associated with technological or industrial accidents, infrastructure failures or certain human activities which may cause the loss of life or injury, property damage, social and economic disruption or environmental degradation, sometimes referred to as anthropogenic hazards. Examples include industrial pollution, nuclear release and radioactivity, toxic waste, dam failure, transport, industrial or technological accidents (explosions, fires, spills).

ENVIRONMENTAL DEGRADATION

Processes induced by human behaviour and activities (sometimes combined with natural hazards) that damage the natural resource base or adversely alter natural processes or ecosystems. Potential effects are varied and may contribute to an increase in vulnerability and the frequency and intensity of natural hazards. Examples include land degradation, deforestation, desertification, wildland fires, loss of biodiversity, land, water and air pollution, climate change, sea level rise and ozone depletion.

Figure1. Table showing the classification of Hazards(*Source*: Aminur Rahman, BRAC University)

2.1.2. Exposure

Elements at risk, or an inventory of those people or artefacts that are exposed to a hazard. *(UNDP, 2004)* The degree to which a risk or portfolio of risks is subject to the possibility of loss. *(MunichRe, 2004).*

For instance, if one picks a community living in the coastal belts of Bangladesh and another living inland; then which community is more exposed to the threat of a hazard? The coastal community is more exposed to cyclone(hazard) and if physical infrastructure along with their livelihoods is damaged then it may turn into a disaster.

Another example of exposure would be as follows: A large number of homes and commercial buildings constructed prior to the 1980s were built with asbestos materials. Those products are considered safe as long as they are contained. But once ripped, broken and burned, blown or washed away, the products become a possible health hazard: asbestos exposure lays the groundwork for the human body to develop mesothelioma cancer years after the exposure. Soon after a natural disaster, these fibers may continue to circulate in the air, making them easily inhaled. Firefighters, law enforcement officials and cleanup crews are considered high-risk occupations for exposure after natural disasters. Homeowners of damaged properties also face these risks and should always use caution when cleaning or searching through debris.

Each natural disaster presents a particular set of circumstances. Hurricane Katrina in Louisiana and Mississippi, tornadoes in Alabama and Missouri, fires in California and flooding in Missouri and New Jersey from Hurricane Sandy are examples of natural disasters that officials fear exposed the public to asbestos.

2.1.3. Vulnerability

Vulnerability is a concept which describes factors or constraints of an economic, social, physical or geographic nature, which reduce the ability to prepare for and cope with the impact of hazards. *(adpc)*

The characteristics of a person or group in terms of their capacity to anticipate, cope with, resist and recover from the impact of a natural or man-made hazard. *(IFFRC,1999)*

Vulnerability is related to poverty. The poorest societies have the fewest resources and are usually the most vulnerable. However, while poverty is generally linked to income or availability of goods and degree of well-being based on wealth, the concept of vulnerability has a broader remit that also embraces cultural and social components. **Not being poor does not necessarily means not being vulnerable, and vice versa**. The average vulnerability of an individual is made up of a set of vulnerabilities connected to different social levels that each individual belongs to. The social levels are:

A)Individual, B)Household, C)Administrative community, D)National, E)Regional, F)Cultural community

For instance, the recent Balkans flood took the entire region by shock as countries in the Balkans have not faced such a situation before. Due to the recent phenomena of climate change, flood occurred unexpectedly and to everyone's surprise wrecking having to the economical, social, physical structures due to lack of preparedness. Even if communities were well-off at the individual, household, community levels, they fell short at the regional level due to climate change. Therefore, it can be said that the poor do occupy dangerous locations and are vulnerable at all times but the fact that the rich are vulnerable in some aspects cannot also be undermined.

Vulnerability can be dissected further into the following categories as shown in the diagram below. Three sets of links that connect the disaster processes that are located at decreasing levels of specificity from the people impacted upon by a disaster are as follows:

- Root causes
- Dynamic pressures
- Unsafe conditions

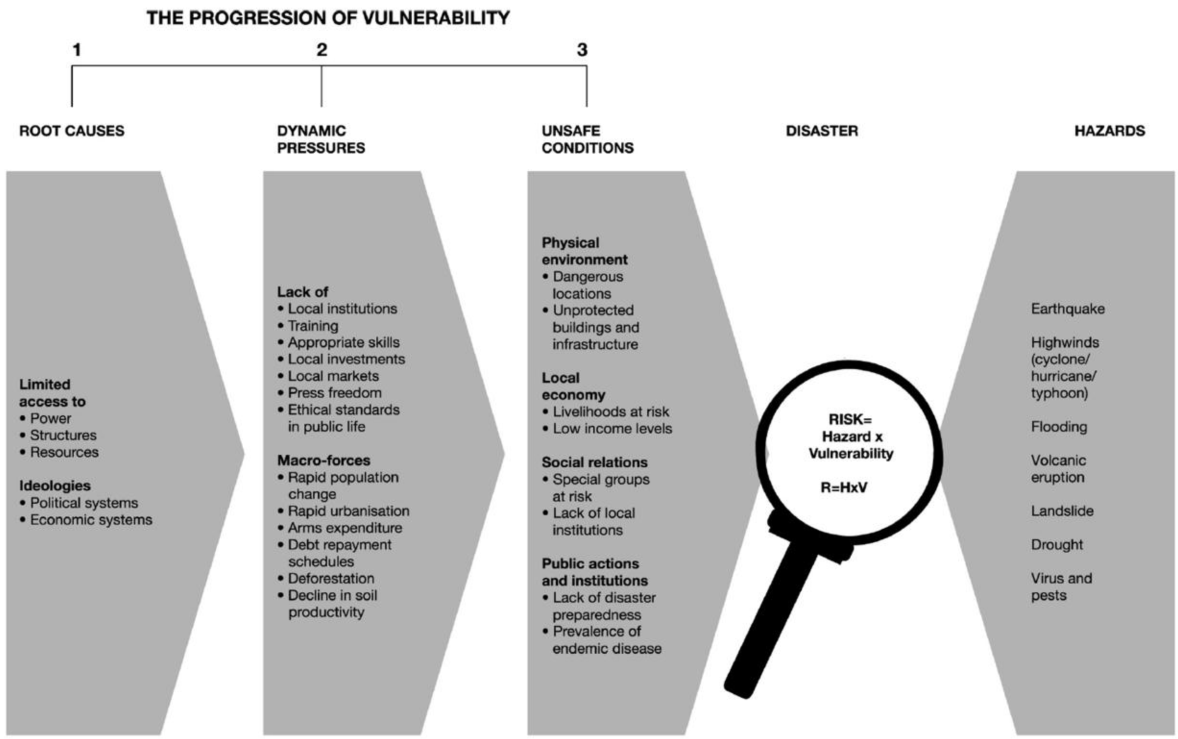


Figure2. Showing the progression of vulnerability (Source: Aminur Rahman, BRAC University)

2.1.4. Risk

Risk is the probability of harmful consequences, or expected loss of lives, people injured, property, livelihoods, economic activity disrupted (or environment damaged) resulting from interaction between natural or human induced hazards and vulnerable conditions. Risk is conventionally expressed by the equation:

Risk= Hazard x Vulnerability x Exposure

Hence, risk is a combination of the interaction of hazard, exposure, and vulnerability, which can be represented by the three sides of a triangle.

If any one of these sides increases, the area of the triangle increases, hence the amount of risk also increases.

If any one of the sides reduces, the risk reduces.

If we can eliminate one side there is no risk theoretically BUT in reality-it is just not the case. There will always be risk and by reducing vulnerability, exposure and the impact of a hazard, a situation can be contained to a tolerable or acceptable level.

Figure3. The risk triangle (Source: Google Image search on Risk)

2.2. Types of Natural Hazards where architects can commonly intervene & how

Natural processes or phenomena occurring in the biosphere that may constitute a damaging event. *(UNDP,2004).*

Natural hazards can be classified according to their hydro-meteorological, geological or biological origins. (Fig.1.)

2.2.1. Earthquake- Geophysical hazard

Definition- Cause- Effect

An earthquake is caused by a sudden slip on a fault. The tectonic plates are always slowly moving, but they get stuck at their edges due to friction. When the stress on the edge overcomes the friction, there is an earthquake that releases energy in waves that travel through the earth's crust and cause the shaking that we feel. It is also the sudden break within the upper layers of the earth, sometimes breaks the surface, resulting in the vibration of the ground or lateral movements of the ground, which where strong enough will cause **the collapse of buildings and destruction of life and property**.

Earthquakes strike with no early warning and can be devastating, but after a major one, aftershocks may be as strong as a new earthquake. They often **trigger landslides, tidal waves and tsunamis.** Powerful aftershocks frequently occur, causing further damage and increasing psychological stress.

Earthquakes are measured according to the Richter scale - the most devastating effects are seen on level 6 and above, and if the epicentre of the earthquake is located in highly populated areas. Earthquakes can cause high numbers of deaths and injuries as well as serious destruction of buildings and infrastructure.

Earthquakes cannot be prevented permanently. However, it can be minimized through preparedness initiatives such as land-use planning, innovative architectural designs for buildings, urban planning, development of possible warning indicators, land-use regulations, building regulations, relocation of communities, public awareness and education programs.

Figure 4. An earthquake affected area (*Source*: www.ifrc.org)

2.2.2. Cyclone/Hurricane/Typhoon – Hydro-meteorological hazard

Definition- Cause- Effect

Tropical storms, cyclones, hurricanes and typhoons, although named differently, describe the same disaster type. Essentially, these disaster types refer to a large scale closed circulation system in the atmosphere which combines low pressure and strong winds that rotate counter clockwise in the northern hemisphere and clockwise in the southern hemisphere.The system is referred to as a **"cyclone"** in the Indian Ocean and and South Pacific, **"hurricane"** in the Western Atlantic and Eastern Pacific and**"typhoon"** in the Western Pacific. Hurricanes and typhoons are the same storm types as **"tropical cyclones"**(the local name for storms which originate in the Caribbean and China Sea region respectively).

A tropical cyclone is a non-frontal storm system that is characterised by a low pressure center, spiral rain bands and strong winds. Usually it originates over tropical or subtropical waters and rotates clockwise in the southern hemisphere and counter-clockwise in the northern hemisphere. The system is fueled by heat released when moist air rises and the water vapor it contains condenses ("warm core" storm system). Therefore the water temperature must be >27 °C.

Cyclones, hurricanes and typhoons can be predicted several days in advance. The onset is extensive and often very destructive. These disasters are usually more destructive than floods. First, in a sudden, brief onslaught, high winds cause major damage to **infrastructure and housing, in particular fragile constructions**. They are generally followed by heavy rains and floods and, in flat coastal areas, by tidal waves.

In the case of cyclones, accurate landfall predictions can give only a few hours' notice to threatened populations. In addition, people generally opt to wait until the very last minute before abandoning their home and possessions. Deaths from drowning in the high tides and sudden flooding and material losses are therefore often very high. "*Apart from the human casualties that resulted from cyclone events, the damage to properties, which include physical infrastructure, livelihoods means and various direct tangible/intangible and indirect tangible/intangible items, is substantial. The continuum of loss and damage caused by these disaster events is very difficult* *to frame; it transcends the spatial and temporal boundaries. The population exposed to the risk of cyclones cannot afford shifting their settlements to a safer location since their livelihood activities are localized. Thus, after every cyclone the people, as if, "rise from the ashes" to get ready to face another*." ***(Shaw, Mallick, Islam, Disaster Risk Reduction Approaches of Bangladesh,2013)***

Cyclones can be minimized through building multipurpose cyclone shelters, coastal afforestation and embankments, creating cyclone resilient structures, infrastructures and habitat and other **innovative measures.**

Figure 5. Cyclone ravaged coastal belt (*Source*: www.ifrc.org)

2.2.3. **Flood -** Hydro-meteorological hazard

Definition- Cause- Effect

General floods can be predicted in advance, except in the case of flash floods. The impact of flooding can include destruction of housing, crops, cattle and people.

Flash floods are sudden and extreme volume of water that flow rapidly and cause inundation. Because of its rapid nature flash floods are difficult to forecast and give people little time to escape or to take food and other essentials with them.

There are usually two phases following flood disasters. During the first phase, people crowd on patches of high, safe ground, together with cattle and other animals, even snakes and scorpions. Drinking water is often very difficult to find and sanitation is terrible. During the second phase, people start to move back to their homes as soon as possible. This is often a prolonged process (certain areas dry up quicker than others) and once home, people face new challenges including destroyed water systems, wells and bore holes that need cleaning up and disinfecting. A couple of weeks after the flood, high risks for epidemics like cholera, malaria and dengue emerge. Subsequent disasters caused by flooding would be landslides/mudslides and dam collapse.

Homes, transport, tools, livestock and seeds are lost or destroyed in floods and cyclones, therefore, help with rebuilding and the restoration of livelihoods is a primary task.

Figure 6. An area inundated with flood (*Source*: www.ifrc.org)

2.2.4. Tsunami - Geophysical hazard

Definition- Cause- Effect

A **tsunami** is a series of waves caused by a rapid displacement of a body of water (ocean, lake). The waves are characterised by a very long wavelength and their amplitude is much smaller offshore. The impact in coastal areas can be very destructive as the waves advance inland and can extend over thousands of kilometers. Triggers of a tsunami can be: earthquakes, volcanic eruptions, mass movements, meteorite impacts or underwater explosions. The Japanese term for this phenomenon "tsunami" (*"Wave in the port" in Japanese*) , which is observed mainly in the Pacific, has been adopted for general usage.

Tsunamis cause massive devastation of physical assets such as housing, urban infrastructures and also ravages through people’s livelihood. Springing back to normal state for a community may get very difficult if sustainable development is not practiced.

Figure 7. A tsunami devastated town (*Source*: www.ifrc.org)

2.2.5. **Landslides -** Geophysical hazard

Downhill sliding or falling movement of cry soil and rock. Landslides are difficult to estimate as an independent phenomenon. It seems appropriate, therefore, to associate landslides with other hazards such as tropical cyclones, severe local storms and river floods. The term landslide is used in its broad sense to include downward and outward movement of slope forming materials (natural rock and soil). It is caused by heavy rain, soil erosion and earth tremors and may also happen in areas under heavy snow.

2.3. Evolution of the DM cycle

Management of disasters has come a long way since its inception in some countries that are prone to disasters. In the yesteryears when a cyclone struck a community, it took millions of lives washing away resources, infrastructure and livelihoods. However, nowadays the concept of comprehensive disaster management has led the way to a more resilient path to fight and spring back from disasters. Even if there are gaps in designing the social and technical strategies appropriately, steps have been taken to minimize the risk of the impact and success stories have been witnessed. Nonetheless, problems and limitations may arise within the process but to keep evolving with ever-changing nature of disasters is a challenge to overtake in a comprehensive manner. The traditional relief and response method saw a more comprehensive and holistic approach. A paradigm shift had evidently happened.

2.3.1. Traditional DM Model or cycle

Figure8. Traditional DM cycle (Source: Google Image search on DMC)

The traditional DM cycle outlines the goals to be the following:

(1) Reduce, or avoid, losses from hazards;
(2) Assure prompt assistance to victims;
(3) Achieve rapid and effective recovery

If appropriate steps can be taken in all the different phases of the DM cycle as illustrated in Figure 5, it could lead to reduced vulnerability and better preparedness for future disasters. The different stages are explained as follows:

a. Mitigation - Minimizing the effects of disaster.
   Examples: building codes and zoning; vulnerability analyses; public education.

b. Preparedness - Planning how to respond.
   Examples: preparedness plans; emergency exercises/training; warning systems.

c. Response - Efforts to minimize the hazards created by a disaster.
   Examples: search and rescue; emergency relief .

d. Recovery - Returning the community to normal.
   Examples: temporary housing; grants; medical care.

These four phases of disaster management does not necessarily occur in a sequence or in isolation, but the stages tend to overlap and the length of each phase depends upon the intensity and severity of the disaster. This model was further developed even more comprehensively afterwards as in this case the process was slow with poor co-ordination among actors because of lack of accountability. Henceforth, the disaster risk management cycle came to being as explained and illustrated in Figure 9 and section 2.3.2.

2.3.2. DRMC: The Disaster Risk Management Cycle

Figure9. The Disaster Risk Management Cycle(***Source*****: Aminur Rahman, BRAC University)**

The disaster risk management cycle is a more holistic take on the traditional DM model as mentioned in the previous section. DRMC is divided into three stages:

- **<u>Pre-disaster</u>**: In this stage the key components are:

  a) **Risk assessment**

  b) Mitigation/ Prevention

  c) Preparedness

- **<u>Disaster response</u>**: In this stage the key components are:

  a)Warning / Evacuation

  b) Saving people

  c) Providing immediate assistance

  d) Assessing damage

- **<u>Post-disaster:</u>** In this stage the key components are:
  a) Ongoing assistance
  b) Restoration of infrastructural services
  c) Reconstruction (Resettlement/ Relocation)
  d) Economic & social recovery
  e) On-going development activities
  f) Risk assessment (Mitigation and prevention)

To note, the highlighted /bold letters indicate the areas where architects are likely to exercise their expertise.

All these activities require key professionals from different field in the likes of planners, engineers, architects and so on to carry out the necessary actions for faster recovery and reconstruction. It also can be easily said that architects can provide great insight into each stages of the DRMC in terms of preparedness (Pre-disaster); assessing damage (Response) and most importantly in restoration and reconstruction (Post-disaster). This will be further explained in the next section 2.3.3.

To sum up the concept of this section**, there is no such thing as a 'natural' disaster, only natural hazards.** (UNISDR)

Disaster Risk Reduction (DRR) through the evolution of these systems aims to reduce the damage caused by natural hazards like earthquakes, floods, droughts and cyclones, through an ethic of prevention.

Disasters often follow natural hazards. A disaster's severity depends on how much impact a hazard has on society and the environment. The scale of the impact in turn depends on the choices we make for our lives and for our environment. These choices relate to how we grow our food, where and how we build our homes, what kind of government we have, how our financial system works and even what we teach in schools. Each decision and action makes us more vulnerable to disasters - or more resilient to them.

Disaster risk reduction is about choices. Disaster risk reduction is the concept and practice of reducing disaster risks through systematic efforts to analyze and reduce the causal factors of disasters. Reducing exposure to hazards, lessening vulnerability of people and property, wise management of land and the environment, and improving preparedness & early warning and also maximizing efforts on the reconstruction phase- for adverse events are all examples of disaster risk reduction.

Disaster risk reduction is everyone's business. Disaster risk reduction includes disciplines like disaster management, disaster mitigation and disaster preparedness, but DRR is also part of sustainable development that can be achieved through reconstruction initiatives. In order for development activities to be sustainable they must also reduce disaster risk. On the other hand, unsound development policies will increase disaster risk - and disaster losses. Thus, DRR involves every part of society, every part of government, and every part of the professional and private sector where architects are one of the many key professionals who can play vital roles in the preparedness and reconstruction phases of the DRMC.

2.3.3. Architect's status in the DRMC

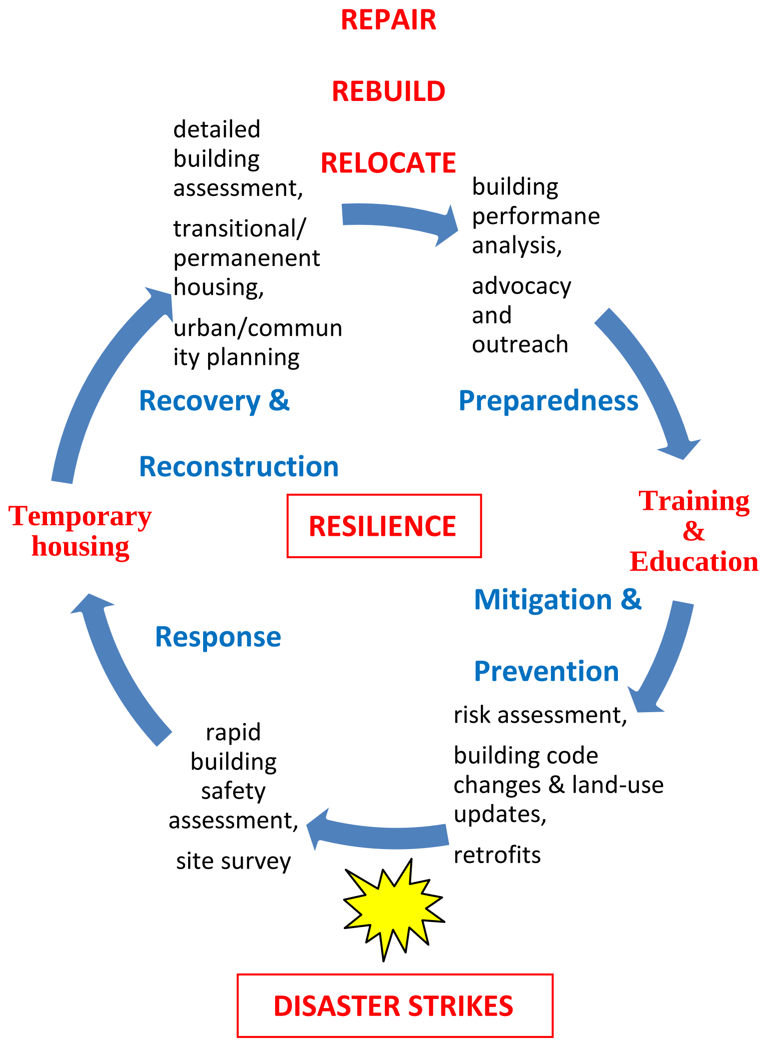


Figure10. Disaster Resilience Cycle & the role of an Architect (*Source*: Minnery 2013 & Author, 2015)

After any disaster many intuitions and organizations take responsibility of combating the situation and normalizing it sooner. NGO's especially and the government set up policies and activities to reduce vulnerabilities. However, due to lack of co-ordination and good governance, gaps tend to exist in the system. This section will hence focus on the role of architects and architecture in each of the three stages of the cycle and how designers-architects can make a significant contribution to the communities and those affected; should they be given the rightful status and importance within the vicious cycle.

- **Architect's in pre-disaster & during impact**:

Following a disaster, infrastructure and households are greatly damaged along with settlements due to unplanned development. Hence, architects should be entitled with the task of recognizing the previous flaws in building codes & policies, urban design and infrastructure and perform damage assessments as it is their forte. Also, requests by residents for assessment or planning for re-construction activities floods in and a job is often left incomplete or unattended as these roles are very discordantly given to unspecialized task force or staff. A team of architects can complete such tasks of assessing damage and planning for reconstruction in a few days resulting in smooth flow of activities and of course timely assistance. This increased capacity allows residents to return more quickly and safely to their homes and work. For instance, an architect would recognize the households better in terms of the danger involved with his technical know-how better than any other volunteers involved. Also, education and awareness for "who" is accountable to do "what" is very necessary and is a step that should be/are taken by agencies to enhance the planning for preparedness. Training programmes for architects and planners before a disaster by learning from the past can propel them to think up better and innovative solutions for the future and also give them more expertise to do assessment tests accurately. Education and awareness should be provided to the all the stakeholders, communities and actors involved along with the architects so to know each others status better.

- **Architect's in post-disaster**:

During this phase, the architect's role best fit into the **reconstruction and restoration** activities and they have a momentous role to play. From past experiences, it had been observed that right after the basic needs (food, clothing, water supply, sanitation and healthcare) had been fulfilled for the sake of the affected communities under a pre-set agenda; the latter activities become slower and go into the cold storage. This is due to certain gaps in the system but should architects intervene and carry out the tasks that require their expertise, results would have been more concrete.

Disasters occur in a specific context and are unique in nature and characteristics. Disaster situations are forever evolutionary and so should be the changes in reconstruction of housing and urban communities. Architect's have the capacity to rethink spaces over and again in line with the situation in hand. Humanitarian architecture with an attitude of "people-first" can only be best thought through spatial planning measures and interventions by such professionals only. This may not solve all the problems but shall facilitate a more co-ordinated and collective effort towards constant development and evolution and not just the resultant being a mere "product". As Quarantelli said "Disaster is first of all seen as a crisis in communicating within a community" and "Sheltering is a process-not just a "product" and also that 'shelter and housing work is the least successful form of aid when compared to other humanitarian intervention sectors' (quoted in IFRC 2003: 4). Interestingly enough this is identified as the area that need major refurbishment while tackling a disastrous situation and who better than the "architect"- these two components being the "bread" and "butter" of the profession.

Cuny found that most NGOs rush to build housing without any experience of the construction industry whatsoever, lacking a subtle approach and long-term commitment. Furthermore, he has shown that the majority of NGOs lack an understanding of the complexities of post-disaster housing, and they fail to link post-disaster housing to the local building process, a critical parameter for an integrated approach. As a consequence, many permanent houses provided by NGOs are deemed to be inappropriate and they remain, in the worst case, unoccupied (Barakat 2003, Steinberg 2007). Studies have highlighted that despite their involvement; projects continue to fail culturally and technically (Ortiz 2002, Karunasena *et al*. 2010, Boano *et al*. 2011, 2012, Tauber 2013, 2014).

What are the reasons? The failure to appoint architects in the right areas of the DM system is a huge gap and it is the architects only that possess the rigorous understanding of how to structure the human habitat. Without involving such professionals, NGO's and other such institutions hurriedly build housing or structures temporarily to meet demands that do not sustain in the long-run. After already waiting on temporary, pre-fabricated shelters, people wait on lottery tickets for permanent houses. Since shelter is a critical determinant of survival, along with water supply, sanitation, food and healthcare; the architect plays an essential role in reducing vulnerability and building communities' resilience. The massive needs for physical reconstruction considering the social-cultural aspects together with conservation of heritage buildings and the ecosystem & environment can open up opportunities to minimize the impact of future hazards and vulnerabilities and sound the siren of sustainability and resilience.

2.4. Resilience & Sustainability – the Concept

Resilience is 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. (*UNISDR)*

In other terms, resilience is the ability to "spring back" from a deformed state to its normal position after being exposed to a stressor. It is in simpler terms the ability to withstand pressure, deal with shocks and bounce back after disastrous events.

Resilient development practices integrates various aspects such as a) DRR, b) Recovery, c) Social risk reduction, d)Sustainable livelihoods approach, e)Climate change adaption f)Ecosystem management and g) Good governance.

Also, it is very important to remember that a country, community or household after being exposed to stresses may not show maximum adaptive capacity even though certain criteria were fulfilled of the resilient development practices. A holistic and appropriate approach should be taken integrating key personnel's in specialized roles (architects and so on) to achieve best results. Otherwise, country, community or household may react in these possible ways:

- **i.** **Bounce back better**
- **ii.** Only bounce back
- **iii.** Recover but gets worse or
- **iv.** Collapse totally

Hence, resilience should focus on **bouncing back better** by **building back better (3B)** by considering physical, socio-cultural and environmental aspects. Here, the final outcome is not a "product" but a series of activities or "process" as mentioned earlier, whereby people can improve their own homes, and also engage to create a safe and secure environment.

Sustainability is the ability of a locality to tolerate- and overcome-damage, diminished productivity, and reduced quality of life from an extreme event without significant outside assistance.*(Mileti, 1999).*

In the field of DM , the areas that deals with reconstruction & restoration is the main focus of architects and this paper. Sustainable reconstruction also looks beyond the structure of a single house to how neighborhoods are laid out from a spatial planning point of view. The design of houses, infrastructure and green and open spaces of a neighborhood shapes the larger settlement and, therefore, has a larger effect on the community and the users' energy use, biodiversity and quality of life. In contrast to conventional reconstruction, sustainable reconstruction aims at using environmentally friendly building materials and technologies. Sustainability may differ from one location to another. Implementers will need to work together with users and other relevant stakeholders to define the scope and application of sustainable reconstruction in their specific context and who better understands context than the locals themselves and ofcourse architects.

The following aspects that are mainly taken into consideration during sustainable re-construction: a) Environmental b)Technical c)Institutional d)Socio-economic. Hence, as discussed earlier sustainable development is a holistic approach that focuses on the process rather than the product which gives the affected community a sense of belongingness to prepare them better for the future. Sustainable development is systematic planning for long-term recovery and is comprehensive in nature—it should rebuild lives and not just houses and infrastructure. How? Like Dr. Camillo Boano discusses that houses and housing is conceived as a one- dimensional standardized physical artifact, constructed as top-down, reactive, technology-driven "end state" product. However, that the house or housing and the urban living environment has social, economic and cultural dimensions are usually sidelined during the emergency response and recovery cycle due to lack of co-ordination and understanding.

This concept of sustainable development requires massive schemes for pot-disaster reconstruction to be realized requiring not only the provision for shelters but also rehabilitating social, economic and urban structures which are mutilated as a consequence of these disasters. This can be better explained by an example of Wuring and Babi villages in Indonesia following the 1992 earthquake that brought about a massive tsunami. Some "international experts" and not "architects or designers" claimed that the above mentioned villages were dangerous for habitation and decided that these villages needed to be relocated to new areas namely Nangahure and Nangehale. However, it should not be forgotten that these villagers were fishermen and their livelihood sustained along the coast. Eight years after the 1992 earthquake, many houses in Nangahure were abandoned because people moved back to their original village of Wuring. It is apparent that the population of Wuring village, which consisted of Bajo and Bugis ethnic groups originating from South Sulawesi, felt more at home in Wuring, which was established by their ancestors a few hundreds years ago.

It is apparent that the decision to relocate them in 1993 to Nangahure did not take the social, cultural and economic factors into account. A preliminary survey in March 2001 reveals among others the following findings: Nangahure was located inland approx 200 meters from the shoreline (far from the beach, because according to the experts advice it shall be relocated inland to avoid tsunami) and the types of houses built were similar to that in a military barrack. In Wuring, the houses were built on poles so that these do not get submerged in water during high tides. These were also in line with their ways of living as fishermen who consider sea as part of their life. By building on poles, the fishermen could tie their boats along their houses during high tides. However, they could not do so in Nangahure because the barrack like houses were built on land.

Therefore, to build back better for sustainable and resilient reconstruction is necessary by considering social, cultural, economical, environmental and physical aspects. Otherwise, for instance, families that are dependant on fishing will relocate to their former habitation spots. It will not be surprising to find people still living in the so-called, transitional accommodations, or to see the newly constructed unplanned, haphazard settlements or houses unoccupied because they fail to address the basic needs and cultural practices of the intended beneficiaries. The disregard for architectural solutions by the institutions at work during DRR, poses a threat not only to an individual but communities and also the environment and stands in the way of sustainable and resilient development.

CHAPTER 03

LITERATURE REVIEW

3.0. Examples of notable works around the globe showing the architect's role in DM –

3.1. EARTHQUAKE

A. The Great Hanshin/ Kobe Earthquake – 1995

On January 17, 1995, an earthquake of magnitude 6.8 hit the southern region of Japan mainly Kobe destroying property and leaving millions homeless with a significant number of casualties.

a. Individual houses to settlements (Hyogo, Kobe & surrounding areas)

Architect Shigeru Ban, responded to the scarcity of housing by introducing an innovative solution in the form of "Cardboard-tube /Paper architecture". Popularly known as "paper-log houses"; these units as (shown in Fig 11) use paper tubes for enclosure (walls) and structure sitting atop bear crates.

Figure 11. Paper log houses shown after construction (*Source*: http://www.houzz.com/ ; HBRC Journal(2014)

This concept of housing follows the open prefabricated system that reaps the benefits of being inexpensive, easy to construct, modifiable, and involve the participation of the community. Here, the light-weight cardboard tubes (measuring 4.25 inch in diameter and 16 inch thick) are made outside the site and transported on situ to be assembled on site into varying forms and configurations. The tubes are put together by nuts and bolts for walls and the foundation is made from bear crates weighted down by sand bags.

Figure 12. The Architect and the locals constructing the walls and structure with paper tubes(*Source*: HBRC Journal (2014)

A fabric tenting material is used for the ceiling that illuminates the interior beautifully and adequately. The roof also features an operable hatch which is opened in the summer to allow air circulation and in the winter to retain warm air.

Figure 13. The hatch in the roof allows for air circulation and illumination of the interior (*Source*: http://www.houzz.com/ ; HBRC Journal(2014)

For insulation, water proof sponge tape backed with adhesive is sandwiched between the paper tubes of the walls. The houses have a 6-feet gap between them which is usable as a common area and the extensions to these units are easily possible. Except for the factory made tubes as one of the raw materials, other materials are considered to be locally available. The skills of the people involved need not be that of an expert and the units cater directly to the needs of those involved. These traits have led the units to be diverse having an identity and beauty of its own.

A variation on the Kobe "paper log houses" can be seen in these houses built in India in 2001. Variation comes in the form of the roofs, which utilize locally abundant mats and extend beyond the cardboard-tube walls to create small porches. Less obvious is the foundation. Due to the location, an alcohol-free Muslim area, the architect used rubble from destroyed buildings rather than the beer crates he used in Japan. The mats framed by bamboo give the one-room interiors a different feel than the rooms in Kobe, filtering the sunlight while also allowing for ventilation.

Figure 14. Another module design of the Kobe paper log houses(*Source*: http://www.houzz.com/)

The paper-log or cardboard architecture of Ban possesses attributes of sustainability and resilience as such creations can easily be constructed without expert skills and knowledge; easily acceptable by the community and given a disaster should incur less damage that can easily be fixed or repaired. These shelters are now slowly becoming permanent homes for the communities and initiatives are already being taken by the local authorities to make their homes permanent through community/urban planning.

b. Urban features

Almost the whole of Japan is earthquake prone to a severe extent and policies have been constructed that requires architects to plan, design and prepare cities capable of resisting calamities to acceptable levels. In Tokyo, several small parks or pocket parks are injected into the urban areas to act as a safe haven or refuge during shaking. Also, the open spaces offer a space for sitting, gathering in the congested urban areas of Japan.

Figure 15. Pocket park, Tokyo(*Source:*14 WCEE, 2008)

B. The Haiti Earthquake – 2010

On 12th of January 2010, an earthquake of magnitude 7.0 hit Haiti causing widespread devastation. This massive earthquake killed thousands and left hundreds of thousands homeless depending only on tents for temporary relief. The displaced people needed to be immediately re-habilitated and provided with homes with basic necessities.

a. Urban city planning (Jacmel city)

Mark Gilbert of Trans city architecture and urbanism along with his team conducted the field assessment in the city of Jacmel and identified the basic social and physical characteristics of the site. It was also found from the survey that the shelters that were being provided did not address the demands of the people and did not comply with the local context. Hence, the architect and his team decided to go forward with the concept of rapid-response housing to provide an economical, cultural and structurally feasible reconstruction proposal that will provide long-term stability to the people of Jacmel.

The survey carried out by the architects of Trans City resulted in certain observations that helped to conceptualize their master plan. Jacmel is recognized for its architectural quality and has been nominated as World Heritage site. Attractive beaches, the greenery and the hills make it a potential site for the tourist economy. Hence, the concept included a master plan that would integrate the many levels of an urban system. The plan is to create satellite cities that are ecological and socially sustainable new towns on the accessible periphery or the edge of the existing earthquake-ravaged city center. These small new towns will act as urban centers with modern utilities and public facilities; safe and comfortable housing of varying typologies in relation to topography and is linked with a proper set of road networks. Locandi, is identified as the initial site for Jacmels's satellite cities. It is located 2 km north of the center of Jacmel and nestled between hills and the rural green landscape.

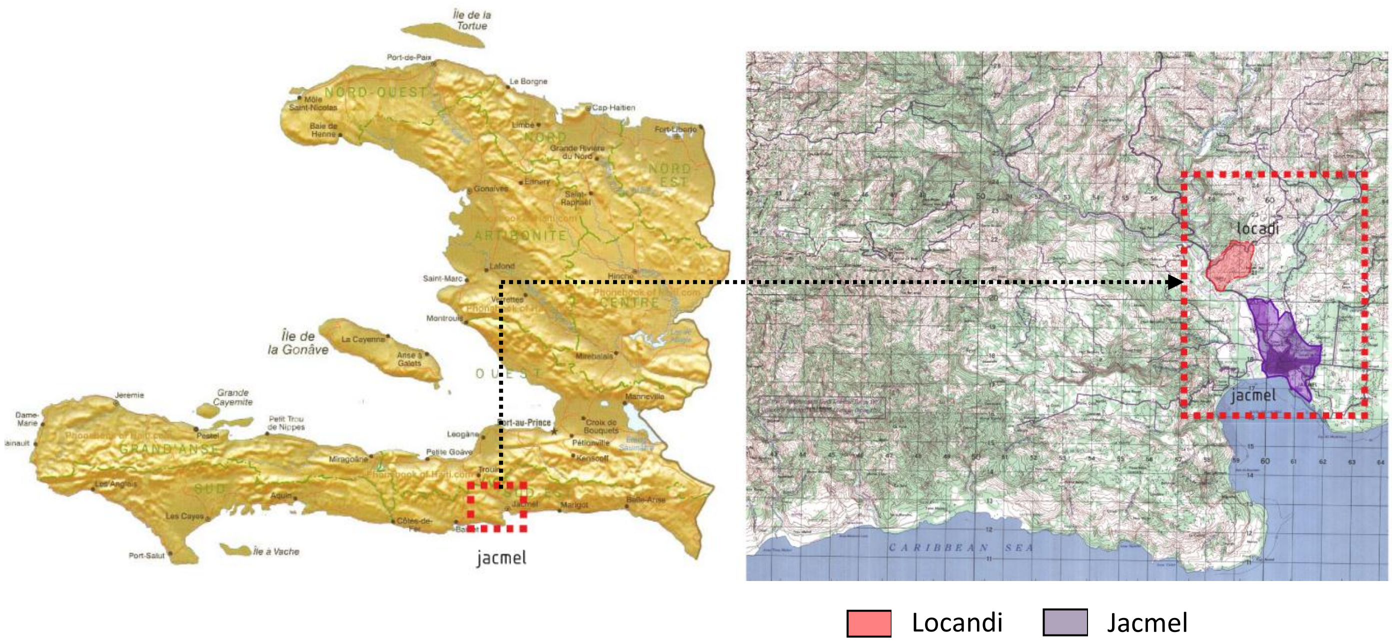


Figure 16. Location of satellite city (*Source*: http://www.trans-city.at/19_jacmel.html)

The site is contoured with ample agriculture and foliage for which it is a topographically challenging site and so the urban plan proposes an ecologically sustainable planning. The entire site area has been divided into three basic zones depending upon their topographic qualities as follows:

1) Steep hillsides, which are not buildable, are to be reforested. The ecology and the context are respected.
2) Valley bottoms, which are also not buildable due to flash-flood dangers, will be terraced and converted to middle intensity agriculture for local consumption.
3) Ridges and plateaus which are more level uplands are inhabitable for the built environment.

These divisions are illustrated in Figure 17.

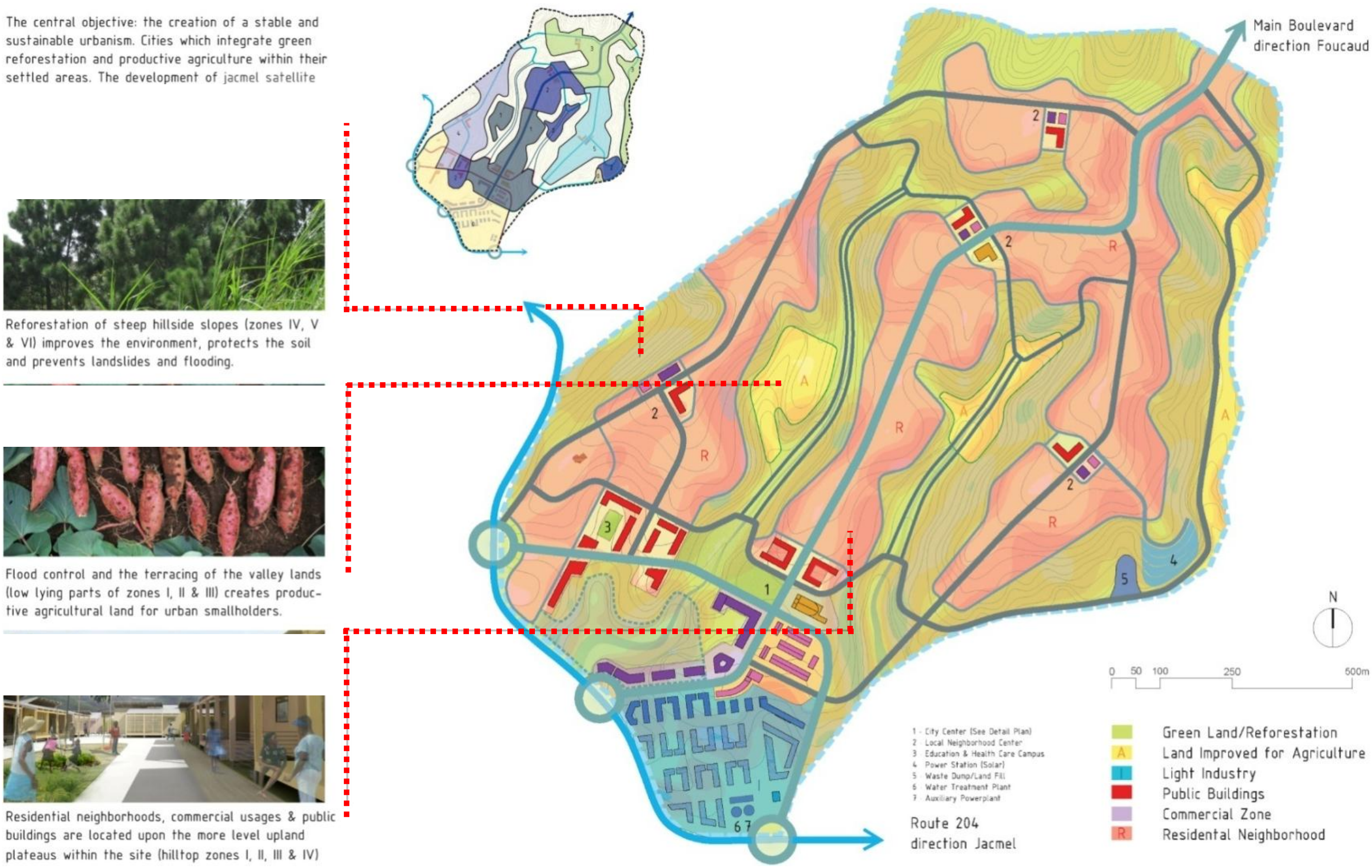


Figure 17. Map showing ecological site utilization and the division of different zones (*Source*: http://www.archdaily.com/tag/haiti/)

Another essential objective of the planning was the construction of ridge-top road network that would link the built-up areas with each other as well as to the access road Route 204 connecting to Jacmel. Along these roads, a series of neighborhoods is developed each with their own school, market and commercial center. These are in turn linked to a central commercial and administration center adjoining a light industrial district which will house textile shops and baseball manufacture which is a traditional handwork specialty of Haiti.

The roads needed to be carefully worked out given the tough site conditions and so it was divided into 5 major types. 1)The main Boulevard connects uptown and downtown and ensures that commercial and private cars do not jam the cities. 2)The secondary Avenue create a cross-town traffic connection and links the commercial and public spaces with Route N-204 towards Jacmel. 3) The main traffic streets makes way for larger vehicles such as omni- buses and delivery trucks and connects the local commercial centers with (1) and (2). 4) The Traffic streets/water course are roads for developing agriculture lands in the ravine bottoms. They regulate the seasonal flow of water and protect against flash flooding.5) Lastly, the Residential Distributor Streets connect the main traffic grid to the one-way, residential shared streets which forms the heart of the neighborhoods. These streets are accessible for cars, yet allow safe and secure pedestrian and moped movement. All the roads are paved and drained.

Figure 18. Overview plan of road network *(Source*: http://www.archdaily.com/tag/haiti/)

The houses are laid out on the ridges and plateau portion of the area and the spatial structure of the neighborhoods are determined by their topographic variations on the site. The housing pattern is divided up into four zones as the spatial structure of the neighborhood is determined by their topographic conditions.

In the flatter areas zones 1 and 2(Fig.19), the streets are laid perpendicular to the Main Boulevard and Avenues in a classic grid-iron system with interspersed green parks; the houses are one-storey high. These modest residential streets are intimate lanes that function as shared space streets. The lanes are accessible for automobiles and trucks and the urban geometry serves to slow traffic allowing vehicles and pedestrians to peacefully co-exist. Each house has a veranda that opens onto the street; these semi-private spaces and stoops activate and enliven the street fronts. Another type of house known as the combi-house provide street-level spaces for ateliers and shops and are distributed on the main street next to parks and squares.

Figure 19. Zones 1 and 2 *(Source*: http://www.archdaily.com/tag/haiti/)

In the steeper areas, zones 3 and 4(Fig.20), the streets track the site contours and are interconnected by a series of planted stairs; the houses that are two stories high and their entries address the terracing of the streets. The sections of these houses are carefully detailed out due to the steep elevation of the site. The individual, one-family houses are stacked, stepped and rotated with each entry at street level. The streets that are connected with plaza-like open staircases connect various levels of neighborhood and offer inhabitants to gather and provide space for informal markets.

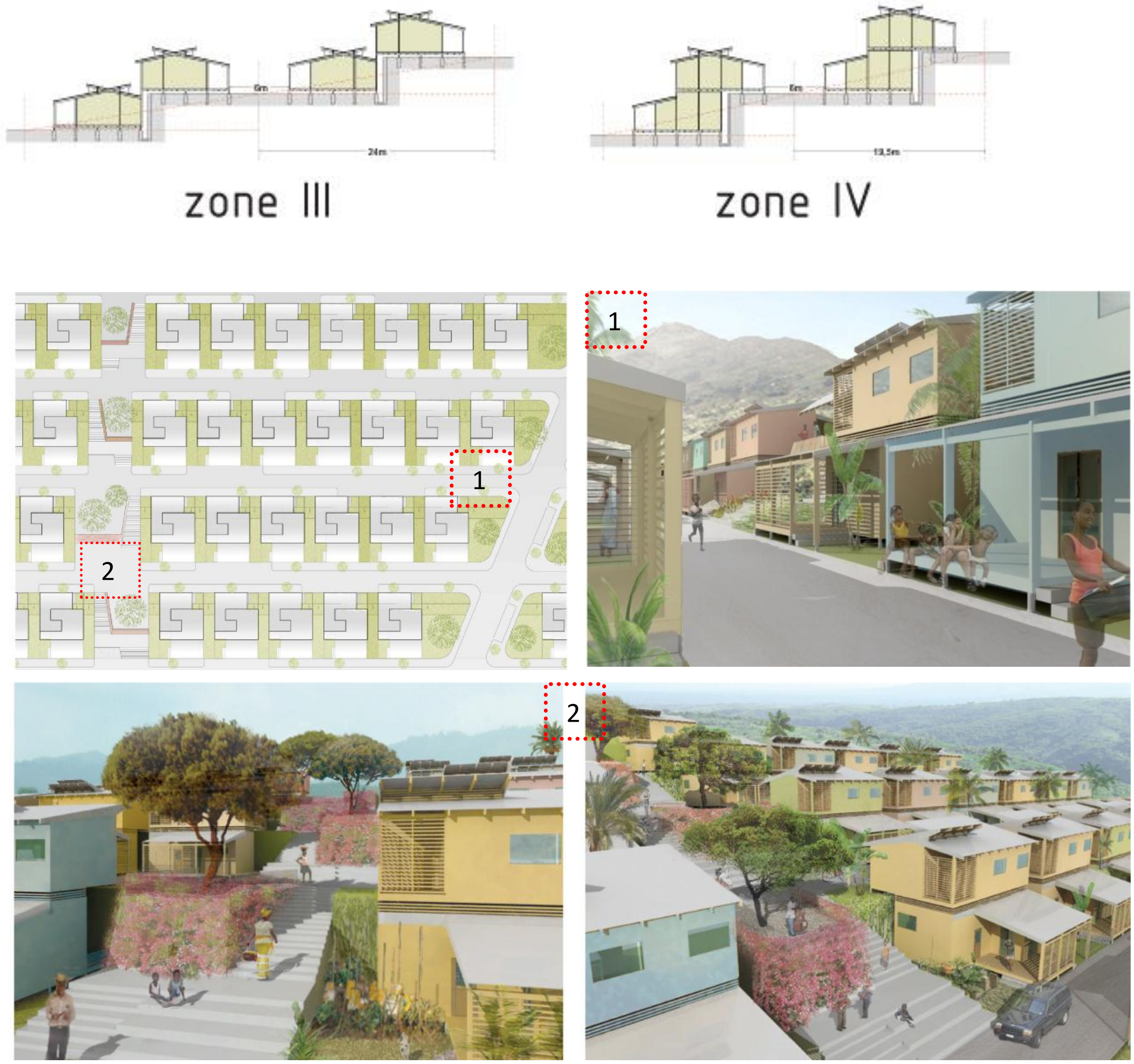


Figure 20. Zones 3 and 4 *(Source*: http://www.archdaily.com/tag/haiti/)

The architecture of the individual houses should be simple and directed to the needs and social practices of the Haitian people and their Caribbean lifestyle, as well as the tropical climate of the region. In final build-out houses will be built using local materials and techniques, but in the critical first phase, prefabricated, massive wooden components produced in Austria (the country being well-known for the timber industry) is proposed to build the houses. Massive timber panels are said to be extremely stable structures. The final residential district build-out plan is illustrated as follows in Fig.21.

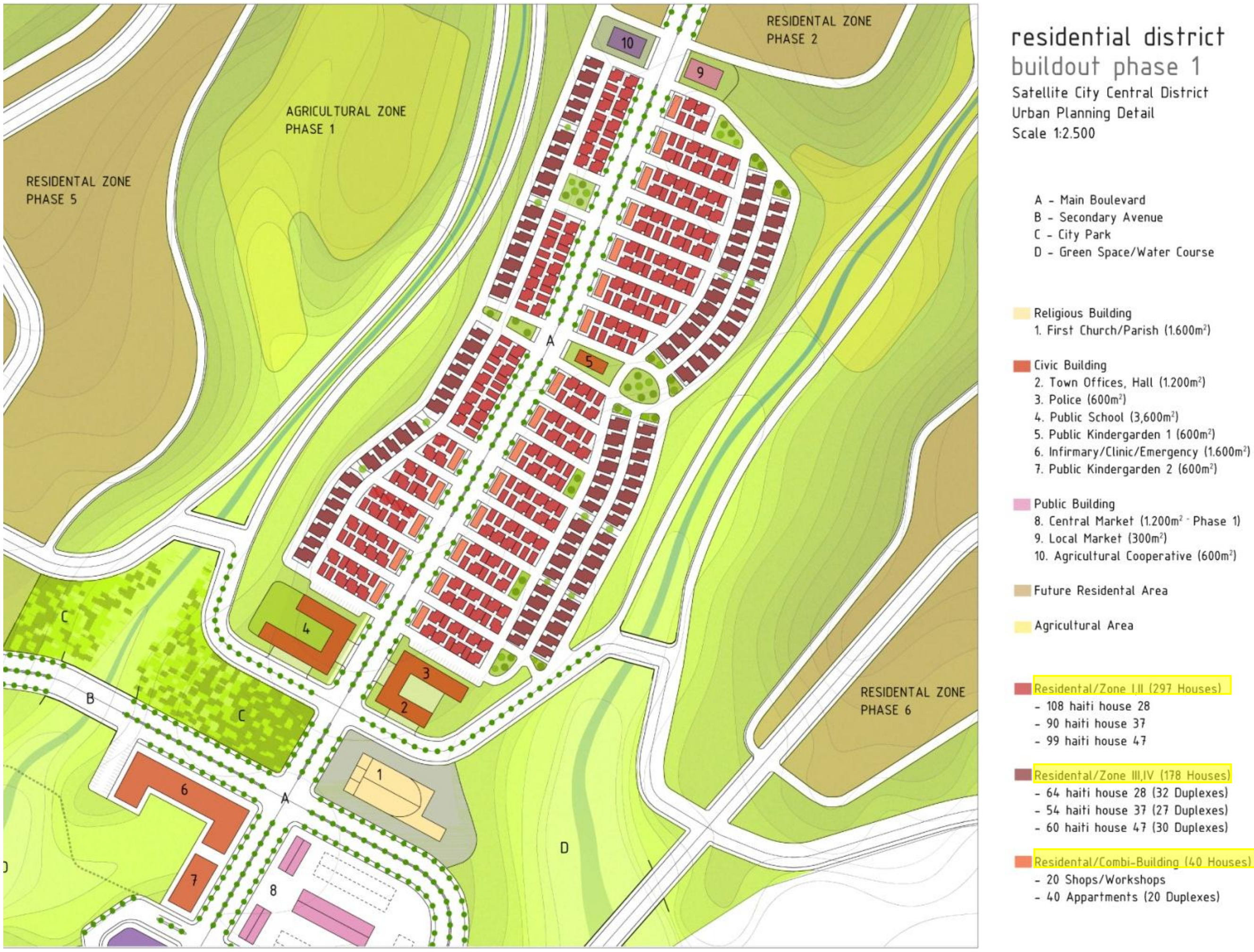


Figure 21. Urban master plan for the residential district of Jacmel *(Source*: http://www.archdaily.com/tag/haiti/)

The residential zones 1,2,3 and 4 follow three types of housing typologies. These typologies originated in the Caribbean and especially in Haiti and so deemed appropriate to be the basis for the Jacmel project. All types use the Creole Cottage typology with its generous front porch which is an important attribute of this architecture. As Caribbean life takes place out of doors, it is believed that the porch, with its advantage of social connectivity, is the ideal element for this culture and climate.

The types are as flows: 1) Dwelling unit or Haiti House 28 : it is a 2+ person family house with convertible living room. Each house has a small nut significant garden plot. The urban plan securely locates these productive spaces within the protective and enclosed backyard; the gardens tend to supply the houses' inhabitants with fresh produce that can also be sold at the local market.

Figure 22. Haiti House 28- Type 01 *(Source*: http://www.archdaily.com/tag/haiti/)

2) Dwelling unit or Haiti House 37: It is a 4 person family house with convertible living room. Here, the front yard serves as a space for parking with its fencing serves the security purpose. Also, the space can be used for outdoor workshops opening into the street. The garden plot at the rear of the house can be used to grow vegetables and food supplies.

Figure 23. Haiti House 37- Type 02 *(Source*: http://www.archdaily.com/tag/haiti/)

3) Dwelling unit or Haiti House 47: it is a 6 person family house with convertible living room and combi-room. Combi-rooms are spaces that can be used as bed-rooms and also workshops that can extend into the front yard and is a good way of income-generation

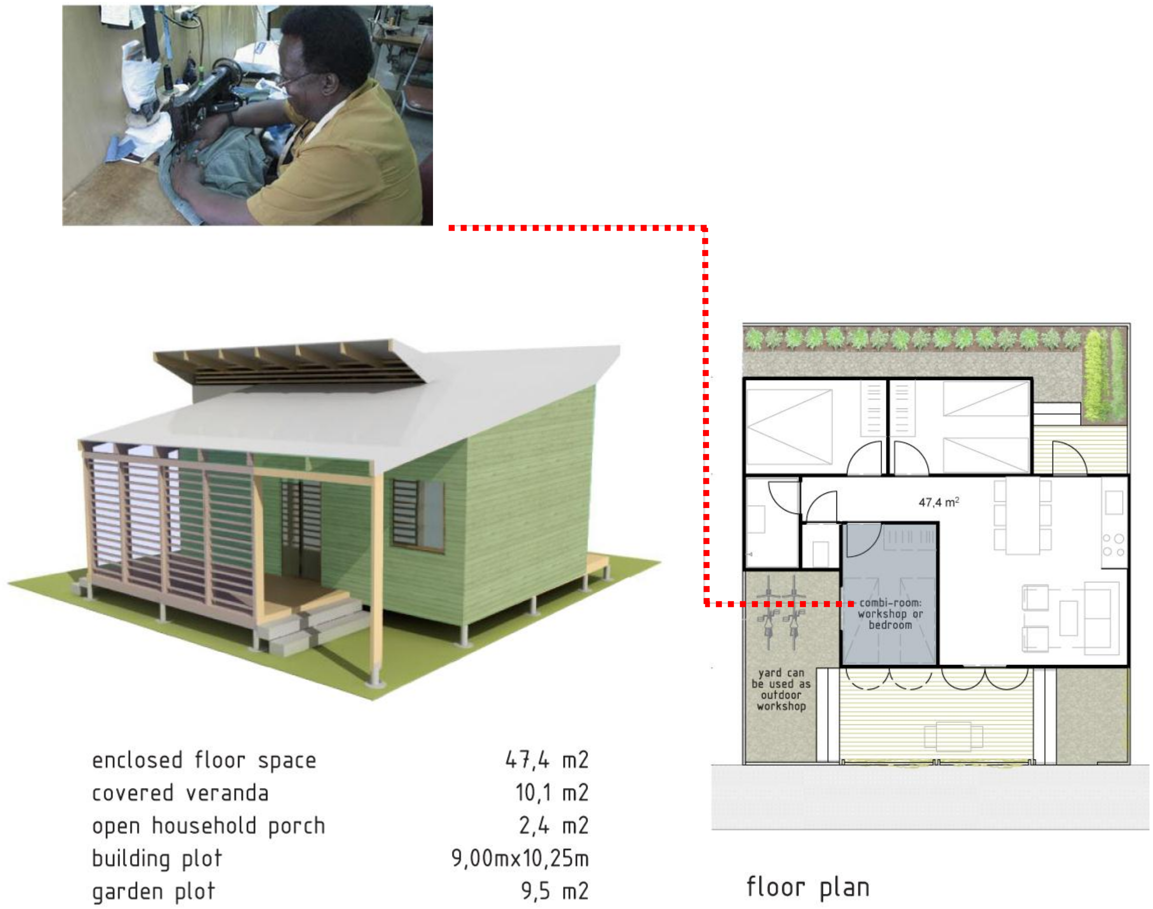


Figure 24. Haiti House 47- Type 03 *(Source*: http://www.archdaily.com/tag/haiti/)

The materials used for all the houses are pre-fabricated timber panels that will be shipped by containers and assembled on site by the locals. The wooden louvers and railings in the porch are custom-made by the locals and so is the fit-out work including paint-finish, tiling, front porch gratings, railings and screens, interior cabinetry to give the houses individual identities. At their summits, the roofs have opposing, projecting eaves in order to provide each of the necessarily small rooms with cross ventilation; intelligently prefabricated hurricane straps protect against wind-damage for storms up and including category III. The grey areas in the zonal diagrams 1,2,3&4 (Fig. 19 & 20) are stabilized by fillers or vertical concrete reinforcement. This prevents the ground from breaking or falling due to lateral movements. Also, the columns are dig deep into the rock layer to strengthen the foundations even more.

3.2. CYCLONE/ HURRICANE/TYPHOON

A. Cyclone Aila – May 25th, 2009

On the 25th day of March 2009, super cyclone Aila hit the coastal areas of Bangladesh causing severe damage to people's livelihoods and homes, businesses, farming and agriculture leaving the people homeless and vulnerable. Habitats became inhabitable; embankments collapsed and agricultural land ruined due to salinity and inundation.

a. Disaster Resilient Habitat (Adarshagram, Sathkhira, Bangladesh)

In response to the carnage that the cyclone had brought about, architect Fuad Mallick together with architect Hasibul Kabir and students of architecture department of BRAC University conceptualized DRH(disaster resilient habitat) to strengthen an entire village and its community through innovative interventions such as cyclone-resilient houses and infrastructure. In this way, lives, livelihood assets could be protected and getting back to normal life would be easier. It was observed that even after two years people were still struggling to get back on their feet due to inadequate recovery activities. Therefore, the main goal of this habitat would be a "bottom-up" and "build back better" approach where communities having local skills would participate in harmony with the technical experts that would socially, physically, economically, ecologically boost up an entire village. Also, the cyclone-resilient habitat is an alternative solution to cyclone shelters that tend to be less efficient during and post-disasters.

The DRH is not just a "simple structure" or a mere "product"- it is a "process" that sees every structure as a cyclone shelter and the entire community as cyclone-resistant. A DRH comprises of an individual house that evolves to become a settlement.

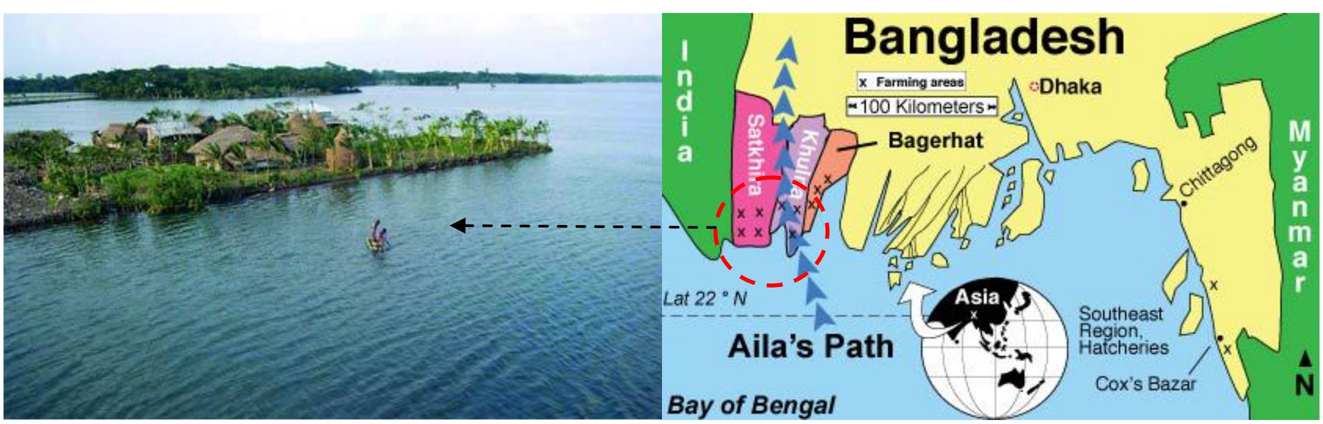


Figure 25. Map showing the path of Aila and post-Aila landscape *(Source*: Google image search/ Aila)

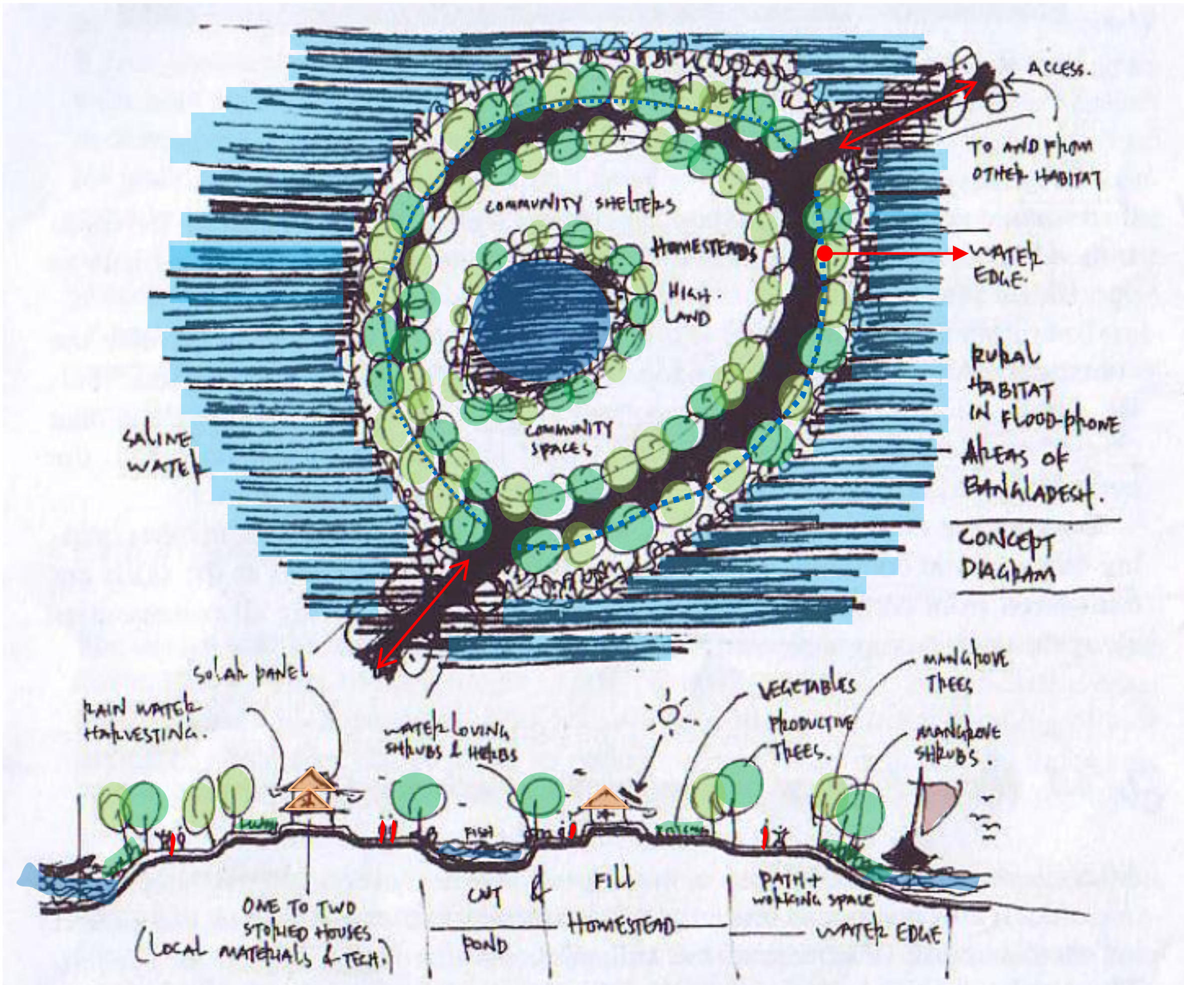


Figure 26. Concept Sketch of Disaster Resilient Habitat by Hasibul Kabir*(Source:* Springer; Rendering: Author)

The project started up with a site visit that connected the team of architects from BRAC University with the local community. A workshop called the "dream house" was later held on site to understand the demands of the community in detail. The design process began with the villagers' insight on their "dream home". Later, to back up their thinking with the technical experts' opinions, a second workshop was held at the Department of Architecture with representatives from the community to hatch even more practical solutions. The number of consultation sessions held led to an exchange of ideas and design developments began so forth.

Figure 27. WorKshops on site & at the Department of Architecture ensured exchange of local and expert ideas *(Source:* Springer, CCA)

Following the sessions, the skills of the locals were identified who had great carpentry skills most of them being boat makers. Also they were introduced to the reinforced concrete constructions by the technical experts. This amalgamation of local and technical knowledge and skills reflected upon a design solution that consisted of a reinforced concrete frame structure upon which would rest another timber frame structure which would eventually act as the "**shelter**" during storms. The structure would be a mixture of modified concrete, locally available timber from plantations in the site that had been replanted later on and clay tiles for roof. A total of 43 houses and a school replacing the one that was destroyed would be built in Adarshagram.

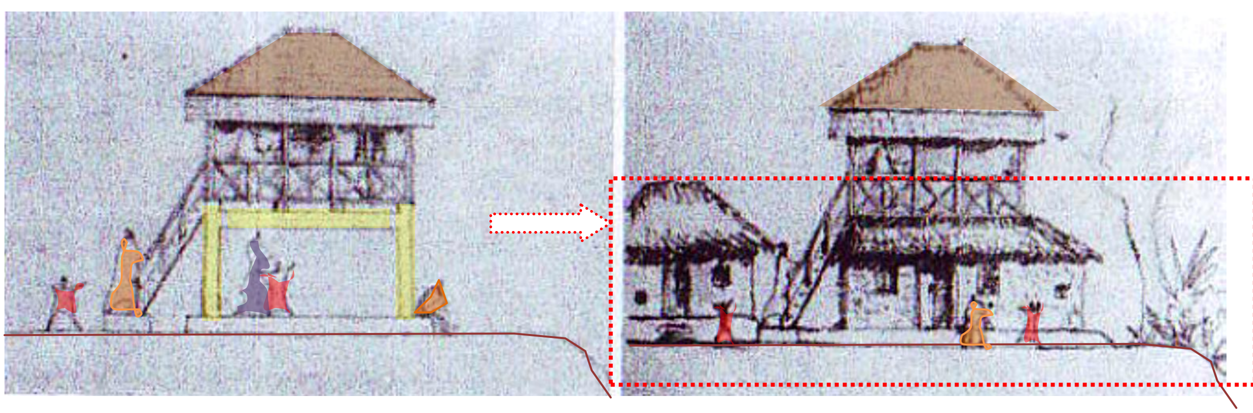


Figure 28. Conceptual sketches showing the initial design and further possible developments/modifications by Hasibul Kabir *(Source:* Springer, CCA; Rendering: Author)

The first test house was built and this ensured that the experience gained while building it would be carried on to build the next houses even stronger. The building process began by digging trenches for foundations by laborers after which the laying of brick over sand was entrusted to the house owner. Skilled labor was used to lay reinforcement bars and minor tasks such as bar binding or tying were handed to the locals. The boat makers or homeowners' skills were used to make the strong timber frame structure whereas the concrete construction was supervised by the engineers and undertaken by skilled labors together with student volunteers and local men and women.

Figure 29. The test house being built in collaboration with the locals, students & architects *(Source:* Springer, CCA)

The houses were 10 ft by 13ft and of height 8 ft and were built on four concrete columns joined by reinforced concrete beams well above flood level. The beneficiaries wanted the structure to be above ground with empty space below for modifications and future extensions**.** Stones instead of bricks and a special chemical were used in the mixture to make the concrete saline resistant. Also, extra gaps were left to prevent steel bars to rust and expand due to salinity. The salinity was caused because the embankments were breached by the villagers for shrimp farming. Again, the homeowners' were given responsibility of providing fresh water while casting concrete. Then, metal clamps were placed inside the concrete beams upon which the timber frame structure was placed. The joineries to attach the timber to the concrete frame were figured out on situ by both the experts and the locals. The timber structure was further strengthened by cross-bracing on all four sides. The roof was supported by wooden truss and strengthened by closer purlins at the roof edge. It was then attached to the concrete frame by special metal straps known as "cyclone straps". The roof was finished with locally available clay tiles with each of them screwed onto the wooden frame below to prevent it from being blown away in high winds.

Figure 30. The timber-concrete structure taking shape *(Source:* Springer, CCA)

The house owner's eventually made modifications in the bottom of the structure suiting their needs. Some made permanent additions to the structure by erecting walls to make rooms. In a few cases, extensions in the form of porch or shed were done to the structure as well (Fig.30 (1)). One other modification was such that two owners mutually agreed to attach two houses together to attain a larger space (Fig.30 (2)). The school building occupied a larger area and was in two levels. On one side of the school, earth was filled to raise the ground to make "killa" that would act as refuge for livestock during cyclone. (Fig.30 (3))

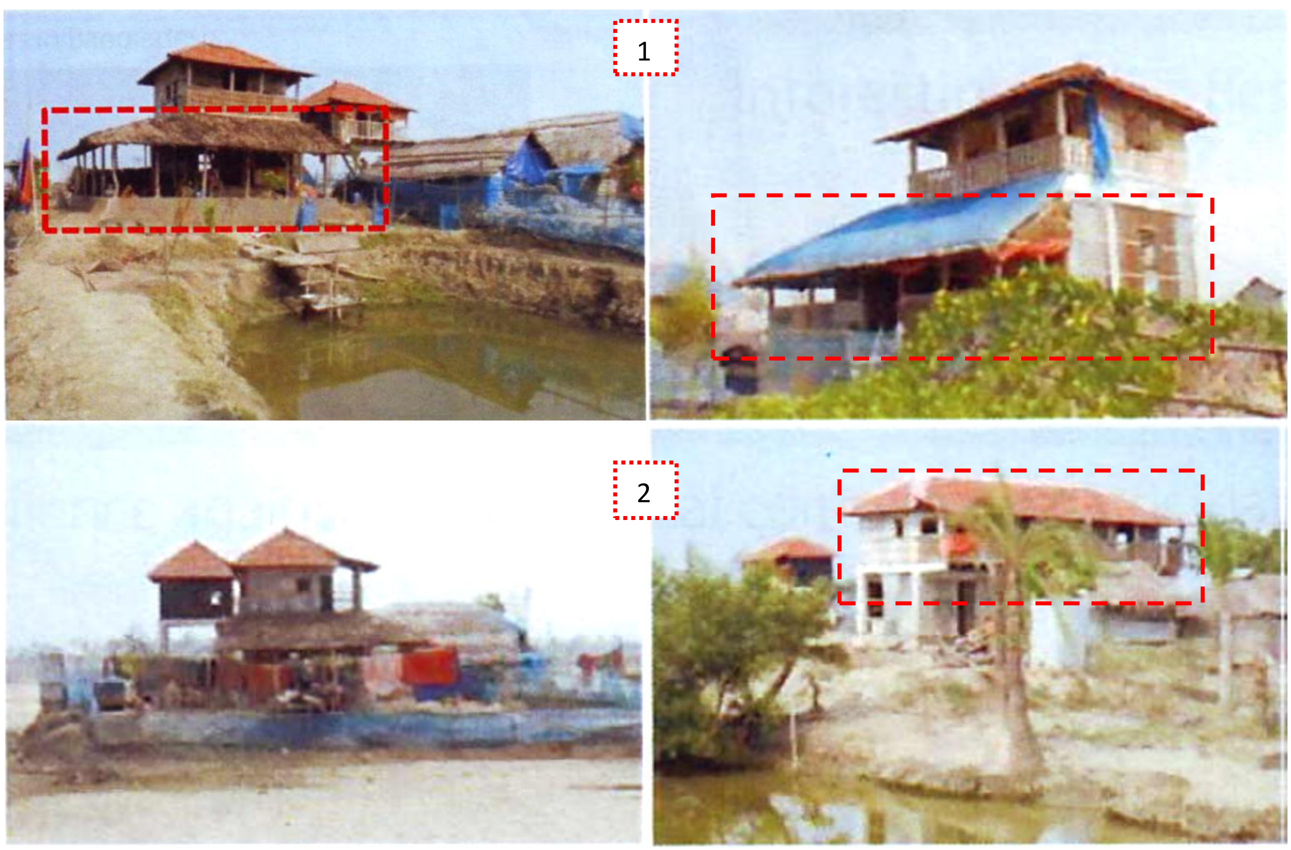


Figure 31. Different types of modifications done by the users *(Source:* Springer, CCA)

The habitat planning is such that the tip of the water is lined with mangrove shrubs and trees to protect from intense wave action. At the water edge, the path come working space which is the access to and from the habitat is fringed with productive trees. At the tree edge begins the homestead where some space is utilized for growing vegetables and the house or “shelter” occupies the rest of the area. The houses are raised on filled earth from pond digging and the dug out pond is commonly used for fish cultivation .The pond is located at the center of the habitat fringed with trees, herbs and shrubberies. Solar panels and rainwater harvest system are also part of the design scheme of the habitat.

“We know how to build strong houses; the challenge is building stronger communities,” is what that lead architect of the DRH said. A more comprehensive bottom-up approach which is a combination of technical expertise, local skill and people’s participation is needed to make a community both structurally and ecologically strong. Recovery here does not mean only building one house but its surroundings too.

Figure 32. The Disaster-Resilient Habitat & the completed adjoining school *(Source:* Google Image Search/ Aila)

B. Typhoon Xangsane– 2006

Typhoon Xangsane caused significant damage to the masonry shelters of the Port city of Da Nang in Vietnam. There were significant adverse impacts on all levels and scales of the social-physical-economic systems. The lack of awareness of people about new building technology and materials led to the easy collapse of houses.

a. Individual houses- Settlement Planning (Da Nang Port City, Vietnam)

A competition took place seeking disaster resilient housing-design ideas in Vietnam with focus on Da Nang City. The team of architects had addressed three points that needed to be considered:

1) Site- Planning: Site-planning and settlement patterns are designed with the emphasis of using non-parallel or zig-zagging roads and unequal distribution of houses.

Figure 33. Site planning : Zig-zag pattern for roads & buildings *(Source:* ISET, 2013)

2) Building Design: Simple building shapes such as squares and rectangles and high-sloping pitch roofs are employed as key principles to design individual houses for storm reduction. Based on findings through field visits, architects decided to work with three types of house forms: a) the tube-house, b) three-compartment structure and c) twin-double storey buildings.

These models were easily acceptable by the beneficiaries as these units were affordable and provided safer and comfortable living spaces.

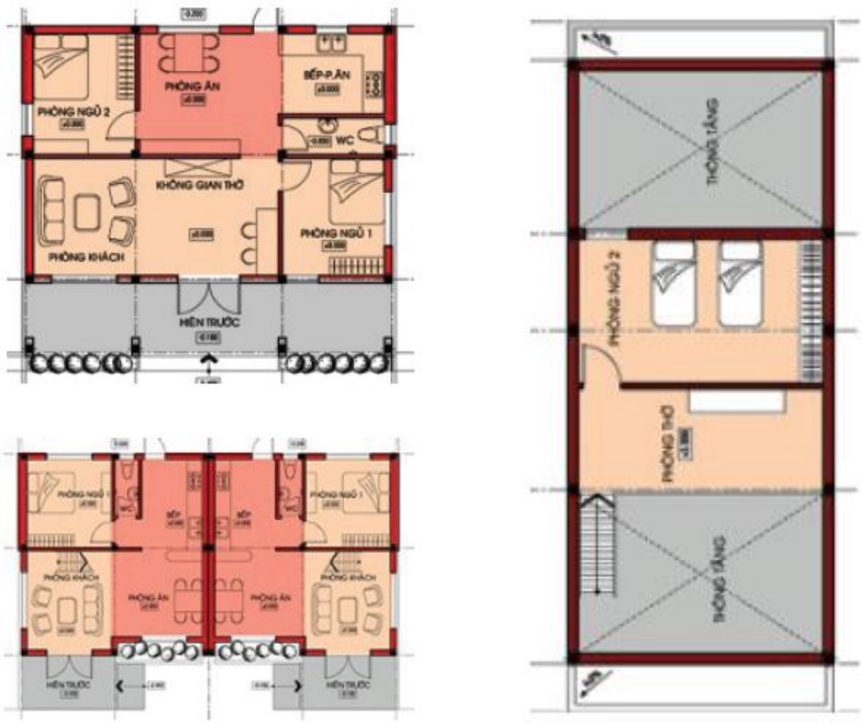


Figure 34. Building Design : Plans in Square/ Rectangle shapes*(Source:* ISET, 2013)

Figure 35. (1)The tube house ---(2)Three Compartment house—(3)Twin Double storey house –Elevations *(Source:* ISET, 2013)

3) Construction Technology: While designing, the architects highlighted two basic principles: (a)all building parts were connected from top to bottom by reinforced-concrete beams and pillars and (b) a strong room known as "safe failure" was incorporated in each house which could be used for escape during calamitous typhoons.

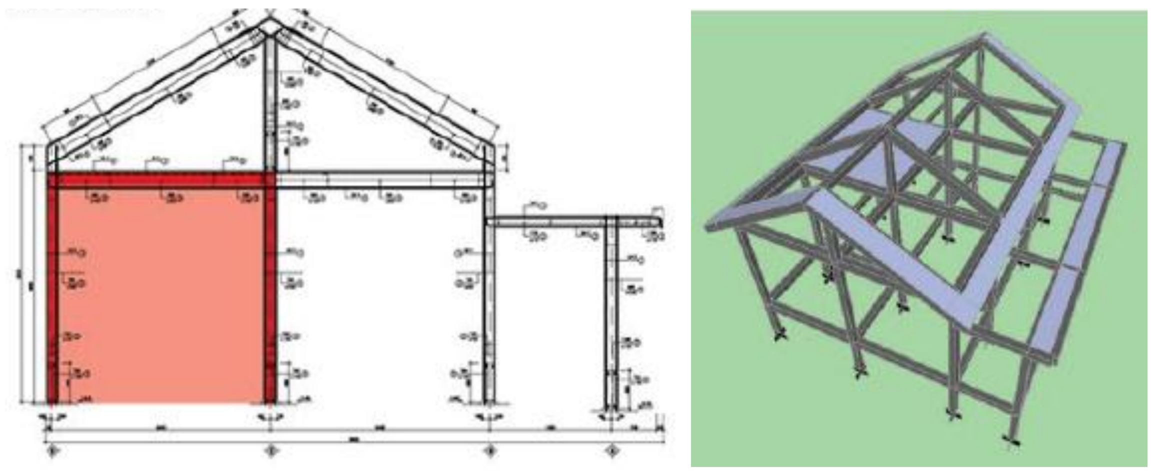


Figure 36. Building technology: Safe failure or solid room and all parts of the building securely connecte *(Source:* ISET, 2013)

The team's approach of the design was to maintain the local design forms of all the houses but to incorporate new and innovative construction techniques to increase technical stability.

3.3. FLOOD

A. Annual Flooding

Almost 60% of the land is inundated due to flood waters in Bangladesh resulting in destruction of homes, livelihood capacities. The rural population has been living with flood for ages and it is slowly becoming a major nuisance in the urban areas or cities. Nonetheless, in rural areas communities have adopted their own coping methods but lack the technical knowledge and have wrong perceptions. Henceforth, designers and building professionals have devised ways to combine the age-old techniques with technology in the existing typologies to come up with cost-effective, quality and sustainable designs.

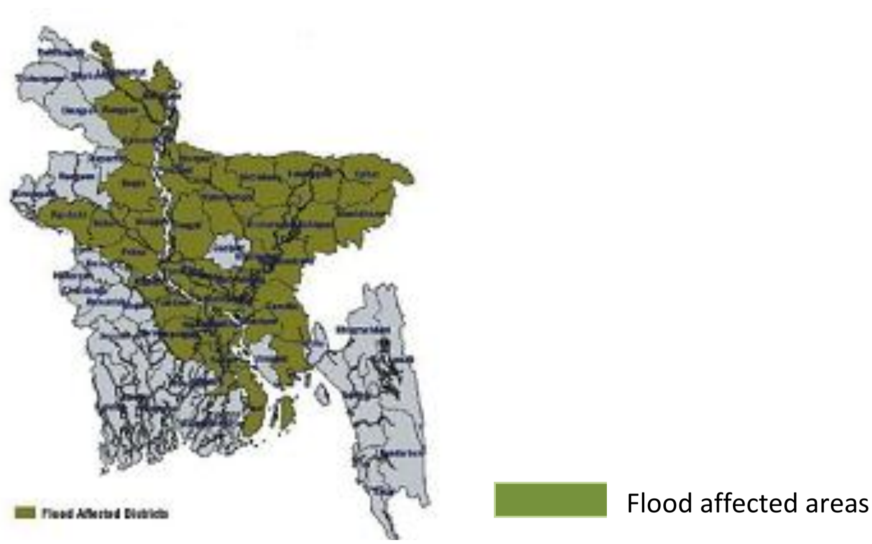


Figure 37. Flood affected areas in Bangladesh, 2004 (Source: Wiki/BD Flood)

a. Individual houses- Homestead & Infrastructure planning- Landscaping (Flood –prone areas, Bangladesh)

- **Individual Houses**:

The basic designs of rural houses are as follows:

1) *Kutcha house*

a) Foundation: Usually earthen plinth and bamboo or timber posts;

b) Walls: Organic materials such as jute, catkin grass, straw, bamboo mat reinforced by split bamboo framing and sometimes earthen walls;

c) Roof: Thatch-rice/wheat or maize straw with split bamboo or reed stalk framing.

2) *Semi-Pucca house*

a) Foundation: Usually earthen plinth; brick perimeter wall with earth infill; brick and concrete;

b) Walls: bamboo mats; CI sheet; timber or split bamboo framing and sometimes earthen walls; sometimes part or full brick

c) Roof: CI sheet with timber framing (split bamboo sometimes)

3) *Pucca house*

a) Foundation: brick and concrete;

b) Walls: brick

c) Roof: Reinforced concrete

Figure 38. Typical Kutcha(1) ; Semi -Pucca(2) and Pucca(3) house types(Source: adpc report, 2005)

The typical problems due to flood are outlined for walls, foundation and the roof.

For foundations, in kutcha types, the earthen plinth tend to get completely washed off and the bamboo or timber posts embedded into it are very weak. The whole building loses stability and collapses during even moderate flood. The in-fill earth floor for semi-pucca structures can experience the escape of soil from below during prolonged floods. For pucca houses due to scouring foundation can weaken.

For walls, in kutcha & semi-pucca houses the bamboo walls decay easily. CI sheets corrodes in contact with water and for earthen walls the whole structure is liable to collapse as flood waters cause serious damage to monolithic construction. Brick walls can experience peeling of plaster, weakening of mortar joints and staining. Cracks develop if the foundation settlement occurs due to prolonged flooding.

For roofs, thatch roofs and CI sheets decays and corrodes respectively. RC(reinforced concrete) roof is more durable but can weaken if foundation settles or walls damage.

Innovative measures applied to these typical constructions make them stronger and more resilient.

Figure 39. Cement-stabilized earthen plinth (Source: adpc report, 2005)

Stabilizing the plinth with a mix of 5% cement with earth and water makes foundations stronger as it resist water much better. (Fig.38). Lime can also be used but requires more quality control and is not available in many areas. After the stabilization process, it is best to compact the earth.

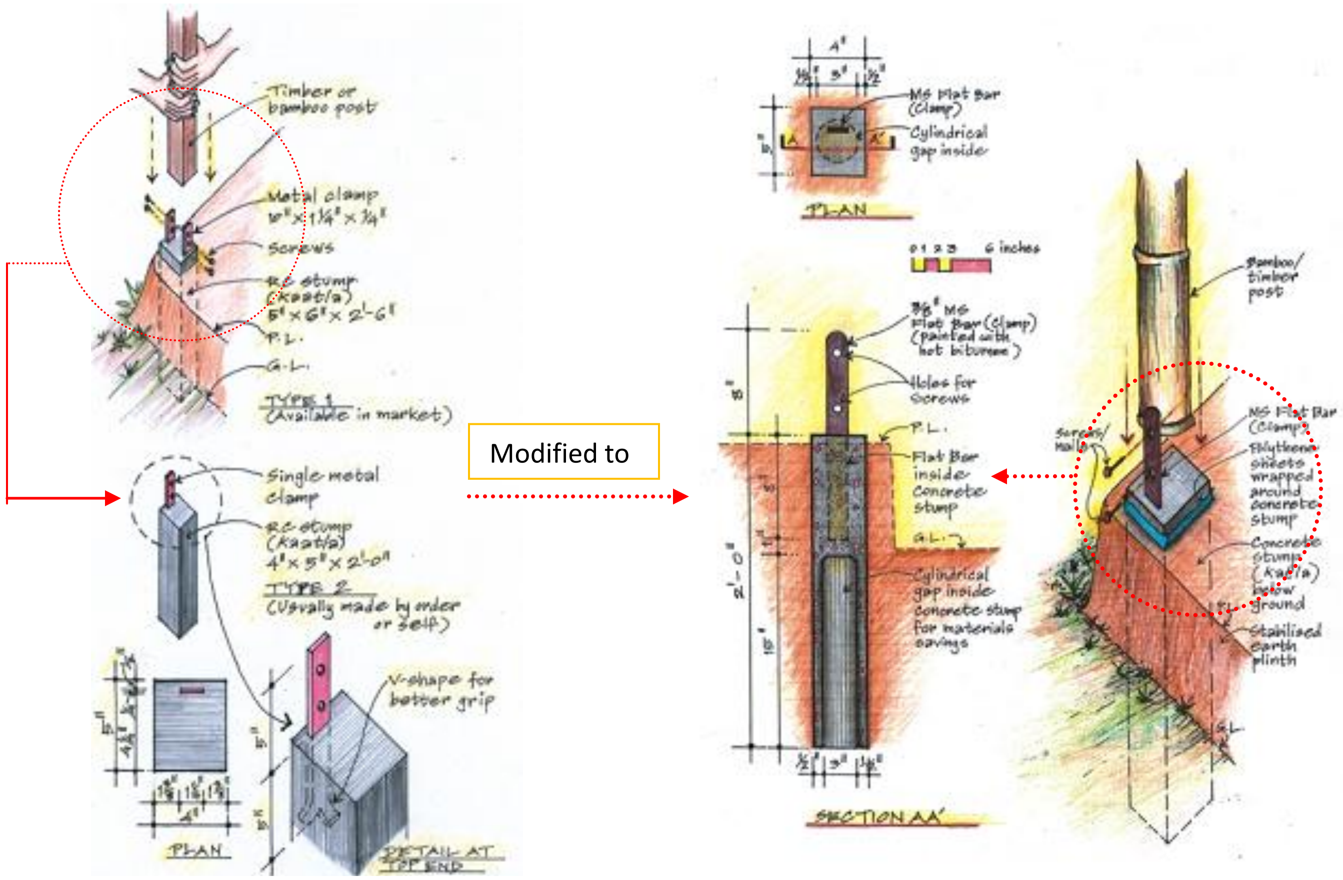


Figure 40. Reinforced concrete post modified to hollow cylindrical RC post (Source: adpc report, 2005)

Concrete stumps (kaatla) are a local method used to protect the base of the bamboo from water but it has been modified by making the concrete stumps hollow (Fig.39). The fabrication using wooden formwork; cement mix; and casting in horizontal position remains same. The only difference is making the Kaatla hollow and it is done by inserting a PVC pipe into it during casting which is later removed. Banmboo or timber posts are nailed to the kaatla using MS flat bars or clamps.

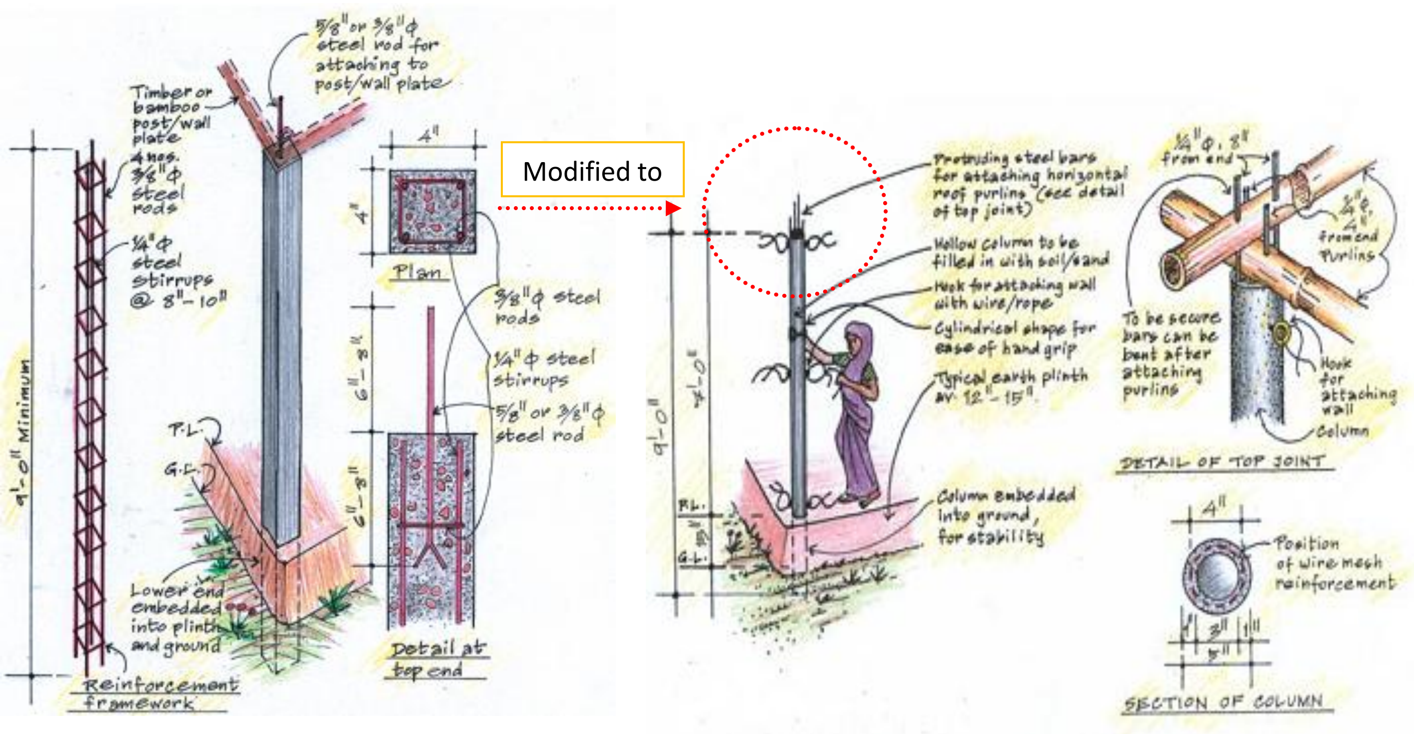


Figure 41. Typical Kaatla modified to Hollow Concrete kaatla(stump) (Source: adpc report, 2005)

The RC posts have also been modified to hollow RC posts (Fig.40) .The regular RC posts are solid square sections but hollow RC posts are cylindrical and is made in a similar manner to that of a hollow kaatla by inserting PVC pipes and later drawing it out. The hollow columns are later filled with sand or earth and yet do not lose the flood-resistant properties. The reinforcement remains protruded from the hollow section to attach the roof. The walls are attached by ropes or wires with the help of hooks protruding from the surface of the hollow posts.

Compressed earth blocks (CEB) are another innovative means of making walls which fares better than any monolithic earthen walls. Only a brick mould is need as formwork and each unit is stabilized by 5% cement mixed with water and earth. (Fig.41)

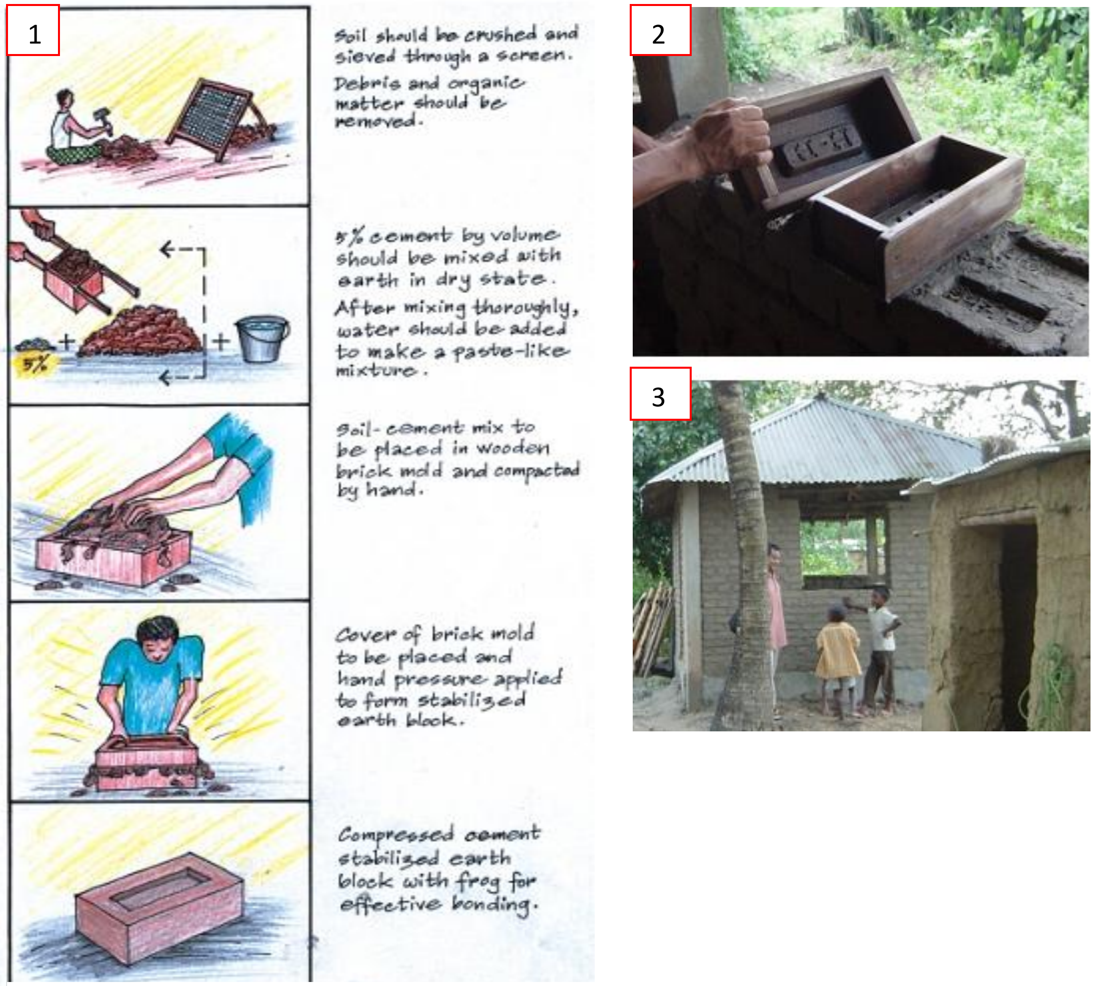


Figure 42. (1) Steps for making CEB's; (2) Brick mould used for CEB making; (3) Monolithic walls compared to CEB walls (Source: adpc report, 2005)

Ferro cement walls are constructed by mixing cement, sand, aggregate and water in the right proportions in two phases: (dry and wet mixing). Two workers, one who will put the mortar on the skeletal steel rods and the other holds a back-up sheet on the outside. Treated bamboo sections can also be used instead of steel sections.

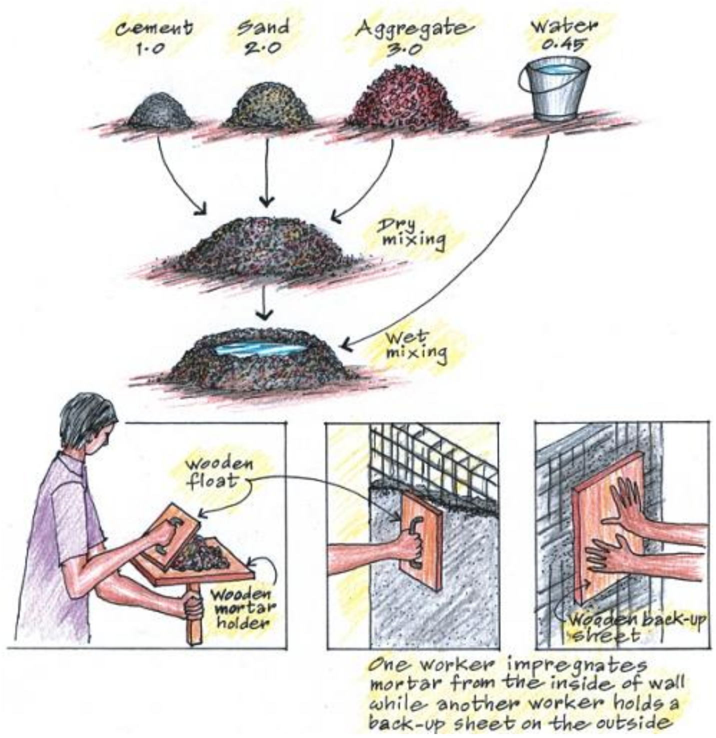
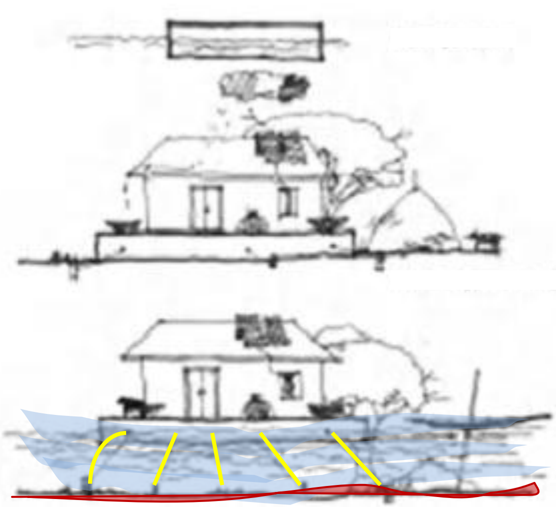


Figure 43. Ferro cement construction process & House made of ferro cement walls (Source: adpc report, 2005)

Another innovative solution for houses or shelters would be floating houses or dismantleable shelters. For floating houses, the concept was such that the house would rise with rise of water while remaining anchored to one place. The other idea is to make structures that can be dismantled and reconstructed anywhere depending on the necessity and the volume of flood waters. It can be easily moved to higher ground and act as safety refuge. (Fig.43)



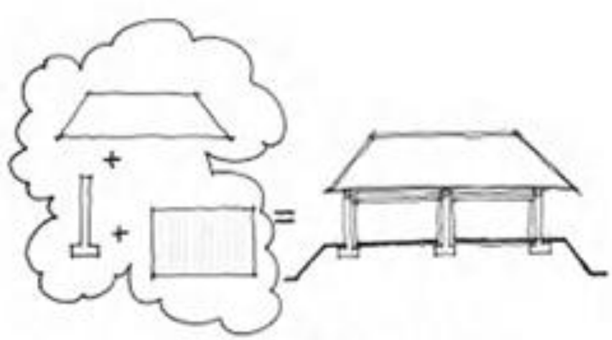


Figure 44. Floatable houses (left) & Dismantleable Shelters (Right) (Source: Springer,CCA)

- **Homestead Planning & Infrastructure planning**

The typical rural homestead layout is around a courtyard where activities take place and through which the other functions such as dwelling units, toilets and other ancillary facilities are accessed from the main route. The homestead layout is introverted with ample trees surrounding it and is raised by mounds of earth from canals and ditches. Fig .44 illustrates the typical homestead and courtyard layout.

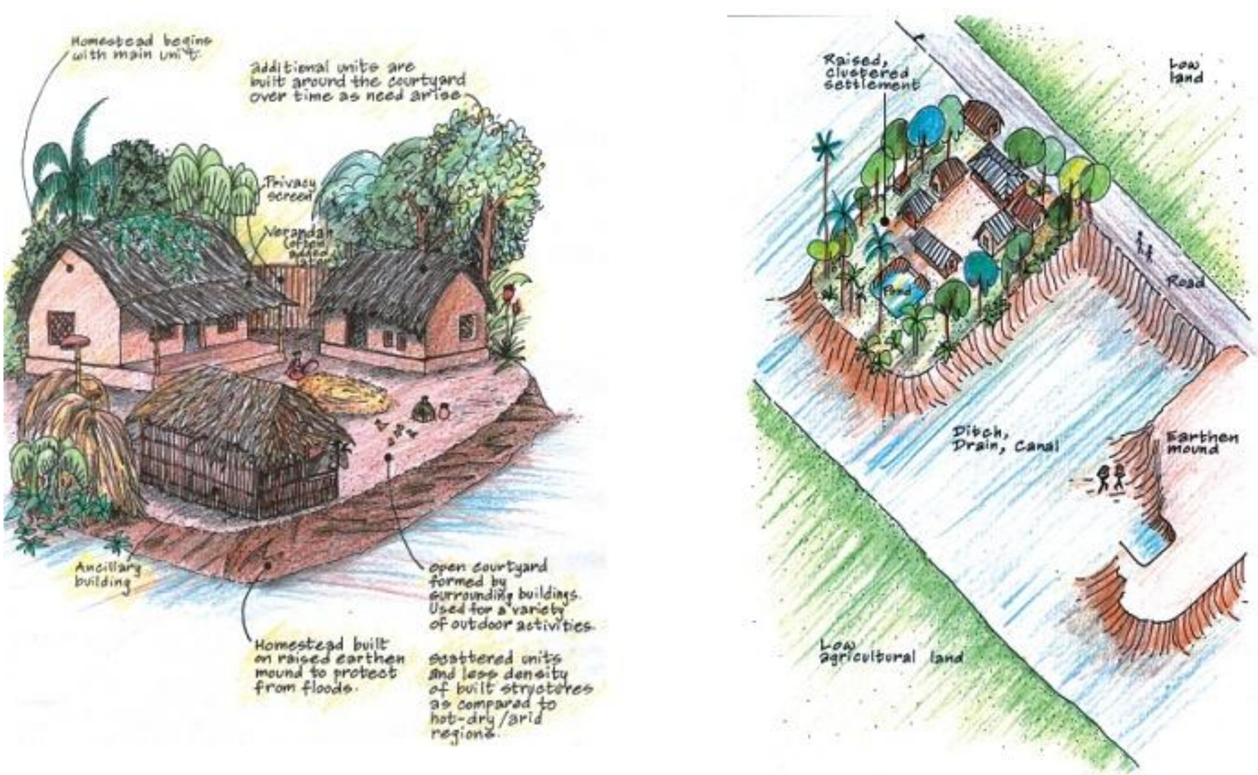


Figure 45. Typical Courtyard layout (left) & Homestead layout (right) (*Source*: adpc report, 2005)

This typical layout can be improved through an organized homestead raising approach where the resources would not be cut and desired results can be achieved. Here, communities are mobilized to raise the ground above annual flood level and in a conscious manner. The earth is acquired from the silted up riverbanks or alluvial deposits and not from the nearby earth mounds at all times. The houses are laid in a more organized fashion with the courtyard and main access roads at high points. New houses are constructed during ground raising by dismantling the old ones in a more clustered manner. Proper slopes are designed to drain out water into nearby water bodies to prevent stagnation.

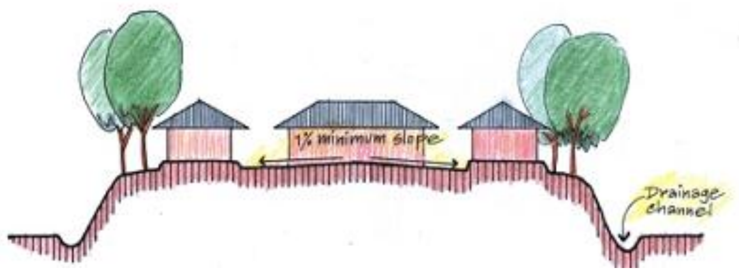


Figure 46. Proper slope need to be maintained for successful drainage (Source: adpc report, 2005)

- **Landscaping:**

Trees are planted around the courtyard in such a manner so that it protects the homestead; ensures privacy and provides the family with food supply. Grasses with affinity for wetness should be planted on the steep slope as soon as the land is prepared to prevent heavy rain from hitting the soil. Planting catkin grass on the edges also protects mound from soil erosion and is a source for building material, fuel and fodder. Bamboo groves are a very important material source and can withstand flood waters and prevent the homestead from erosion. Trees for timber and that bears fruit should be given importance and the ones with deep root systems (coconut, date) should also be used on slope to keep the mound together. Trees such as hijal ,gab should be planted in the lower parts to withstand flood waters for a long time. The vegetable garden should be allocated on high ground as native vegetables cannot survive in flood water and also adequate amount of sunlight should reach the garden.

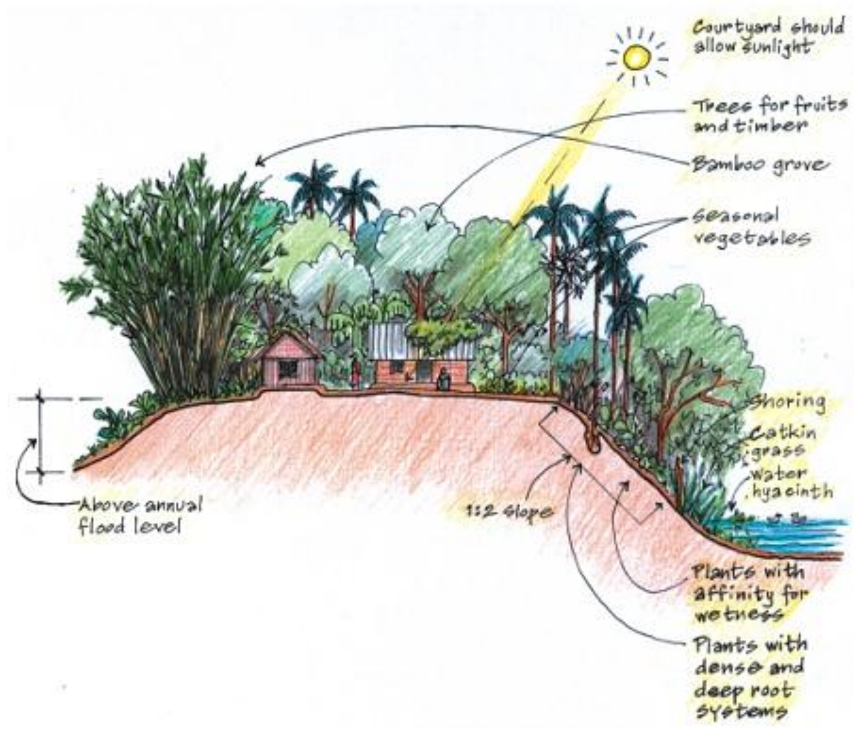


Figure 47. Landscaping criteria for homestead in flood-prone areas (Source: adpc handbook, 2005)

One such infrastructural innovation would be in embankments. Embankments are typically built to resist flood waters. This often becomes a place for shelter during floods for a large number of people. An idea is such that, the embankments are connected to homesteads and community centers or schools with access routes. Hence, it is actually the widening of the embankment at certain points of the community where large number of people can gather safely.

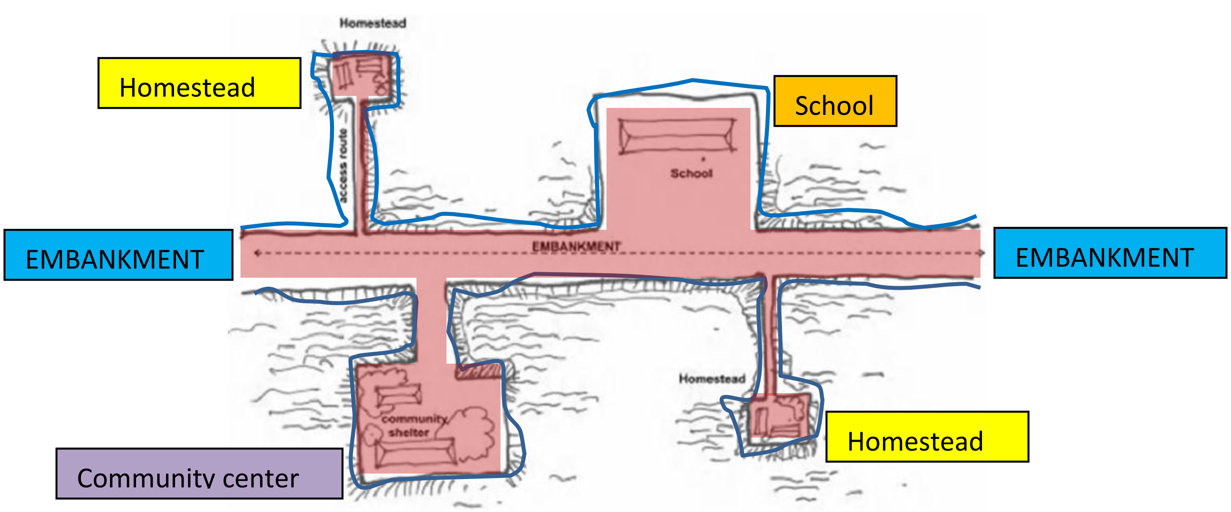


Figure 48. Embankment design for flood adaption acting as one single unit (Source: Springer, CCA: Rendering: Author, 2015)

3.4. TSUNAMI

A. Great East Japan Tohuku Earthquake come Tsunami – March 11th, 2011

On March 11th, 2011 an earthquake of magnitude 9.0 occurred off the Pacific coast of Tohuku (north-east region of Japan) triggering a massive tsunami having a maximum height of 40m. This led to extensive reconstruction measures described below.

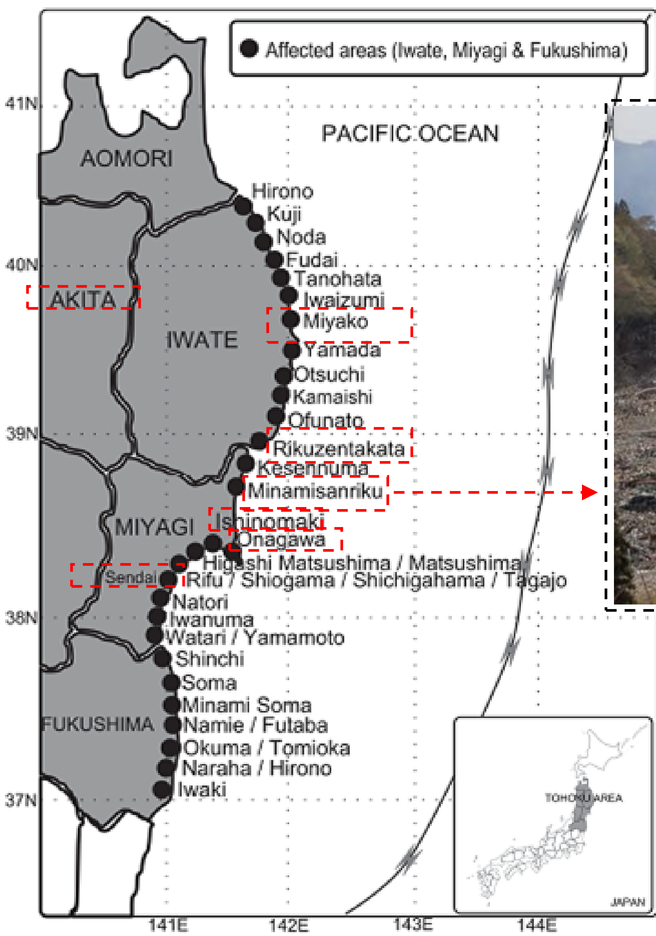


Figure 48 Minami Sanriku town after the Tsunami(Source: http://archnet.org)

The red box indicate the case studies chosen

Figure 49 Map showing Tsunami-affected areas in the Iwate, Miyagi & Fukushima regions (*Source*: Journal NDS, 2012)

a. Urban Community Space Planning through trainings-workshops-participation (Minami Sanriku)

- Minami Sanriku with its hilly topography was one of the hardest hit towns by the Tsunami. A team of architects and landscape planners led by Professor Kanda responded to the calamity through the MIT Japan 3/11 initiative.

  The main goal of the program was to re-vitalize the small town from its mundane, redundant state as a result of the tsunami through the injection of community centers. Also, to spur collaboration between MIT and other Universities in order to educate young architects and citizens in the study and implementation of disaster-resilient planning.

  Once the area was surveyed and SWOT analysis preformed, keen observations were made. The residents were shifted to a relocation site from their former homes and were living in temporary housing units provided by the NGO's. In the hurry to provide shelter immediately after the disaster, the shelters were not satisfactory and did not take into account the areas cultural and social values.

  In Japan, social interaction and bonding with neighbors over a cup of tea is a lifestyle. Through this exchange of ideas they share a sense of belongingness with each other and ties in the community become stronger. **The housing units were uniform pre-fabricated boxes attached to one another arranged in rows and were depressing opposing the Japanese cultural tradition**.

Figure 50 The described as "depressing" aluminum pre-fabricated housing units arranged in rows (*Source*: MIT 3:11 report)

To boost up community bonding and participation, the community spaces were designed in between two rows of housing in the alleyway. The community space is a 175 square foot of meeting space built with wooden frame and poly-carbonate roof called Babadoru 5-Chome where "baba" is a colloquial Japanese term for grandmother; "doru" means street ; "chome" means intersection and "five" refers to the row where the little community center now sits.

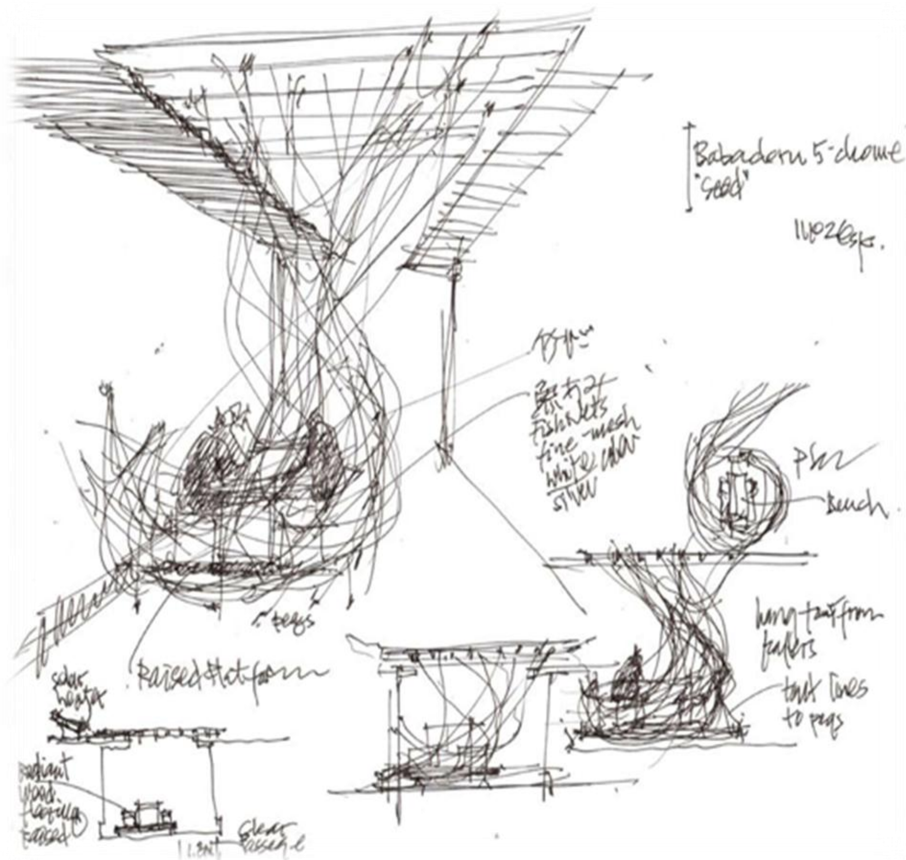


Figure 51 Conceptual Sketches of Babadoru- 5-Chome/ Community center (*Source*: MIT 3:11 report)

The construction materials were locally available and the structure built was very light and could be dismantled and re-constructed very quickly and easily. The wooden deck features the seating arrangements whereas the wooden frame constructed over the roof of the pre-fabricated units supports the light poly-carbonate roof. This roof allows for proper light and ventilation and ensures transparency with passer-bys in the alleyway for interaction.

Figure 12 Installation of the poly-carbonate roof, wooden deck & frame and seating (*Source*: MIT 3:11 report)

The space immediately grabbed attention as community participation was encouraged during the building process and also because it gave peoples an opportunity to share stories, ideas to start over their lives anew. The mundane alleyway is now bustling with crowd who assemble there to talk, sip tea and get a taste of their tradition. It is occupied by elderly and children alike and in the architect's own words "*Every time I visit, they're all laughing and joking," says Kanda. "They're a very happy bunch." The $2,000 project is a "humble start," he says.* ***"It is a seed for more to come."***

This idea has now circulated around civic leaders who are planning for more permanent solutions. The poly-carbonate roof and wooden support is now being replaced with more robust materials such as cedar frame and roof and the wooden deck is replaced by a stone base. The area of the meeting space will be larger where people will not only gather to share ideas but make crafts items and generate income.

Figure 53 Women & elderly enjoying and relaxing; a mundane alleyway was converted into a happening and colorful place for the disaster stricken residents of Minami Sanriku (*Source*: MIT 3:11 report)

b. Urban design & Landscape features (Rikuzen-Takata City, Akita City, Sendai City)

- The planners decided to build disaster memorial parks to educate the mass about tsunami and also constantly remind people of the devastation so that it may better prepare them psychologically, socially and physically.

- Pine woods have been planted along the coastal belt of the cities to protect the people and property from the impact of Tsunami. After the Tsunami the only pinewood tree that survived is represented now as a symbol for planting more number of trees for barrier against the waves and also promotes tourism.

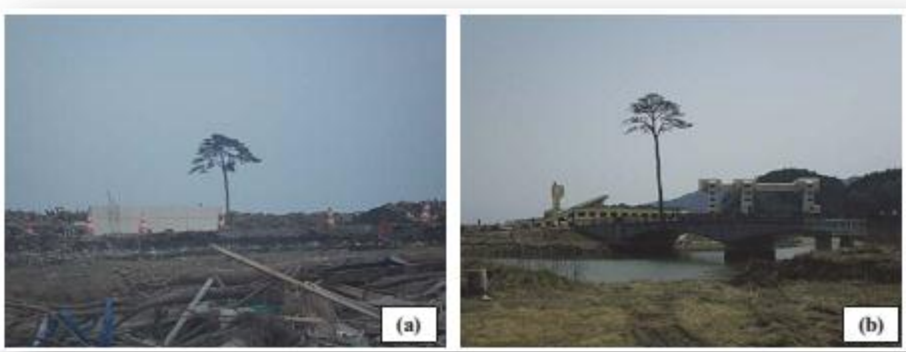


Figure 54 The only surviving pinewood tree (a) after 3 months (b) after one year (*Source*: Journal NDS, 2012)

- Concrete stairways are now being built along the Sendai east expressway, which is located approximately 5km from the sea. Many people survived from the tsunami waves by climbing onto the expressway where the waves could not reach because of its higher elevation.

Figure 55 Concrete stairways being built for access to the surface of the expressway (*Source*: Journal NDS, 2012)

c. Infrastructural innovations (Taro village, Miyako city)

- The sea walls are now being planned in a way so that they are distant from the river as the foundations tend to become weaker in loose, wet, unstable soil. Also, the intersection between two walls is avoided because the two lines of sea walls in Taro village were destroyed because the walls crossed in an X-shape. This pattern concentrated the tsunami at the center of the sea walls making them unstable from the wave impact causing the collapse. Therefore, the walls are now being built with adequate connections to one another and in separate lines without intersections or crossings.

Figure 56 (a) Height records of historical tsunamis in 1896 & 1933 (b) destroyed sea walls in 2011 (*Source*: Journal NDS, 2012)

d. Individual Household structures(Ishinomaki)

- After the post-disaster site survey the planners and architects came up with observations on different types of houses affected by the tsunami. Three types of houses were inundated at the same depth of 4m but the damages were different for each house. The reinforced concrete (RC) two-storey house had only broken windows but no structural damage; the two-storey wooden house had damage to some walls and columns; and the one-storey wooden house had totally collapsed. Hence, the architects are devising plans where a balance between a light structure such as wood and a stronger structure such as RC can reduce shear forces due to earthquakes and hydrodynamic forces from a tsunami respectively. The typology of the buildings shown in (Fig.9) will remain the same depending on the comfort of the users but the technique of construction and use of material shall differ.

  According to the graph in Figure 9, the possibility of damage at a 4m inundation depth to an RC house, a mixed RC and a wooden house is 0.3, 0.7 and 0.9 respectively.

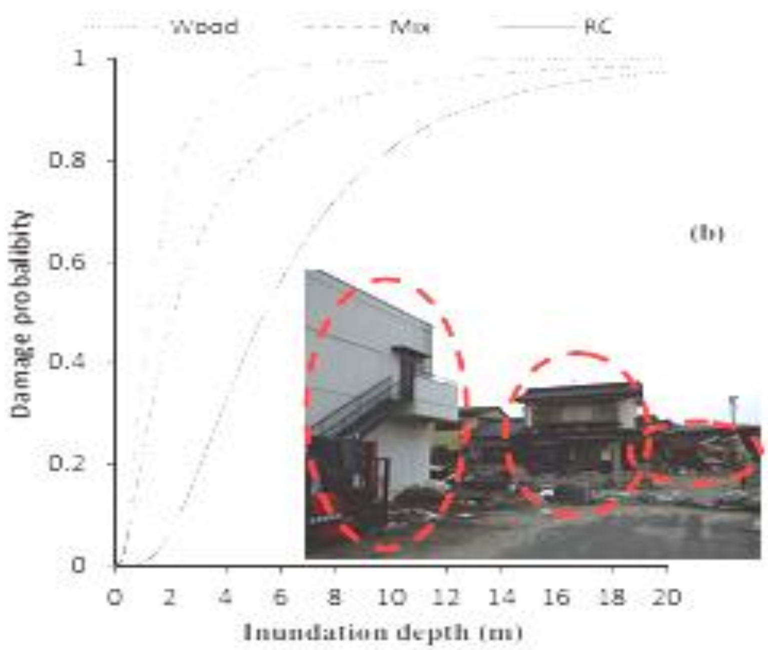


Figure 57 The difference in damages in 3 different types of houses at the same inundation depth of 4m. (*Source*: Journal NDS, 2012)

e. Housing settlements (Onagawa City)

- The Japanese architect, Shigeru Ban responded to the shortage of housing in Onagawa town. Shipping containers were stacked three stories high and arranged in a check-board pattern. Since, all the houses were attached to one another; the pattern created living spaces between units. The units were constructed by using the skills of the locals along with technical persons. The materials used namely steel frames for structure with metal sheets/boards as walls and corrugated sheets for roof are light, durable and robust structures and are feasible for areas with Tsunami warnings as they can easily be mantled and dismantled.

  These housing units were modified in terms of the technique (for assembly) and skills even though the containers were factory produced initially.

Figure 58 Shipping containers as housing units by Shigeru Ban (Source: http://www.houzz.com)

The shipping containers used for this particular housing is a "closed prefabrication system" meaning that the containers have been assembled in factories in standardized dimensions. Here, the users did not have enough freedom to exercise their own modifications in their own houses as the "containers" have been built in non-modifiable configurations only to be assembled in situ. Ban responded to this restriction by creating living spaces to bring back the communal participation & bond and enhance connection with the neighbors.

Figure 59 The open living spaces between units as seen from the interior of the houses (Source:http://www.houzz.com)

- In response to the widespread need for temporary housing in Japan, Yasutaka Yoshimura Architects developed design solutions that also (like the open-fabricated units designed by Ban) utilizes the format of shipping containers into housing solutions. The "Ex-container" represents quick and easy solutions for the displaced populations in terms of implantation and transportation. The containers are closed pre-fabricated houses fully constructed in factories and assembled on site. These units are made of light, steel frames that are redesigned by reducing unnecessary parts to fit the housing regulations of Japan. The steel frame structure makes these units strong and durable.

Figure 60 The complete assembling of "Ex-container" in factories(Source: HBRC Journal, 2014)

The users cannot modify the walls, roof or the internal layout of the house but the flexibility here lies on the arrangement of these containers according to the need and requirements of the area and population. Three types of configurations have been designed as follows:

First, the units can be adjoined horizontally by using two 20-feet containers side by side which results in a 28 square meters space including a bathroom, kitchen and living room.

Second, the units can be assembled with intervals between them resulting in a larger surface area of approximately 50-60 square meters.

Third, in smaller sites where areas are significantly tight, the units are stacked vertically on top of one another converting it into two-storey housing.

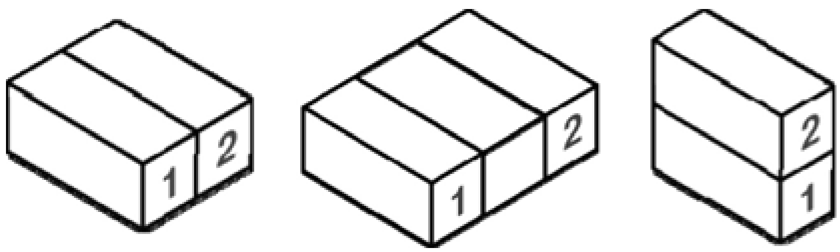


Figure 61 The different assembly configuration of the "Ex-container" concept (Source: HBRC Journal, 2014)

B. The Indian Ocean Tsunami – December 26, 2004

The 9.1 magnitude earthquake in the Indian Ocean caused immense waves-some 30 m high sweeping through the Indonesian province of Aceh causing destruction of buildings, coastal communities and infrastructure. It was one of the largest urban disasters till date.

Figure 62 Mass destruction in the region of Aceh in Indonesia (Source: Google Image search/ Tsunami/Banda Aceh)

a. Urban settlement / Housing (Banda Aceh, Indonesia)

- Banda Aceh is a low-rise metropolis along the delta of the Aceh River. Due to its low-lying plains the anti-poverty network called UBA (Uplink Banda Aceh) took strong stance to reconstruct the village where the villagers previously lived. In this case study, Uplink worked with the technical persons (architects and planners) along with the local residents. The villagers decided to stay back in their former settlements close to their livelihood and hence the plans were devised accordingly.

  Firstly, the pre-tsunami village demographic characteristics were documented and the post-tsunami areas surveyed for their strengths and weaknesses to better target recovery efforts. Then locally a group was formed where enough wood from the tsunami debris was collected to build temporary shelters through participatory effort before turning the structures into permanent houses. Jakarta architect Marco Kusumawijaya worked with UBA and decided to keep the mosque-centered layout of the previous settlement and build upon it. Most people wanted a "clean slate" of land to start the building process but the architect decided to keep the structure and the road pattern of the original village intact to value the culture and tradition of the area. These previous attributes were adjusted by providing enhancements like better escape roads, access to quality land that could enable move to a higher elevation.

Figure 63. Single storey-house (*Source*: https://placesjournal.org/

The houses provided were a combination of single and double-storey houses. The single storey houses had RCC (reinforced cement concrete) foundations and structure whereas walls were made of brick with wooden frames and shutter for doors and windows and sometimes glass shutters were used. The gable roof's structure was that of wood covered with tin.

Figure 64. The 2-storey homes with wooden top floors and raised ground floor on RCC columns. The ground floors can be utilized for storage of livelihood items or support small businesses (*Source*: https://placesjournal.org/

The two-story homes were raised above the ground and this design offered greater protection from floodwaters or minor tsunamis, while yielding a covered, protected space on the ground floor that could be used to store fishing and farming equipment or support a small business. The reinforced concrete columns provided the structure with greater stability from hydro-dynamic forces of the tsunami whereas the upper wooden floor reduces lateral movements of an earthquake.

b. Individual houses—Settlements & Landscaping (Kirinda, Sri Lanka)

Following the Tsunami of 2004, the Muslim village of Kirinda in Sri Lanka, a small fishing community lost majority of the houses and residents were forced to live in temporary accommodations. In the aftermath architect Shigeru Ban designed the settlement with the goal to relocate residents back to their former homes and livelihood so to retain the pre-disaster social and cultural structure of the village.

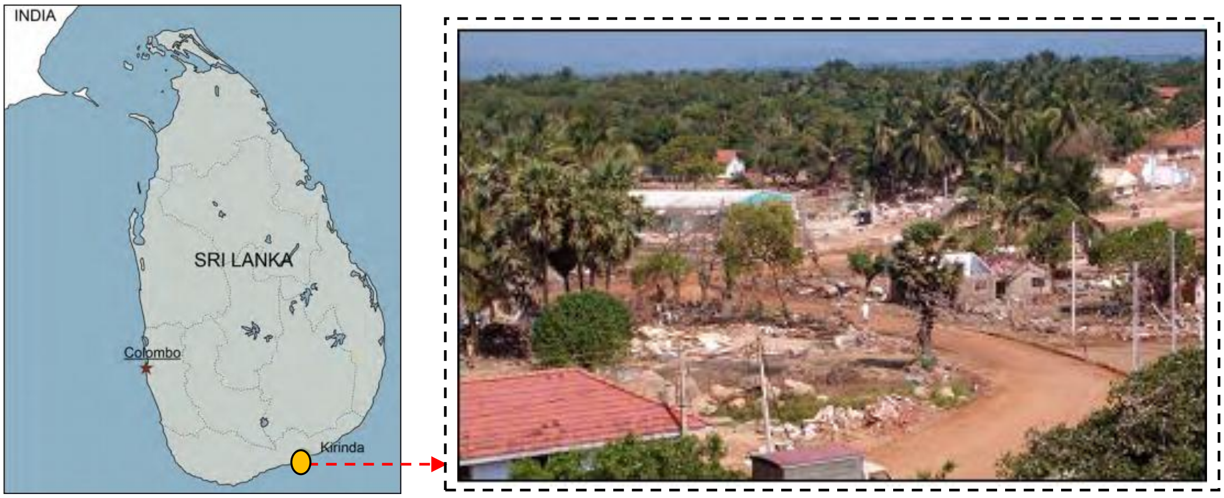


Figure 65. Picture showing the majority of houses destroyed in the village of Kirinda(*Source*: Sultan Barakat report, 2013)

- The Architect and his team surveyed the local architectural character, site and surroundings, climatic conditions, historical background and topography to come up with appropriate solutions for the housing settlement. The following observations were made:
  - Kirinda is a popular place for pilgrims because of its legendary stories,
  - The livelihood of people comprises of fishing and diving for sea-shells,
  - The climate is such that no heating is required in the household and precipitation occurs of 30 mm.
  - The project site is located 200m from the Indian Ocean .The main road runs through the centre of the site that branches into smaller roads. The critical civic facility which is the mosque is slightly north off the centre and was severely damaged and a Buddhist temple sits on an elevated position close to the project site.
  - The surrounding landscape includes dust/green areas, shrubberies and palm trees around the houses and at the verges of the roads. Kirinda is usually a level site and the village's buildings were arranged in rows. The site also features three ponds/lakes on either side of the main road.

With this information, an appropriate architectural master plan was laid out and the evolution of the design concept began.

- **Individual houses:**

The houses are single-storey with an area of 71 square meters and features two-bedrooms, a hall and a roofed court, which is a semi-open space. At the far end of the roof court are a bathroom and kitchen.

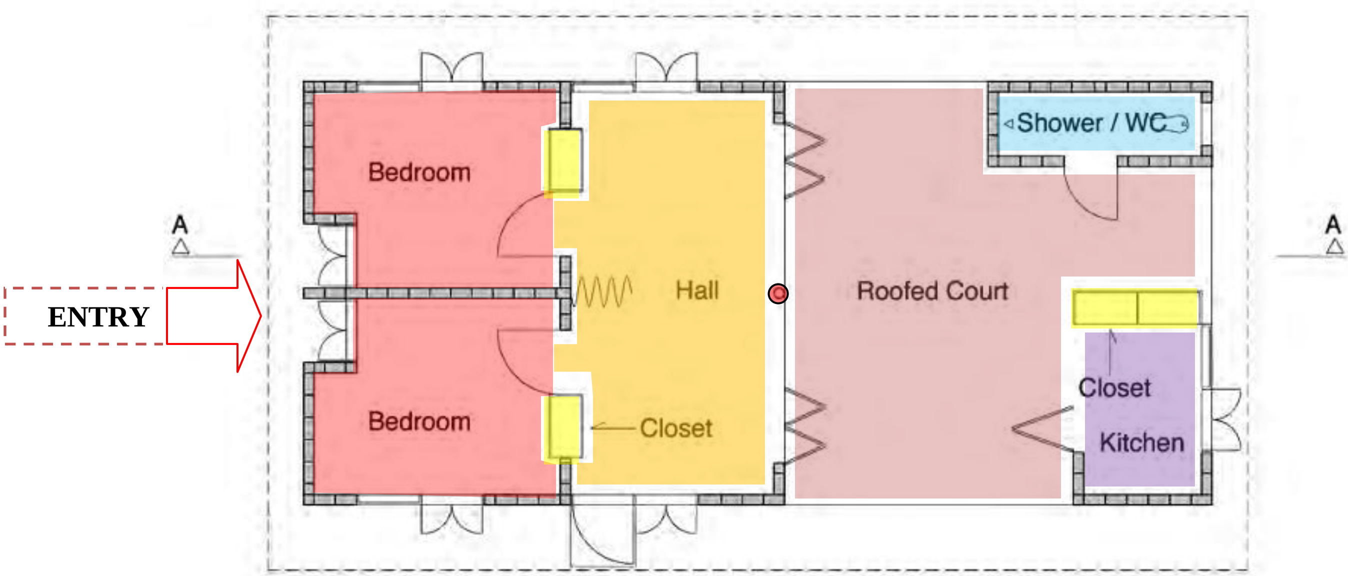


Figure 66. Plan of individual house units (Source: Sultan Barakat report, 2013; Rendering: Author)

The bathroom and shower were separated by means of a roofed court to ensure privacy of the women of the house from outsiders or guests as the community was a conservative Muslim community. Also, the folded partition between the hall and roofed court was designed with women's privacy in mind. The court was designed to provide a shaded, ventilated area where inhabitants could carry out various important functions such as eating, socializing, repairing fishing nets or equipments. Ventilation and cross-circulation of air is further enhanced through the slatted upper walls of the houses at the gable ends as the climate is hot and humid.

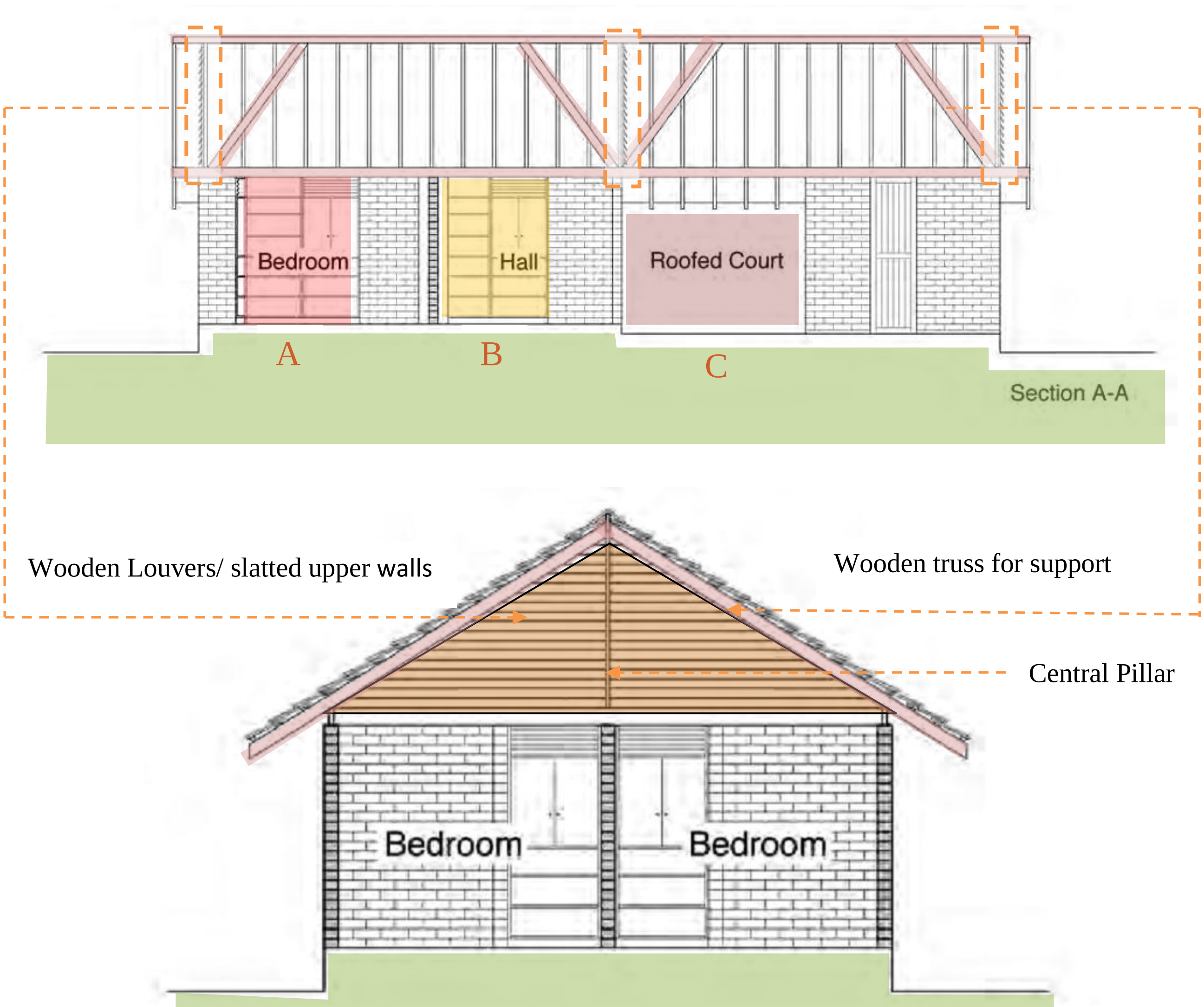


Figure 67. Longitudinal Section & Front Elevation showing the details of the housing units (Source: Sultan Barakat report, 2013; Rendering: Author)

Letters A, B, C indicates the 3 main functional spaces of the house units shown in the images

The principal material used for the walls was compressed earth blocks (CEB's) which is a compressed mixture of sun-baked clay and cement available in Sri Lanka at a low cost. Parts of the walls were also composed of pre-fabricated furniture units made from rubber trees and are also a locally sourced material and are in abundant supply. Clay tiles were used on the roof on top of the timber trusses. A slatted timber screen was used for the top section of the walls at both gable ends and also between the hall and the roofed court. Wooden panels were used for making the folded partitions and wood sections were made from coconut, teak and rubber trees. Varnish was not used on the exterior panels.

Figure 68. Bedroom--Hall--Roofed Court (Source: Sultan Barakat report, 2013)

The construction technology used was largely informed by economic efficiency and availability of local materials. To speed up the construction process, the homes were designed to be assembled from modular units pre-fabricated in a local workshop, off-site. Due to its strength, a central pillar made from coconut wood was used to support the roof. The walls were constructed by CEB blocks mixed with cement. Compressed earth blocks has uneven surface which can be easily interlocked to one another like LEGO blocks without using skilled labor.

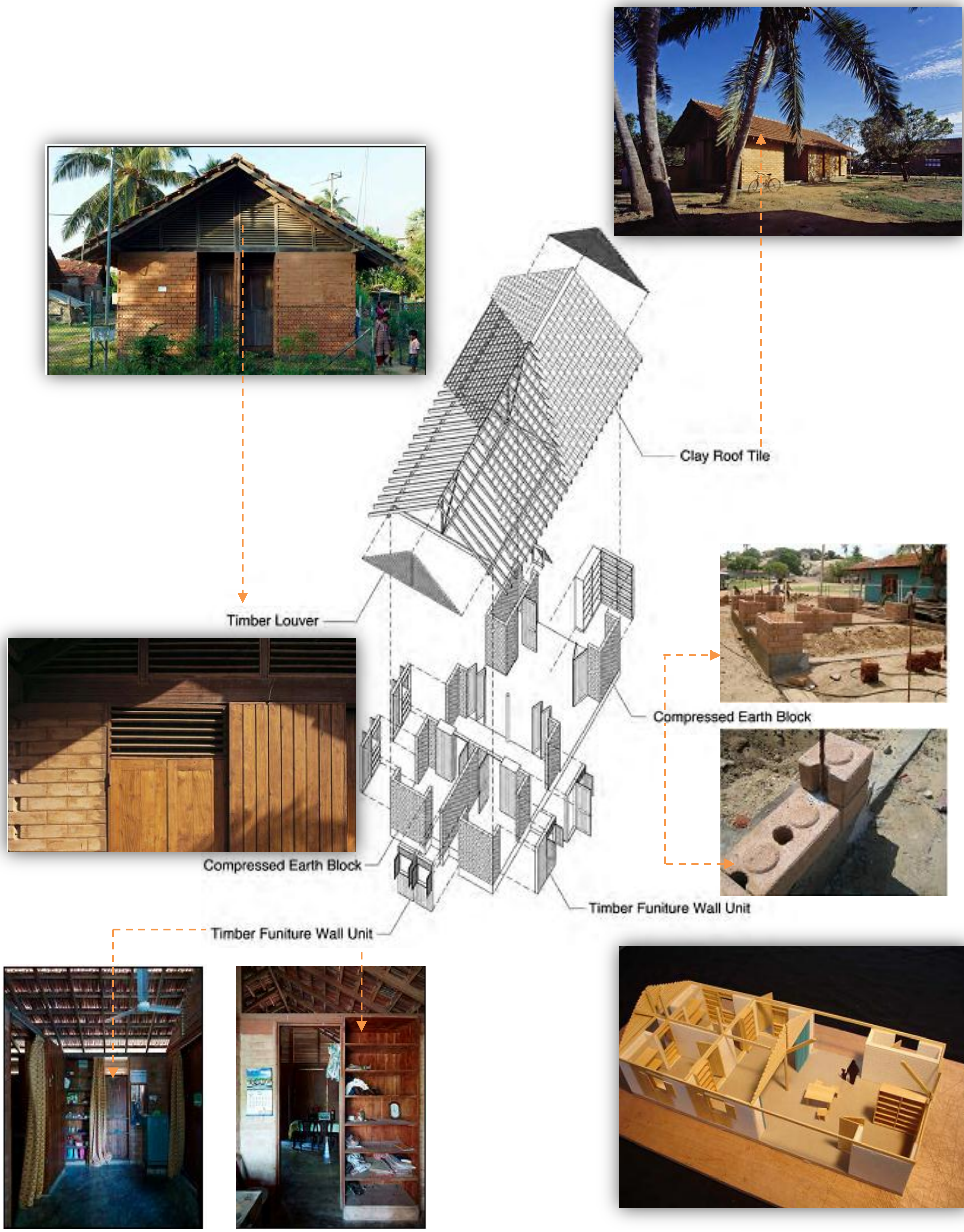


Figure 69. Parts of the house shown in sectional 3-D

(Source: Sultan Barakat report, 2013)

- **Settlement and Landscaping:**

Figure 70. Master plan of village Kirinda (Source: Sultan Barakat report, 2013)

The master plan was laid out in the former site as demanded by the beneficiaries. The orientation of the building was such that the shorter side faced the water so to allow the movement of water around the structure easily. Drainage systems for the small lakes/ponds that surround the village have been installed to help flush out excess rain water during the monsoon causing flood threats. The mosque being the center of the village and an integral part for the growing settlement is being reconstructed as it is the primary hub of all activities and also the meeting place for the entire community.

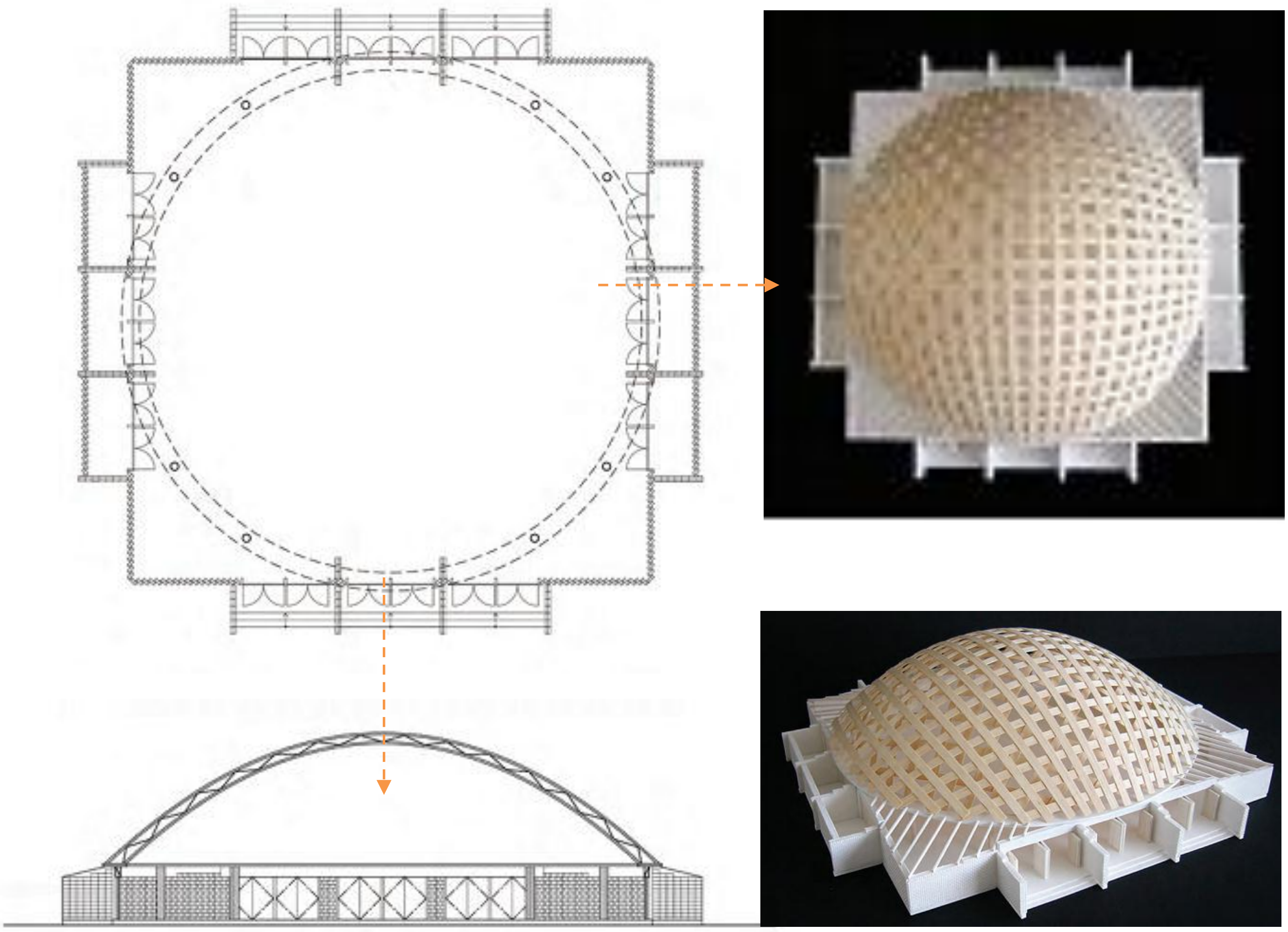


Figure 71. Plan / section and model representation of the mosque (Source: Sultan Barakat report, 2013)

The prayer space of the mosque measures 36m X 36m. Local brick was used for the wall and each brick is built up leaving gaps in between so to invite the light in and for natural ventilation inside the mosque. The roof is made of timber plank and is bent in a parabolic shape to be structurally and socially robust.

The project also involved the planting of native trees such as coconut, palm trees in the plots of the houses. Also, gardening and planting of shrubberies have been encouraged to enhance knowledge of the inhabitants about the local flora and fauna and how it can protect against the Tsunami wave action in the future.

Figure 72. Plantation in the individual house slots & lush, green plantation in the settlement (Source: Sultan Barakat report, 2013)

c. Coastal/ Shoreline development & Landscaping --Individual houses & civic facilities (Majority of southeast and south west coastal communities of Sri Lanka)

The southeastern and south western shores have been severely exposed to the impact of 2004 Tsunami. A team of AIA (American Institute of Architects) and SLIA(Sri Lankan Institute of Architects jointly carried out activities such as risk assessment and disaster reconstruction of the coastal landscape. The team's main focus was how to plan and design around the inundation zone of the coastline in order re-house and re-settle the displaced population and minimize future risk of coastal communities from tsunamis. The preparation of the risk-assessment report led to the systematic series of actions to carry out the reconstruction process.

Coastal development in Sri Lanka contained different settlement patterns in contrast to the inland farming communities as per the risk assessment report. The coastal communities evolved from older fishing villages that laterally urbanized and expanded with time.

In the south western shores, the population formed larger urban centers and the coastal villages and bazaars developed in a string-like continuous pattern. On the other hand, the eastern shore developed in a random manner with intermittent pattern with a long stretch left undeveloped. The features of the shore in these coastal zones are as follows:

- The settlement pattern along the coastline was contained within the inundation zone (majority on the concave portion of the shoreline as shown in Fig.73).
- The shore did not have any natural barriers such as barrier islands, wetlands ,small inlets, sand dunes or coral reefs bordering it with deeper waters near the shore Fig.74 a & b)
- The shores have relatively flat topography (Fig. 75 a & b)
- Inappropriate house design and planning (Fig. 76)

These features exposed the coastal communities to greater risks of the deadly tsunami of 2004 and are illustrated in Figures 25-

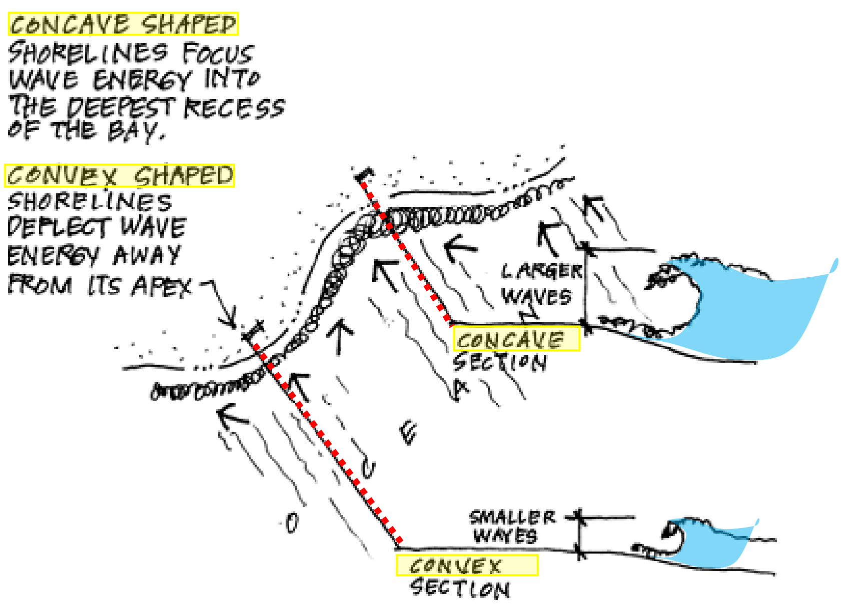


Figure 73. Effects of shoreline aspect or shape on the coastal community (*Source*: AIA report, 2006/Author,2015)

The settlement was concentrated more on the concave portion of the shores and this focused the wave energy on the deepest apex of the bay resulting in the formation of larger waves. This is how entire coastal communities were wiped out during the tsunami event.

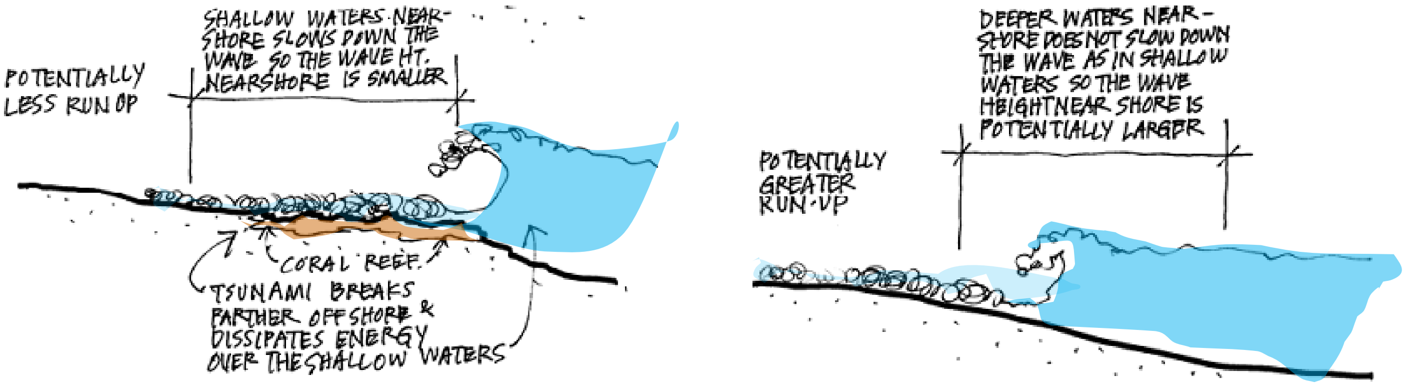


Figure 74. Deep waters- shallow waters (coral reef) affecting size of tsunami waves (*Source*: AIA report, 2006/Author 2015)

Due to the presence of natural tsunami barriers such as "coral reefs" the water tends to be shallow near the shore and wave height remains smaller. The extra layer of reef acts as a wave break and dissipates the energy over shallow waters; hence the run up of water is usually less. In contrary, deep waters causes run-up of water as wave height is larger.

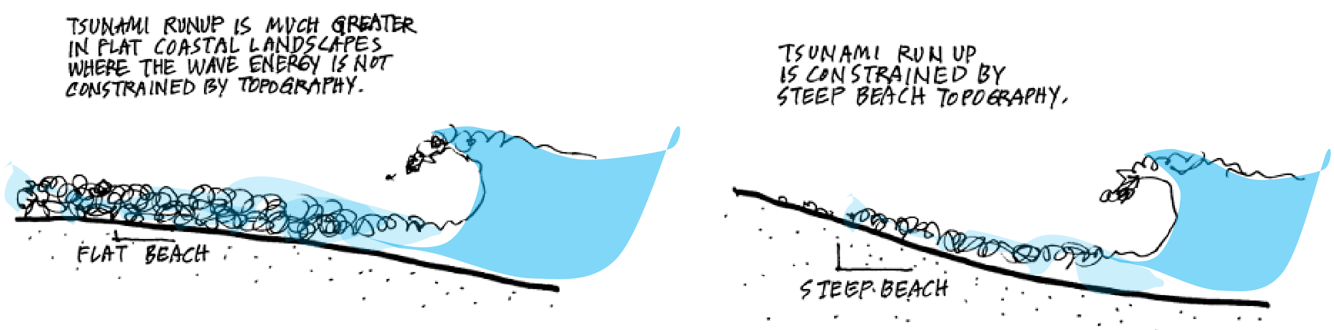


Figure 75. Effect of onshore topography on coastal settlement (*Source*: AIA report, 2006/ Author,2015)

The wave run-up is much greater on flat beach rather than on steep beach as the wave energy is not restricted by any sort of barriers causing greater damage to habitation.

The sketches below show how the towns and villages expanded along the shoreline with major roads parallel to the shore with very few narrow inland roads. The inland areas are cultivated in rice and field agriculture restricting access. The houses and town centers near the major coastal road where the population was greatly concentrated occupied the inundation zone to a great extent. The railroad was also very near to the coastline along the lateral urbanization. The eastern shore is also constrained by long and linear waterways.

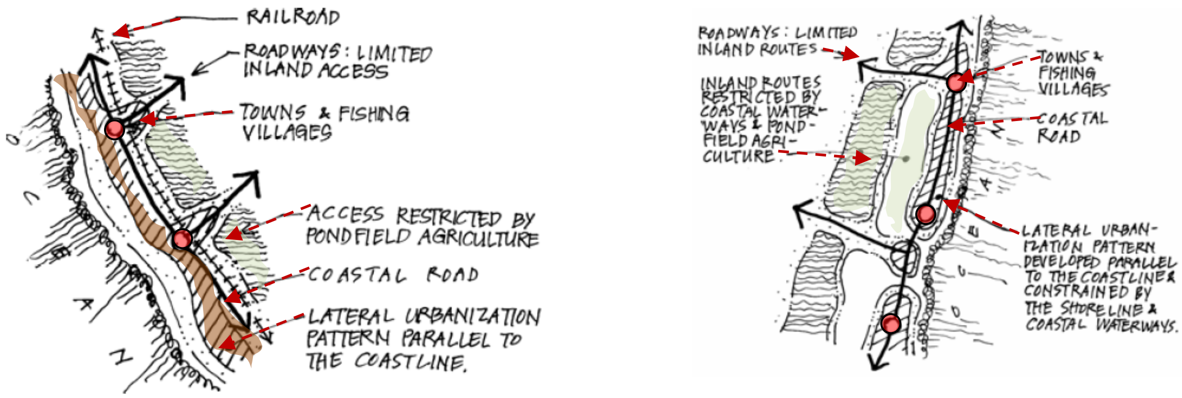


Figure 76. Map of the coastal & agricultural geography, landscape and coastal towns (*Source*: AIA report, 2006,Author,2015)

- The mapping of the sub zones resulted in the designing and proposal of urban landscape schemes for the coastline to make it more sustainable. More number of inland routes was proposed centrally to serve higher density population, so to offer shortest distance out of the inundation zone. The narrow inland roads were also widened with proper landscaping to accommodate huge number of people while evacuation.

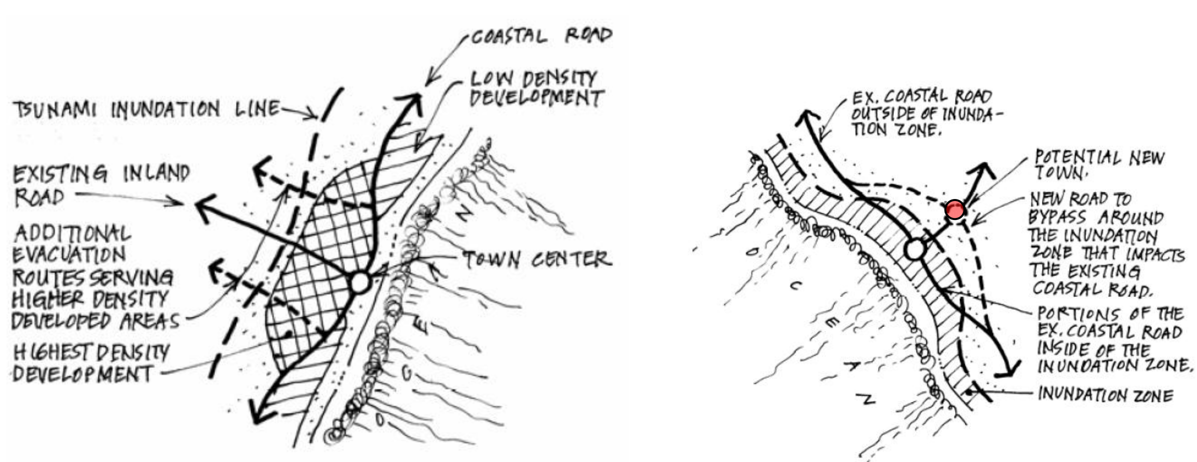


Figure 77. Sketches showing the interventions for roads in inundation zone (*Source*: AIA report, 2006)

The dotted lines show the creation two separate new routes with shorter distances via the main coastal road. A bypass or new road acts as the new coastal main road as it branches away and outside the ex-coastal main road with potential new town.

The landscaping also involved the uses of inexpensive “escape hills” that varies from 5-12 meters and is located at 200 meters intervals giving a 15-minute evacuation time to escape a tsunami. This helps to mitigate the impact of tsunami run-up. Also, the hills are raised above base flood elevation and connected to evacuation routes for timely evacuation.

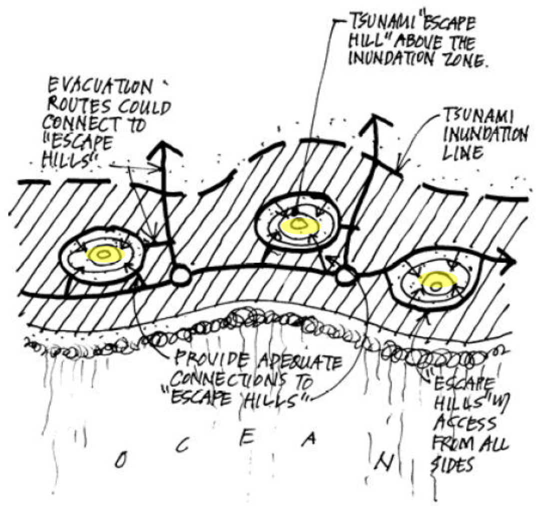


Figure 78. Escape hill plan (*Source*: AIA report, 2006)

Another affective way to reduce the tsunami wave action is by protecting and rebuilding coastal dunes and coral reefs. In Sri Lanka, the Yala resort was destroyed because the designers agreed to remove the sand dunes to have a better view of the sea. The dunes are formed by constant wave movement towards the beach brings with its skeletons of marine organisms and when the wind blows sand into the beach. These dunes are stabilized by dune vegetation till a larger wave event washes the sand dunes away and the cycle continues. The beach profile flattens when dune is removed making way for large waves to the land.

However, to rebuild dunes certain landscaping proposals have been suggested that includes the re-vegetation method and the sand-fencing method. These methods are illustrated in detail in Fig. 31. Also, the coral reef system needs to be protected by means of similar methods as coral reefs minimize the speed, height and run-up of waves as it leaves only shallow waters near shore.

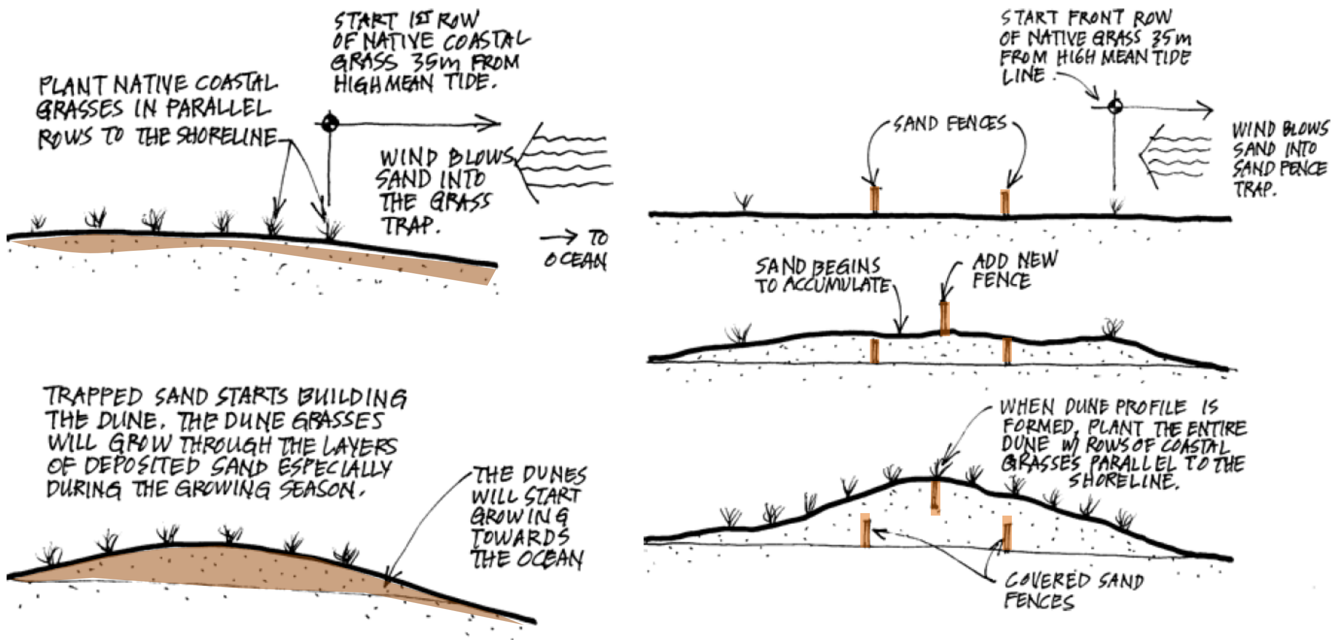


Figure 79. Drawings of re-vegetation and fencing to rebuild dunes (*Source*: AIA report, 2006/Author,2015)

The native grasses or salt-tolerant plants have extensive root systems that can hold back the sands on the beach and also prevents erosion. The plants trap the sand to build the dunes and eventually the layer become thicker, stronger and finally starts growing towards the ocean. Another way to trap dunes is to use fences and then after a mound is formed, it is stabilized by means of vegetation. To prevent the pedestrians from trampling on the sand dunes while crossing in the beach -protective boardwalks, fencing and crossing points can be made.

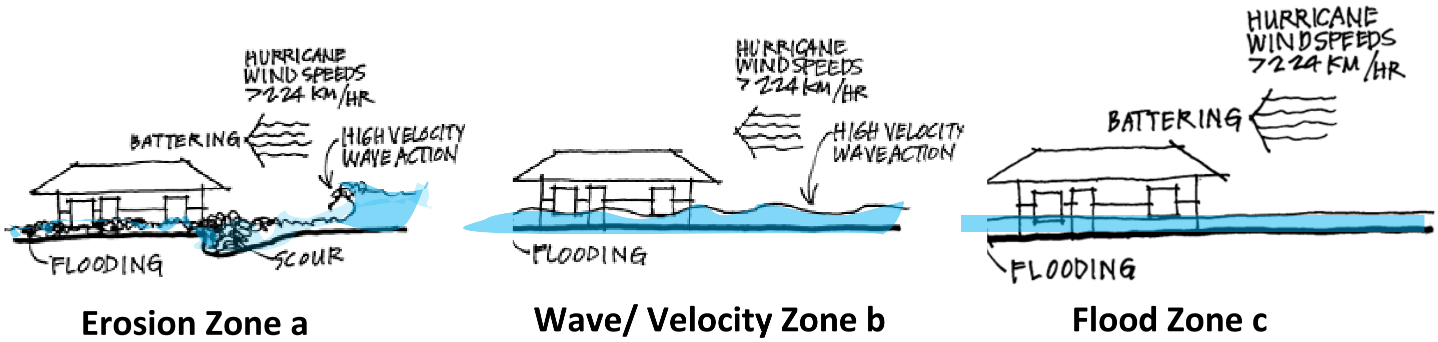


Figure 80. (a) (b) (c) Three types of hazard zones for structures--Erosion zone- Wave/Velocity zone- Flood zone(AIA,2006)

- Houses that are nearest to the shoreline occupy the erosion zone and are exposed to scour, erosion, wave action, flooding and wind forces. People and property are most vulnerable in this zone.(Fig 80a) Farther inland, the houses are susceptible to high velocity wave action, possibly scour, flooding and wind as these areas occupy the wave or velocity zone as shown in (Fig.80 b). Even farther inland is the flood zone and is subject to wind, flooding and possibly lesser wave action.(Fig 80 c) .

The planning included placing the houses with a minimum set-back outside the **erosion zone a *(not buildable)*** and then basic construction measures were proposed for houses in the zone b and zone c ***(buildable)*** respectively. **In wave zone b**, the design measures were addressed by elevating structures on piers or columns with proper foundation to resist scour, hydrostatic and hydro-dynamic forces. **In flood zone c**, the design measures included elevating the structure above base flood level elevation so to allow the passage for incoming and out flowing waters to relieve the pressure of the flood zone.

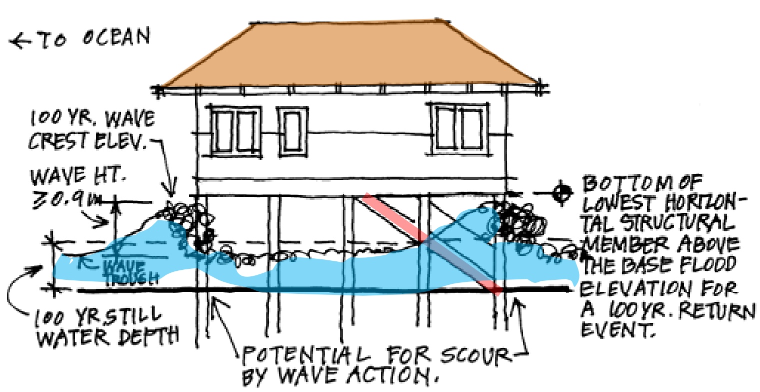


Figure 81. Construction / design measure for zone b- Vertical evacuation of structures should be included (*Source*: AIA report, 2006 / Author,2015)

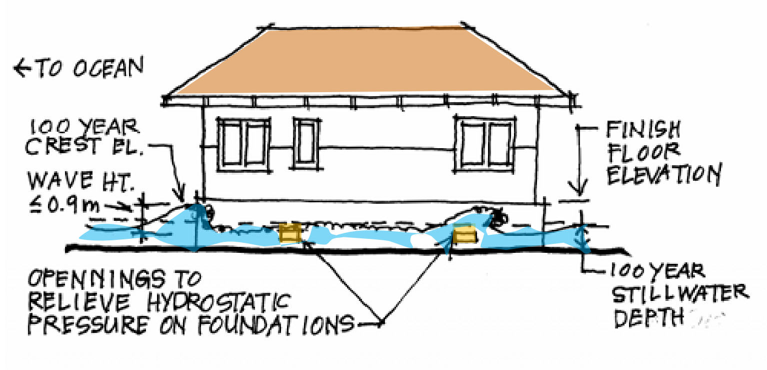


Figure 82. Construction/design measures for zone c- elevating structure above base flood level & create openings in plinth level (*Source*: AIA report, 2006 / Author,2015)

The architects of Olshesky Design group proposed designs of houses and civic facilities design for the urbanized coastal communities with the basic construction measures incorporated (as described above).

The following design scheme (Fig.83) features a two-bedroom, 530-square foot, linear home with a living room, courtyard, kitchen and a toilet perpendicular to the shoreline. The house sits with the shortest side facing the shoreline to divert water away from the structure and to allow the movement of water efficiently around it.

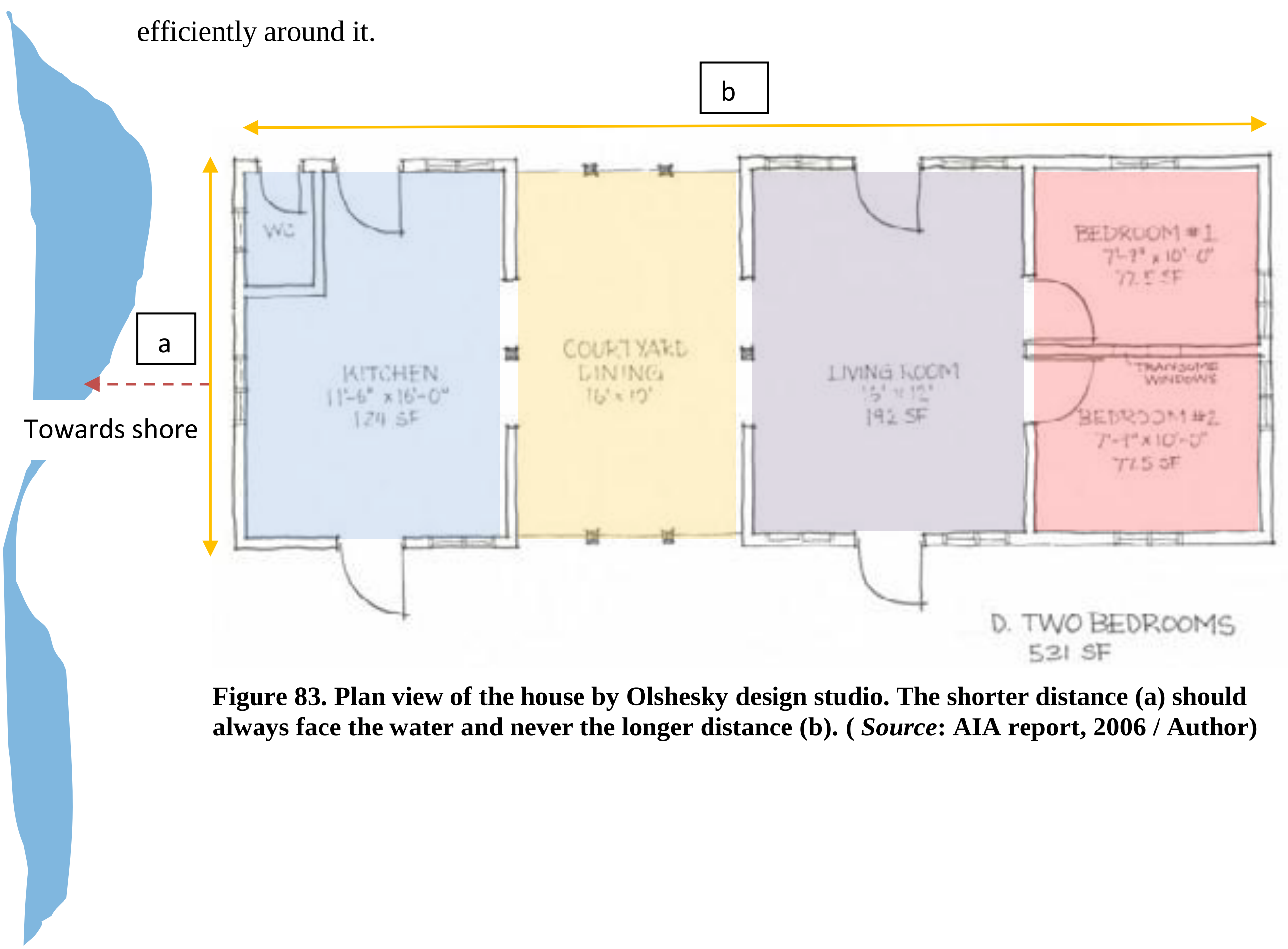


Figure 83. Plan view of the house by Olshesky design studio. The shorter distance (a) should always face the water and never the longer distance (b). (*Source*: AIA report, 2006 / Author)

Figure 84. Elevation showing the elevated house on pilings in high-risk zones (zone b/c) (*Source*: AIA report, 2006 / Author,2015)

The house scheme of 530 square feet shown in Fig. 84, is elevated by means of pilings/piers above base flood elevation for high-risk zone areas (zone b/c). The pilings can be made from concrete, steel, wood or bundled bamboo depending upon the risk factors of the zone. The space below the structure must be free of obstructions or enclosed by non-supporting break-away walls or panels that can collapse under stress without putting the main structural support (pilings) under stress. Thatched roof is proposed for dry zone whereas clay tile roof for wet zone. Large number of openings is proposed to allow water and wind to flow through easily and bamboo grill windows allow cross-ventilation, light and privacy at the same time. The materials can be availed locally and so such a design can be afforded by the lower income group.

Another scheme was proposed by the design group for a major civic facility or town center of 3500 square feet- in this case a civic pavilion situated in a high-risk area (zone b) where flood waters move with a comparatively higher velocity. This design is composite and uses a combination of different materials and joineries for extra stability. The facility features an open plan defined by many columns which allows the tsunami waters to flow through. Also, it is multi-purpose and can be used as storm shelter or otherwise as a market place for the fishing communities. The first floor is above base flood elevation (BFE) and is constructed with round concrete piers with pre-cast concrete floor beams covered with wood structure and bamboo roof .The structural members above BFE are rounded wood piers and for the roof is a combination of wood and bamboo as these materials are easily available and cheap. The roof is hipped which is most efficient for high velocity winds as it has fewer lesser corners and fewer distinctive building geometry changes than any other roof types.

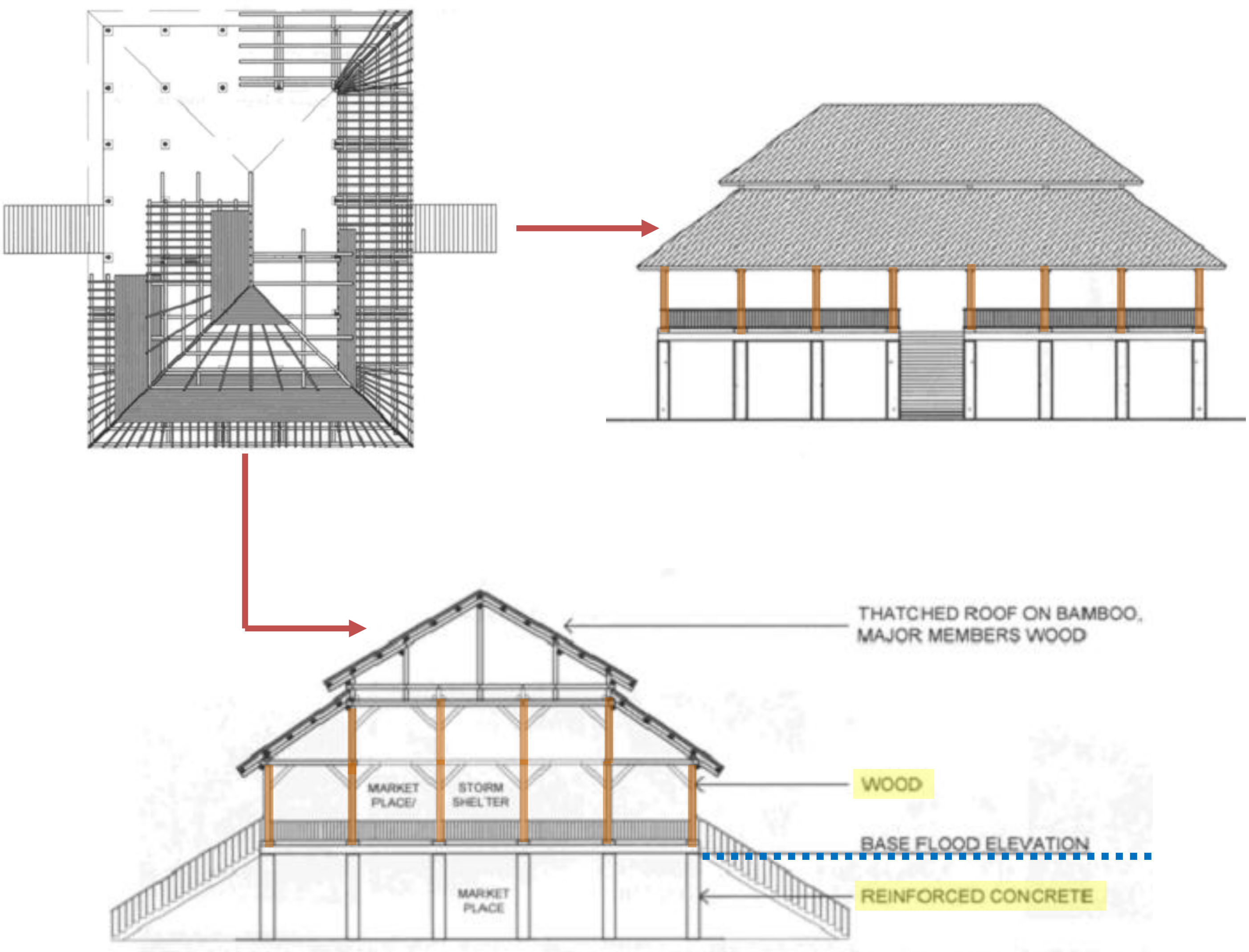


Figure 85. Plan and Elevations of Civic pavilion in high-risk zone(*Source*: AIA report, 2006 / Author,2015)

For mid-risk areas (zone c) away from the coastline where the waters move with a lower velocity; impact of the wave energy is lower –scheme shown in Fig. 86 is proposed. Construction can be done with brick masonry piers and bamboo frame as it is cost effective. This particular scheme is planned on a 630 square feet area with two-bedroom, a living room, courtyard, kitchen and a toilet. Reinforced masonry piers can be used in wet conditions and bamboo for dry zones. Bamboo grill for windows is used for cross-ventilation. Thatched roof or clay tile roof is preferable for dry and wet zones respectively. Such a construction is suitable for areas with low wave energy impact as masonry piers can easily develop cracks on impact. Bamboo allows the breeze to easily move around a structure and this material is best for zone c (as described in Fig. 28) as the houses in the zone is impacted by the wind speed.

Figure 86. Plan and Elevations for a masonry and bamboo house in mid-risk areas (*Source*: AIA report, 2006 / Author,2015)

3.5. LANDSLIDE

A. Peradeniya landslide – 2009

Peradeniya is a hill country situated in the intersection between Nuwera eliya and the historic city of Kandy. It is known for its scenic beauty with the Mahevela River on the east and the mountains in the west and is a tourist spot. Its location is on the landslide prone slide as natural slope was modified to build the Colombo-Kandy. The place has a lot of commercial and residential activities within the reservation area which needs to be resettled. Hence, a hypothetical design was thought where architectural interventions and engineering together would create a landslide resilient resettlement urban center with socio-economic values while re-arranging the physical setting of the town.

a. Resettlement of Urban center to Future communities (Peradeniya, Sri Lanka)

The landslide in Peradiniya is such that soil layers and soil banks tend to break away and the top soil layer was weakened due to unplanned settlement. To create the urban center, the top soil susceptible to erosion was removed and so was the soft or nice layer of rock (granite layer) beneath which exposed the hard layer of rock to build on. The top soil was cleared in the form of steps sloping down towards the river. Drip ledges were created enabling the storm water to be drained naturally and the toe of the hilly site would be reinforced by large rock debris from the removal of the nice layer of rock. The space created by removal of soil is to be carefully integrated for the architectural intervention- the urban center.

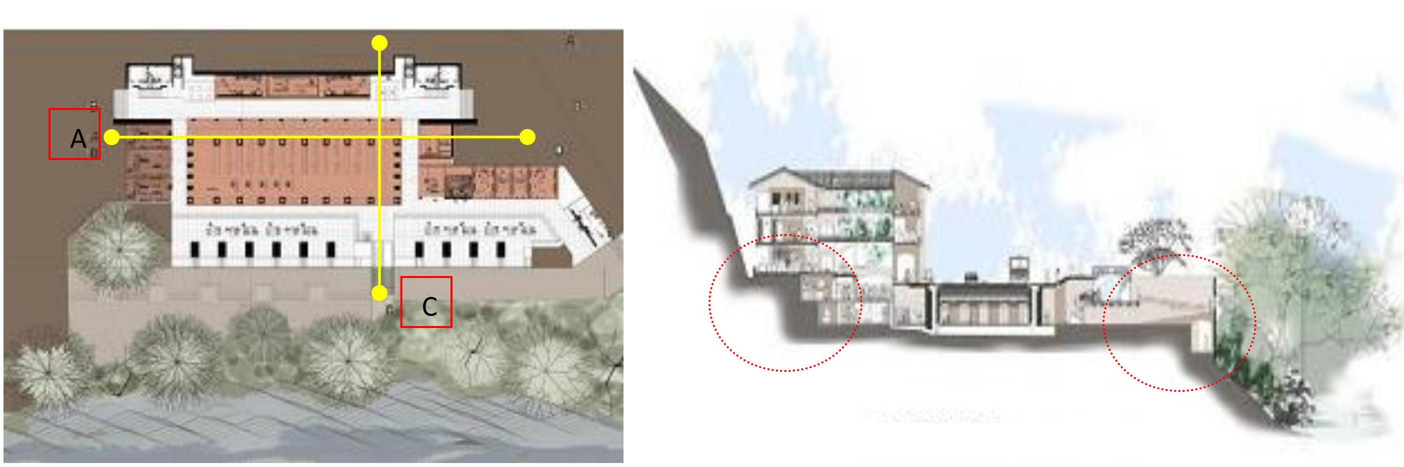


Figure 87. Plan & Section CC (vertical) showing the stepped slopes and retaining walls (in red circles)(source: Dilshan, university of Moratuwa, Sri Lanka)

The removed granite is to be re-used for construction of the new building and the soil is to be utilized for landscaping. Bricks are being used for the construction instead of concrete to regulate the temperature in a more eco-sensitive manner. This is to further allow the lower parts of the building to regulate their thermal requirements without the usage of air conditioners. Thus, the whole process of intervention explained this far is to be sustainable in terms of both economic and environmental aspects.

Figure 88. Section AA (Horizontal) (Source: Dilshan, university of Moratuwa, Sri Lanka)

B. Ratnapura town landslide – May 2003

Ratnapura town is 70ft above sea level and surrounded by mountain ranges and is prone to landslides especially due to the extensive mining of gem stones. In May 2003, heavy downpour caused severe inundation and landslide causing extensive damage to homes and livelihoods.

Figure 89. Location of Ratnapura (Source: adpc, 2005)

a. Resettlement of houses (Ratnapur, Sri Lanka)

The relocation sites being mid-risk areas and low-risk areas were selected by planners to relocate the homeless people. Special features were included during the design and construction phases to control soil erosion and earth slips. The features were as follows:

1) The roads were sited parallel to the contour lines.
2) The house designed in split levels minimizing disturbance to the hill slopes. Cutting and filling was hardly done except for a suitable amount of earth filling under the platforms. The concrete columns were embedded on the hardest layer (bedrock) for maximum stability.
3) Engineered retaining walls were used within the split levels and
4) Natural vegetation was retained to the maximum during site clearing.

The house had three levels that could be accessed by a continuous single flight stairway. The materials used was brick, reinforced concrete and stone. A stepped plan was conceived to integrate the house with the hills without interfering with the soil below.

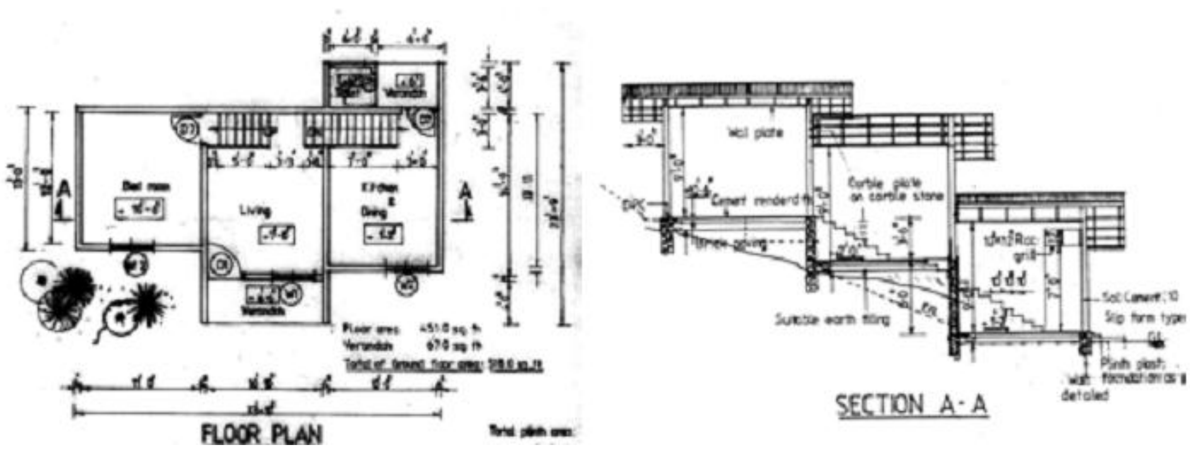


Figure 90. Plan & Section for houses in Ratnapura (Source: adpc, 2005)

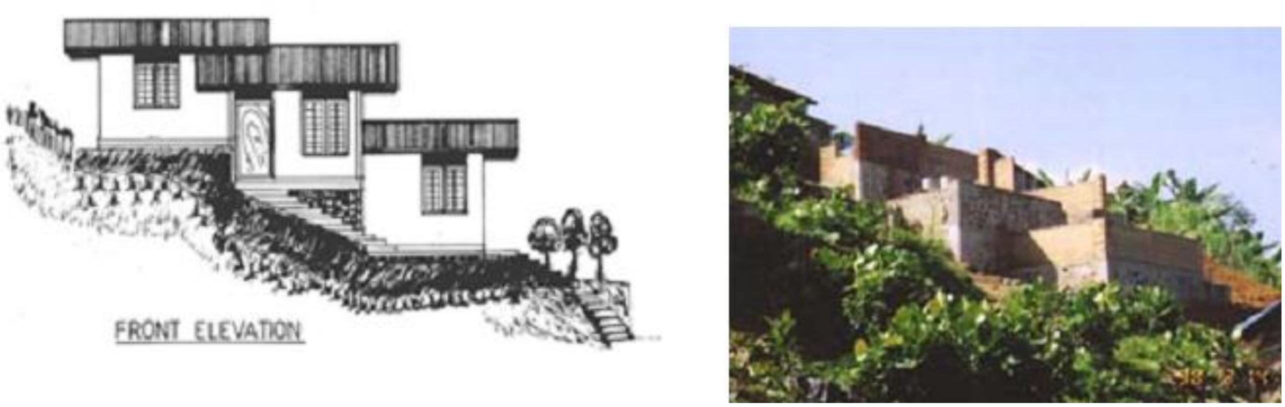


Figure 91. Architect's perception of Elevation(Left) & Actual Construction (Right) (Source: adpc, 2005)

C. California Landslide , Rancho de Palos Verdes– 2012

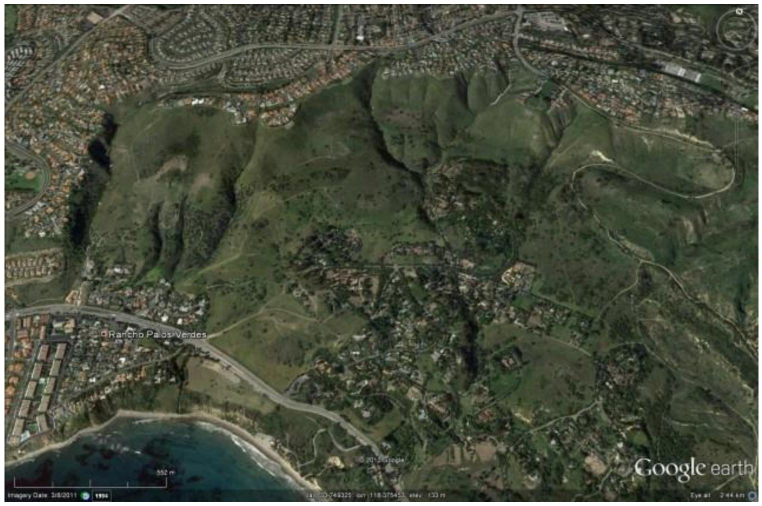


Figure 92. The landslide -prone site in California years (Source: http://blogs.agu.org/landslides/)

a. Landslide Mitigation Houses (Rancho de Palos Verdes, USA)

Landslide Mitigation Housing" by architects Jared Winchester and Viktor Ramos are residential units to be intentionally constructed on a landslide site. The inspiration is a location in California at Rancho de Palos Verdes, near to Los Angeles, where there is a site that is currently impossible to inhabit because of an active earth flow.

The proposal, which is very conceptual at this stage, is to locate housing units onto the landslide in order to (in the words of the architects): *mitigate future catastrophic events, salvage currently unbuildable landscape, and to evolve an architectural vernacular of dwelling within tight topographic settings*. The idea is to tether a network of houses onto the landslide. The design appears to tie the houses onto the slope using a network of cables linked to ground anchors. The houses themselves are designed to be able to change form as the landslide moves beneath them.

The idea seems to be to slow down the movement of the landslide by using these housing units to provide a drag force. Presumably therefore the cables are tied in below the shear surface and the movement of the landslide then pushes against, and is impeded by, the houses. Thus, the landslide is partially mitigated and the slope is inhabited, but the natural system continues to function.

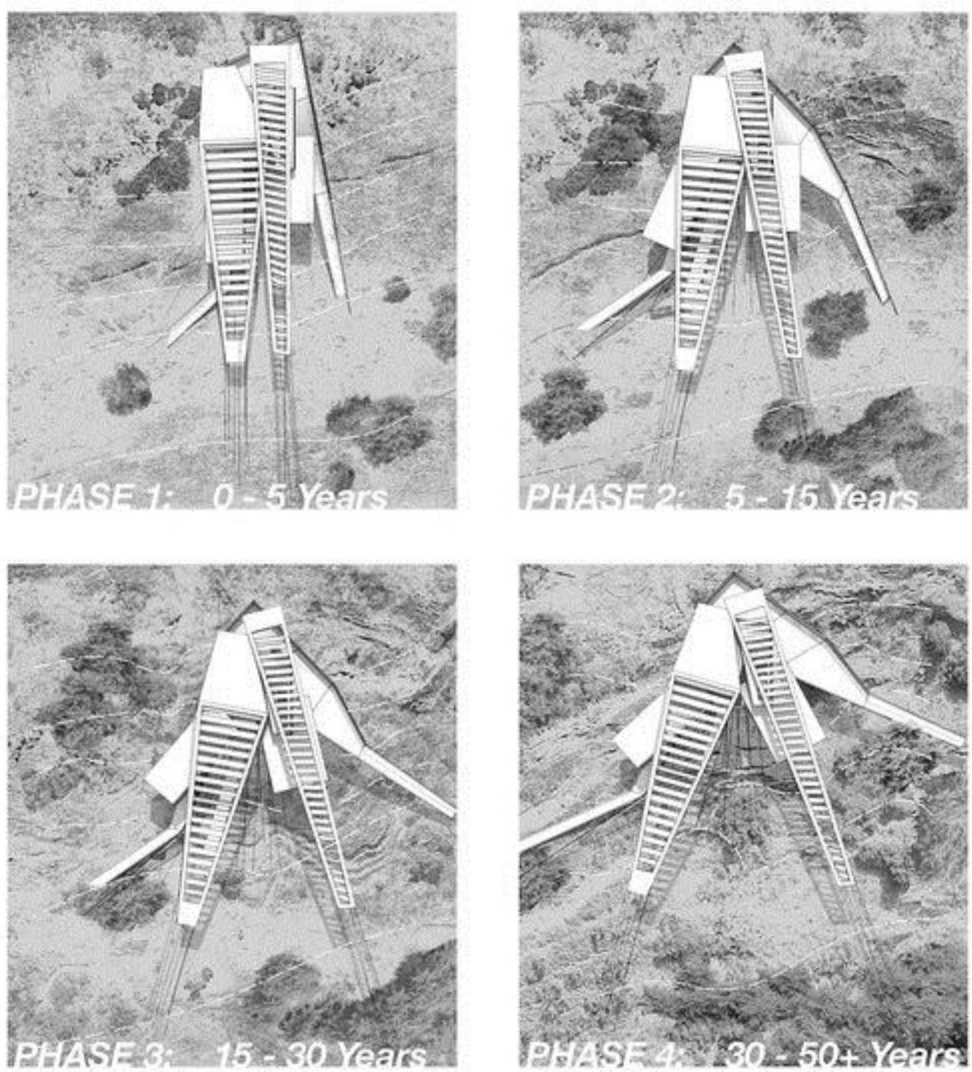


Figure 93. Houses changing form with landslide movement over the years (Source: http://blogs.agu.org/landslides/)

CHAPTER 04

RE-DEFINING AN ARCHITECT'S ROLE THROUGH THE LENS OF AN ARCHITECT TO ACHIEVE SUSTAINABILITY & RESILIENCE (ANALYSIS)

4.0. Architect’s contribution in designing strategic/innovative measures
(Household level (micro) & Urban/ Community level (macro)) –

For a Sustainable & Resilient Future

This chapter can be summed up as the dissection of Chapter 3. Here, the positive’s and negativities of examples explored from different countries are scrutinized and analyzed for each hazard outlined in detail in chapter 3. In each example, architects had made contributions in either the socio-cultural, physical, environmental aspects by hatching innovative ideas or concepts for implementation of sustainable homes or communities. These contributions are mostly apt in the “reconstruction phase” of the DM cycle in almost all the case studies chosen as “re-building” after destruction best fits the role of architects. Nonetheless, for further clarity of the dissertation research each example were exposed to the three main components of the DM cycle being pre-disaster situation, during/immediately after impact and post-disaster situation. This helps to give an overview as to where and why the architects are frequently needed and which of the following phases can accommodate the architect at best.

4.1. EARTHQUAKE

A. The Great Hanshin/ Kobe Earthquake – 1995

a. Individual houses to settlements (Hyogo, Kobe & surrounding areas)

➢ *ANALYSIS : Pros & Cons / Comments*

- **Pre-disaster situation(Preparedness)**
  - No elaborate actions were taken during this phase for the examples shown.
- **During/ Immediately after impact(Response)**
  - Architects did not play a major role during this phase but the immediate necessities were provided for by other professionals in this case.
- **Post-disaster situation (Reconstruction & recovery)**
  - In the design of the temporary “blog house” considerations such a making this housing solution cheap, easy to assemble, and insulated in both summer and winter without sophisticated craftsmanship were all sustainable approaches.

- The cardboard tubes were factory made but the assembling was done by architects along with local participation involving the community in the process. Also, the houses can be modified or remodeled as required by the users. Extensions to the original "paper-house design" can be made in the extra parcel of land which reinforces the sense of belonging to the architectural solution and helps the occupants develop an identity of their own: two factors that govern a sustainable successful housing design.

- The units are easy to mantle and dismantle by a group of 4 people in 6 hours only while the materials can be easily recycled.

- The sensitive decision of using warm color and wood resembling materials on the outdoor and indoor of the units is strongly argued to give a "homey" feel. Also, the 6-feet wide space between houses is usable as a common area.

- The paper house architecture not only serves the purpose of providing temporary shelter but is more concrete in nature. The features of the housing units such as the operable roof, the shape and orientation, the planning- all could be retained but the materials can be modified in the sense that more robust but environment friendly materials can be used.

- The tubes can be made by casting concrete over it and reinforced by wire mesh (similar to the hollow post/ stump in Bangladesh), the rooms can be doubled henceforth and a miniature gardens (as in Haiti) can be incorporated for growing fruits and vegetables. Slowly, by considering the environment impact assessment of the houses and the types of materials used and the way it can function, decisions to convert temporary houses to permanent ones is a way forward towards sustainability.

B. The Haiti Earthquake – 2010

a. Urban city planning (Jacmel city)

➢ ***ANALYSIS : Pros & Cons / Comments***

- **Pre-disaster situation (Preparedness)**

- The field assessment reports performed by the architects along with volunteers, interns determined the unique characteristics of the site which is otherwise overlooked when random shelters are provided to counter the fast growing response to housing. Nonetheless, through this practice of going back to site every time for a solution in the master plan better prepared the architect as well as the community.

- The input from the beneficiaries was insightful and vice versa. This way the community is more educated and aware of what to do and how to cope for future calamities and also helps the experts to move forward with the reconstruction process.

- **During/ Immediately after impact(Response)**

  - Here, the response phase was entirely taken care of by other apt professionals as during this phase the immediate need for architects is slim. It is the later phase, as described below is where architects play the most significant role. Also, some selective works are undertaken by designers, planners and architects in the previous phase described above.

- **Post-disaster situation (Reconstruction & recovery)**

  - Jacmel was a land of opportunities being a World Heritage site and yet very vulnerable. It weakness was made its strength in this particular case.

  - The revitalization pointed to the entire city rather than just a part of a community and its households. In this city, every household, every street, every corner and nook and the landscape is connected to one another. Hence, to maintain its characteristics culturally, ecologically and economically, the urban plan was layered into components to make every component function as one unit-- a sustainable approach.
  - The typologies and planning principles can be applied to any other designated satellite town development site as it’s replicable, affordable and functional. The methods are exemplary and can be successfully adapted to other locations.

  - The master plan can be manipulated according to context keeping the vital components intact such as organization of the concepts but the housing types and materials can easily be different for other locations.

- Three important components were addressed, the houses and sanitary conditions; quick and long-term design and create settlements that fit the need of the people and generate income.

- In response to the demand of land and people, two components reforestation and agriculture was incorporated in the urban planning. This would provide the community with food supply, materials and as well add to the aesthetics of the city.

- The road networks connected a satellite city with the other developing cities in the future; with commercial and public zones; with the agriculture zones through layered road network for the ease of access and safety. Such planned routes can prove to be successful evacuation zones also.

- The houses maintain different typologies and are organized in different zones. The ones on the higher elevations are stepped or terraced and are protected from lateral forces but heavy concrete retaining walls. The timber panels may not be local but high quality material from Austria and are extremely stable and resistant to shaking, impervious to termites. Nonetheless, timber is being reproduced in the forest area nearby of similar quality.

- The pre-fabricated houses were brought in containers which were again recycled as building blocks for the popular light-industry in Haiti. Nothing was wasted.

- Each house follows the principles of self-sufficiency and social inter-connectivity which can be the back-bone for a socially sustainable settlement. Each house has a front porch and sometimes a convertible room that can function as a workshop on the street side and act as a social platform suiting Caribbean ways. The chunk of green plot on the back gives the residents ample food supply which can also be sold. The roofs ventilate each and every single room and are a storm-catcher as well.

- Jacmel is designed as such that each house unit would function as a self-sufficient unit and each neighborhood would be independently function and stay connected with the other neighborhoods in a balanced manner giving rise to a socially, ecologically ,economically and physically stable habitat.

4.2. CYCLONE/ HURRICANE/ TYPHOON

A. *Cyclone Aila – May 25th, 2009*

a. Disaster Resilient Habitat (Adarshagram, Sathkhira, Bangladesh)

➢ ***ANALYSIS : Pros & Cons / Comments***

- **Pre-disaster situation (Preparedness)**

  - The site-visits, workshops and discussion sessions between the beneficiaries and the professionals helped the community to become more aware of the looming dangers and the surroundings. The constant exchange of ideas between two parties helped to prepare the designs according to the needs. The transparency in information transfer and skills and sharing of knowledge prepared the individuals and community to adopt the idea successfully.

  - With the success in Adarshagram, two more communities decided to take up the initiative of building DRH. The participation of the community in identifying threats, mapping escape routes and helping to build homes prepared the community to believe in the project. This allowed a sense of belonging; induced skills into people which are transferred from community to community People came together to "build back better" their own through extensive preparation to be able to implement and realize their concept of "dream home".

- **During/ Immediately after impact(Response)**

  - Architects had no role during this phase but the immediate necessities were provided for by other professionals in this case.

- **Post-disaster situation (Reconstruction & recovery)**

  - In DRH, every "home "was seen as "cyclone shelter" meaning that people had to no longer abandon their own lands to seek refuge somewhere else. This would retain the self- identity, dignity and the homes of the people.

  - The cost of the disaster-resilient houses was much cheaper than building a cyclone shelter. All the materials used were local and the technique used could be easily replicated in other places unlike a cyclone shelter that requires expert skills and is also not functional always during and post-disaster.

- The participation of people in the building process was a valuable resource, if not with money they helped out with their skills and labor. In the later phases, the locals monitored the quality of construction as well.

- Reconstruction should be an evolutionary process, hence there was never a pre-conceived design of the DRH, and in fact it evolved on site with time. The technical know-how in combination with local skills created a solution that was acceptable by all.

- The joineries of the foundation to the structure and the structure too the roof was carefully designed and implemented. However, materials (concrete, brick) had to be transported to the site by boat at high tide which was a risky business. Also, the detailing and connections need to be periodically monitored and maintained by the owners without having the feeling that such activities are a hassle.

- Timber was not used from the forests but from plantations and was replanted as sustainable approach.

- The construction of the roof was a bit elaborate as the local practices with “golpata” were not resilient enough and concrete roofs were expensive. Every tile had to be screwed on to the roof structure as clay tiles were the only available and sustainable material there. Such a process is labor-intensive and intricate but then again labor was the best resource that could be expended.

- The houses on stilts are faring well with the climate so far and are little used by the people except in adverse conditions. Instead extensions and modifications of the lower area and homestead is slowly becoming a continuous process making the community even more diverse and strong.

- Should sea-level rise, the houses on stilts would be useable but transportation will be possible only by boats. For food supply, saline resistant crops need to be grown. To eliminate the latter problems, the access paths need to be raised or elevated by means of water-resistant landscaping to work better. This maybe a scope for the project to evolve.

- The habitat had also brought about a change in the social fabric of the community in terms of unity, security, confidence and self-sufficiency. On the contrary, the flourished house-owners have lost their right to accept aid from agencies as they are better-off. This some people say is disadvantageous to them but in the long-run they get a self-sustaining, permanent habitat.

- DRH is an integrated and evolutionary approach. Further work on access routes, public facilities, landscaped features need to be addressed to make it even stronger. Such is the beauty of the project that as people become more conscious of the problems, more innovations will emerge and what started out from a single unit and a small village will spread out and be a catalyst for DRR and sustainability.

B. Typhoon Xangsane– 2006

a. Individual houses- Settlement planning (Da Nang Port City, Vietnam)

➢ ***ANALYSIS : Pros & Cons / Comments***

- **Pre-disaster situation (Preparedness)**

  - Design competitions locally and internationally is a very effective way to come up with ideas for resilient designs. The potential entries were publicly displayed to educate the mass about the local context and the risk of living in vulnerable housing. This way a community is better prepared and aware of future disasters.

  - Field visits were a means to gain knowledge and insight on the present housing settlement and housing typologies of the city.

- **During/ Immediately after impact(Response)**

  - Architects had no role during this phase but the immediate necessities were provided for by other professionals in this case.

- **Post-disaster situation (Reconstruction & recovery)**

  - The road network for the settlement was arranged in a zig- zag pattern and the houses followed along the pattern. This resulted in unequal positioning of houses and interesting notches and corners were created. With the high winds coming in, the corners, notches or turns serves to fragment wind flow and reduces wind effects pressed on buildings.

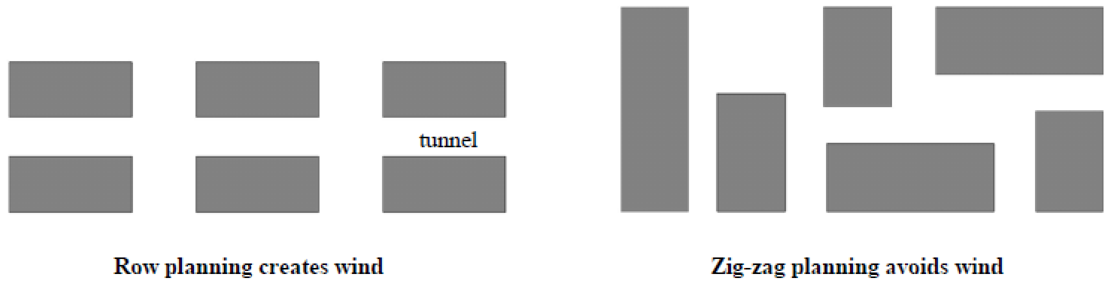


Figure 94. Comparison between zig-zag and row planning (Google image search on building orientation)

- The rectangle and square shapes of the buildings is effective at reducing wind pressures. Si,ple, symmetrical shapes allows high winds to go around them easily so that it is distributed in different directions and not concentrated in one point.

- The house forms were appropriate to people's lifestyles and community settings. The three different building typologies have windows in front and on the rear in one line which lets the wind pass through easily minimizing wind impact.

- The slanted roof of (type1-tube house)in front is made steep enough with appropriate angle to deviate the wind. The slanted roof on the rear side is offset from the first roof at a higher elevation and is dotted with louvers or openings sometimes called the "cyclone trap". As high winds move through it, the speed is reduced and so is the impact on the building. Also, even if partition collapses, it can be easily replaced later without putting much stress on the structure.

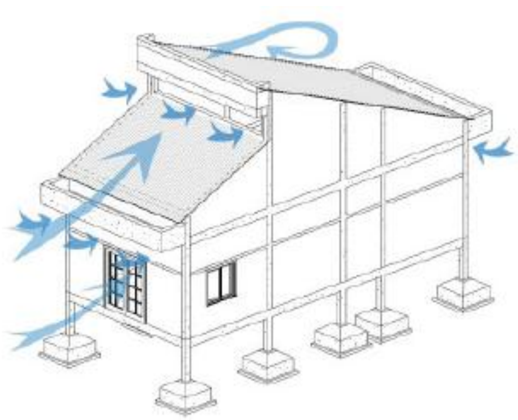


Figure 95. The tube house roof design & structure (Source: ISET, 2013)

- The second type 02(three-compartment house) has a gable roof which is less efficient than hip roof in deviating high winds but in this case, another second roof or shade extends over the porch. This roof is placed a little lower than the main roof and takes all the impact so even if it is destroyed; it is not a part of the main structural system protecting the house. Also the overhang or the gable roof extension is minimal to avoid uplifting.

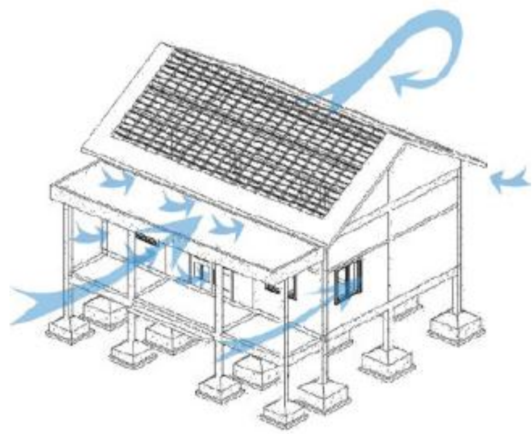


Figure 96. Three compartment house roof design & structure (Source: ISET, 2013)

- The third type 03 (Twin double storey) has a gable roof similar to type 02 houses with minimal overhangs minimizing wind impact on structure but yet is vulnerable. Here, the uplifting of the roof is avoided through proper construction technology such as connecting the roof with the structural posts and the posts to the foundation.

Figure 97. Twin double storey roof & structure (Source: ISET,2013)

- The louvers and ample windows at the front and rear capture natural light and intensify natural ventilation in the hot-humid climate of Da Nang.

- The proposed design is nothing exotic but is an outcome of the dominant local setting modified to an extent to resist and withstand enough stress that can be easily reconstructed or revived. Hence, interventions need not be structural only but a combination of both (structural and non-structural aspects. Similarly, here the cultural values were retained through context-based architecture (non-structural) whereas the structural system was improved through construction technology.

4.3. FLOOD

A. *Annual Flooding- (Bangladesh)*

a. Individual houses- Homestead planning-Landscaping (Flood –prone areas, Bangladesh)

This analysis is done from an overall point of view of Bangladesh. Since, flood is common is nearly almost every part of Bangladesh, the interventions used is similar and hence the analysis is deemed to be similar for the entire country given the similar context.

➢ ***ANALYSIS : Pros & Cons / Comments***

- **Pre-disaster situation (Preparedness)**

  - Communities were involved during the input of these innovative means which means it led the people to become more aware and educated about the flood situation. Also, the sharing of expert knowledge helped the locals to combine their own ideas and be creative with the solutions.

- **During/ Immediately after impact(Response)**

  - Hardly any actions are seen to be performed by architects, planners in this particular phase for flood.

- **Post-disaster situation (Reconstruction & recovery)**

  - Plinth stabilizing is one of the best ways to protect houses since the plinth cap which is about 2 to 3 inches thick holds the posts firmly in place. The soil below the cap is compacted and because of the cap prevents scour and movement of soil from underneath during prolonged periods of flood.

  - The kaatla or concrete hollow stump is advantageous over solid stumps because it saves material cost by 10%. The hollow space is filled with inexpensive earth before placing in the ground and strength is not compromised. Bamboo need not be replaced continuously as the kaatla double sthe lifespan by protecting it. It is wise to paint the lower end with bitumen and place polythene the bottom of the post and kaatla top to prevent from damping or termite infestation.

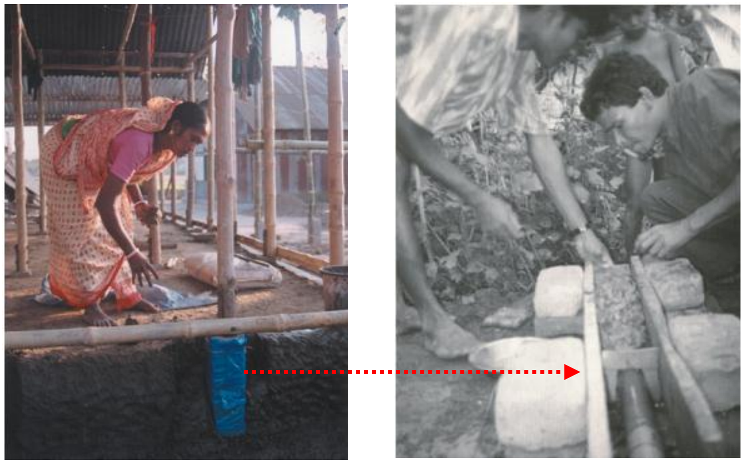


Figure 98. Regular kaatla(Left) Hollow kaatla (Right) (adpc report, 2005)

- The RC posts are popular but cannot be afforded by all. Hence, to make it more universal, the posts have been made hollow so to save materials and reduce cost. Also, it is light weight and is easy to handle and transport. It provides better handgrip because of it cylindrical shape and no corner chipping happens unlike the regular posts. In contrary, the production requires training and quality control and is difficult to make.

Figure 99. Regular RC post (Left) & Hollow cylindrical RC post (Right) (adpc report, 2005)

- CEB's can easily be made by local skills and can be constructed because of the irregular surface it possesses. The blocks interlock with each other so that walls have stronger bonds.

- Ferro cement walls are strong and durable and can resist flood waters for long periods. This is because it is itself a type of reinforced mortar in which closely spaced and evenly distributed thin wire meshes are filled with rich cement-sand mortar. This why the structures can be constructed in any desired shape and thickness as thin as 1 inch without formwork.

Figure 100. Ferro cement construction process (adpc report, 2005)

- The typical rural homestead layout has been followed by the rural communities for generations and is both a cultural and contextual practice. This is hence improved and not changed through an organized homestead raising approach where the resources would not be cut and desired results can be achieved.

- Here, sustainability is not achieved through "spectacular" planning nor is the dominant or typical layout discarded. Interventions in the form of innovative structural systems, joineries and at a broader angle homestead planning proved to be successful.

- A conscious decision of integrating the houses, the homestead, the infrastructure, the landscape together is enough for a community to achieve resilience and so can be true if all the innovations described in section 3.3 come together.

- Landscaping is seen completely as a separate entity because trees are an essential part of the village architecture as it provides food, material to build and signifies a homestead's identity.

- Floating houses can be a very effective because the land on which the property and livelihood is built is retained to a great extent and not washed away completely. In a few places, raising the ground only prove to be unsuccessful during heavy flood and so if houses can be made to float, then flood waters could not have caused so much devastation.

- Embankments if widened at important areas such as homestead and community centers, then the embankment could act as one single flood resistant unit. More people could live safely over a larger surface area. Also, the people do not have the danger of being scattered and lost. Slowly, the areas can develop into more organized zones with proper homestead planning and landscaping which could result in the whole area as a safe zone.

4.4. TSUNAMI

A. *Great East Japan Tohuku Earthquake come Tsunami – March 11th, 2011*

a. Urban Community Space Planning (Minami Sanriku)

➢ ***ANALYSIS : Pros & Cons / Comments***

- **Pre-disaster situation (Preparedness)**

  - The affected site was surveyed by architecture students through the 3/ll program (a part of the training workshop initiated by professors of MIT) helped to raise awareness among future architects as to how to build more sustainable structures for future calamities.

  - A graduate spring studio course was also designed to educate young architects about the calamity. This kind of education where architects are taught and prepared to “rebuild” rather than “just build” gives birth to a socially conscious set of designers and planners. This will prove to be a basis for resilient and sustainable construction.

  - A team is again expected to travel to the disaster affected site to build structures conceived during spring course. The exchange of ideas between the community-experts-students should enhance the implementation phase later in the cycle. Such kind of preparedness through education and awareness triggers better, safer and healthier planning and design.

- **During/Immediately after impact (Response)**

  - The post-disaster site was surveyed, SWOT analysis and rapid/damage assessment performed by student-teacher team of MIT. The team recorded information about debris, vegetation, soil, topography and other environmental features required for appropriate planning. No time was wasted during the documentation process and timely collection of basic data was achieved. Appropriate information about physical, social and economic damage was extracted.

- The findings were scrutinized later during a three-week long workshop and potential sites were suggested to the communities for future interventions. The initial assessment done by architects ensured that activities were to smooth and timely and collection was not overlapping or flawed.

Figure 101. MIT Students & professors surveying the Tsunami affected site and surroundings (Source: IT 3:11 report)

- **Post-disaster situation (Reconstruction & recovery)**

- The community centre helped to revitalize the community and brought back the sense of belongingness. It was a useful way of restoring the cultural and traditional values for the displaced individuals.

- The sites chosen for the temporary housing were at a safe distance from where the disaster had repeatedly struck time and again. People from different spaces had gathered after losing homes and livelihood and would live here for long until they could call a place their "home" again.

- Even though, the "community center" was built upon a "temporary housing", it acted as a catalyst to build concrete solutions in the future as the idea was being accepted widely by the inhabitants and later by the civic leaders also.
- The injection of community spaces spurred interaction and collaboration between the residents over tea or chit-chat (a cultural practice of Japan) and enhanced it while the community

participated during the implementation of the project. Eventually this led to the generation of income through making crafts and so on.

Figure 102. Community participation during building phase
(Source: IT 3:11 report)

- With the community bonding revived and generation of income and activities underway; this idea could be made concrete by replacing the temporary houses with permanent ones. Also, since the polycarbonate roof and wooden deck of the centers were being replaced by even more robust materials such as cedar framing and stone base for deck; this site would easily be accepted by residents to build their permanent homes. The combination of both structural intervention (physical building) and non-structural intervention (psychological building) are key components of reconstruction and such was true in this case.

- An idea of an interesting "public space" in a small alleyway of temporary houses incorporated all the attributes needed for a "cluster" of people to function systematically and become a community. The acceptance of a temporary site; the interaction amongst strangers and participating as a community to build a structure of their own; the demand for activities to bring money--all were stimulated from such an idea of community center.

- Such spaces act as a hub that helps communities to rebuild resources that would not otherwise garner appropriate attention or support. These hubs help to diminish isolation, cultural gaps and homelessness after a disaster and later acts as resilient public spaces in which permanent solutions(such as housing) can be built on. These spaces double as resources and build safe, self-sustaining communities in the long run.

- The nest-like space impregnated the sense of "home" once again into the people to create a permanent habitat around it. This is a way forward towards sustainability.

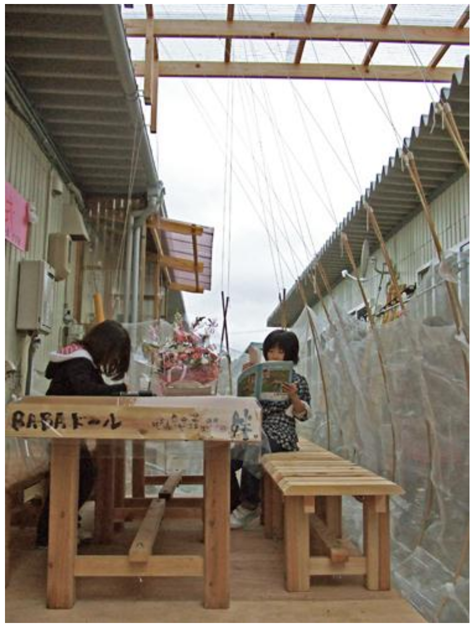


Figure 103. Children reading in the community space during leisure (Source: IT 3:11 report)

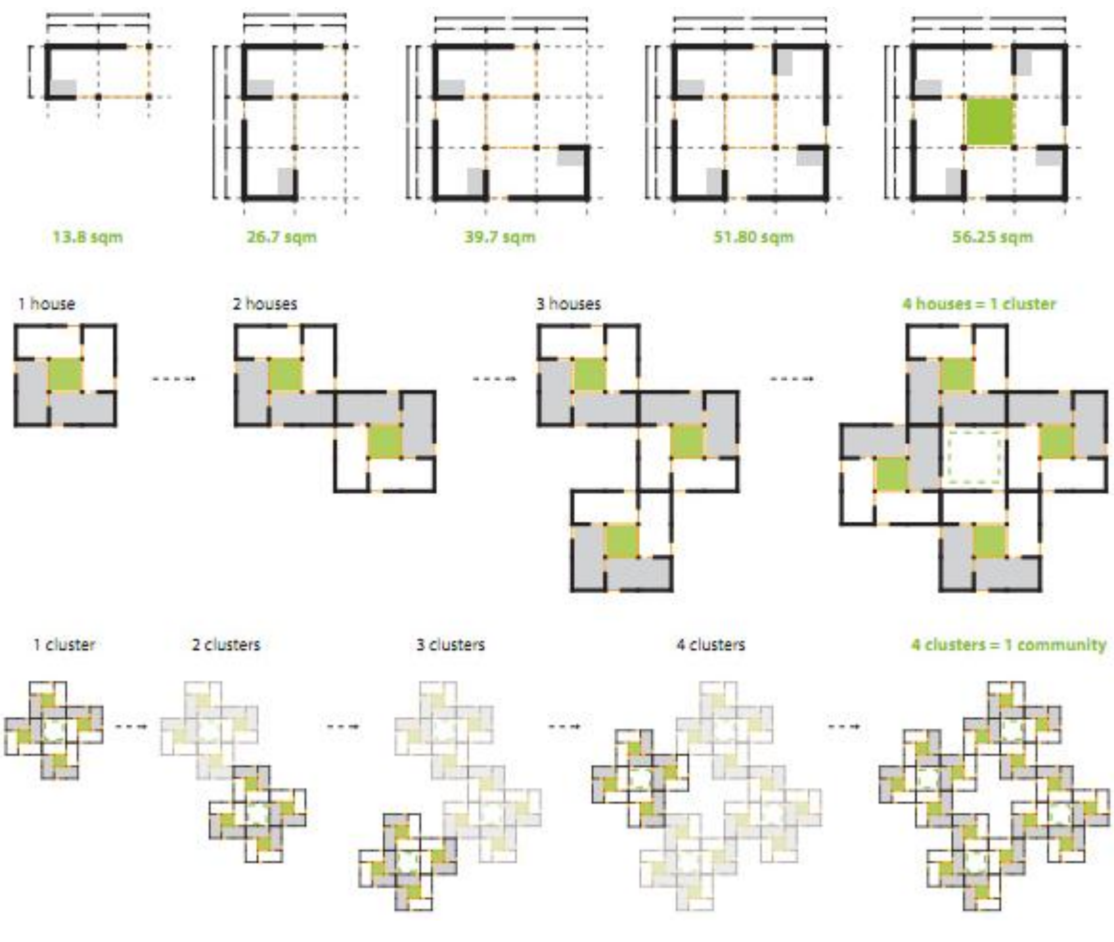


Figure 104. Progression showing how a simple unit can evolve to become a community with similar essence of Babadoru- 5-chome (MIT competition website)

- The progression of drawings in (Fig.4) show how a simple unit or module can add up to become a house which later can become a cluster and then eventually into a new community. This example is a work exercise by the students of MIT for a disaster-prone community and its relationship with Babadoru-5-chome lies in the small idea of how a simple community center in a temporary settlement could trigger activities and later become a hub around which a whole community could comfortably develop. The injection of the community center as a unit added up to become a hub and center of the people living there who considered making the temporary place permanent through grow progress. The housing units (taking up similar idea as shown in Fig.4) can evolve around a central public space and these units can have the flexibility of modifications according to necessity of the beneficiaries. This could prove to be a sustainable and resilient approach in the long run.

b. Urban design & Landscape features (Rikuzen-Takata City, Akita City, Sendai City)

- ***ANALYSIS : Pros & Cons / Comments***

- **Pre-disaster situation (Preparedness)**

- The architects decided to build attractive and informative disaster memorial parks that would act as leaders of tsunami preparedness and awareness. Such parks would attract tourists and people of all ages to enjoy themselves, commemorate the victims and as well as learn from past history. It is a way of story-telling through means of apt design.

- Pinewood act as buffers to intense wave action and so planting ample number of such trees is recommended to obstruct the tsunami and as well as be a part of the urban landscape for beautification. However, it would be wiser to start plant those trees parallel to the shoreline and not in random fashion. Also, the trees need to be at a considerable distance from the shore so that not all of them are uprooted when waves hit the coast because at a safe distant the wave impact is lower. Less destruction would mean less debris; faster recovery work.

- Concrete stairways can be a beautiful landscape element; a place of rest and gathering and a place for refuge during tsunami. Here, the elevated stairs should be above base flood level and can be incorporated with a plaza-like space to give it a land-mark feel so that during a disaster, people can easily identify and access it.

- **During/ Immediately after impact(Response)**

  - Hardly any actions are seen to be performed by architects, planners in this particular phase.

- **Post-disaster situation (Reconstruction & recovery)**

  - Elaborate actions are yet to be taken here; nonetheless the preparedness phase for this case study is a siren for more activities to be undertaken in the latter phase – reconstruction.

c. Infrastructural innovations (Taro village, Miyako city)

➢ ***ANALYSIS : Pros & Cons / Comments***

- **Pre-disaster situation (Preparedness)**

  - No notable actions were taken by architects.

- **During/ Immediately after impact(Response)**

  - Hardly any actions are seen to be performed by architects, planners in this particular phase.

- **Post-disaster situation (Reconstruction & recovery)**

  - Sea walls and tsunami gates should be constructed with the purpose of mitigating the Tsunami and not to totally stop it as the waves can overtop the walls if the waves are higher. New technology uses steel construction and reinforced concrete to build sea walls but sometimes falls short of budget and time even though such construction is very effective. To maintain budget, Taro village planners have worked out solutions in terms of design techniques and not just material use to make it more effective; segregated design is much more effective than intersecting design and can be said to be a noteworthy innovation.

d. Individual Household structures(Ishinomaki)

- ***ANALYSIS : Pros & Cons / Comments***

- **Pre-disaster situation (Preparedness)**

  - No notable actions were taken by architects.

- **During/ Immediately after impact(Response)**

  - Hardly any actions are seen to be performed by architects, planners in this particular phase.

- **Post-disaster situation (Reconstruction & recovery)**

  - The combination of wood or timber and reinforced concrete is a very effective solution for building houses. The timber structure is usually elevated on top of the RC structure over base flood level. Hence, when inundation occurs the timber structure is less affected as the RC structure can efficiently resist hydrodynamic forces.

e. Housing settlements (Onagawa City)

- ***ANALYSIS : Pros & Cons / Comments***

- **Pre-disaster situation (Preparedness)**

  - No notable actions were taken by architects.

- **During/ Immediately after impact(Response)**

  - Hardly any actions are seen to be performed by architects, planners in this particular phase.

- **Post-disaster situation (Reconstruction & recovery)**

  - Onagawa town had limited space for building was over-populated with homeless people. Such conditions demand rapid response to housing and Ban acted with limited resources. The containers were used as housing units because it was cheap, readily available and could be transported easily to site to meet demands.

  - To break monotony of being called just a “shelter” but beyond it, the architect gave the settlement its own identity through a clever innovation by shuffling with the containers in a playful manner. This resulted in creation of living spaces and break-out spaces amongst the packed containers. This psychologically boosts the community spirit and encourages people to do a bit more.

  - The transitional accommodations are a common response mechanism to fight scarcity of housing disaster but this cannot be a solution as proved by Ban’s work. People sometimes live for years in such shelters and they need to be designed so that it at least caters to the humanitarian basic needs of an individual such as “belongingness” and “identity”. These are the foundations for a successful reconstruction project.

  - This housing also used local skills and materials to be incorporated so that the beneficiaries can directly be involved and learn how to build for the future.

  - The downside of the project is that the materials and techniques used to build the basic house unit were fixed as it was standardized from factories. Nonetheless, Ban highlighted the strengths by creating spaces and encouraging participation with the resources in hand.

  - Temporary housings are often ill-planned, but these innovations can easily make way for these transitional shelters to become permanent through land-use planning, community/ settlement development and using more robust materials for building. Same design module can be followed but with the use of different means of construction and material.

  - The ex-container designed by Yoshimura architects is similar to that of Ban’s but the design modification is slightly different to meet the needs. Here the units are non-modifiable and manufactured in factories but can be shuffled and re-shuffled to form three different kinds of modules as chosen by the user. The material used is robust.

B. The Indian Ocean Tsunami – December 26, 2004

a. Urban settlement / Housing (Banda Aceh, Indonesia)

➢ ***ANALYSIS : Pros & Cons / Comments***

- **Pre-disaster situation (Preparedness)**

  - No notable actions were taken by architects.

- **During/ Immediately after Impact (Response)**

  - Before the settlement was planned the pre and post-tsunami site characteristics was surveyed by the experts. An anti-poverty network helped with the architects and added a new dimension in planning where both agreed to build on the same land with the same resources but slightly inland from the danger zone.
  - The decision of construction on the former site and not in a relocation area boosted up the community's spirit and propelled them to participate in the building process. The community was culturally and historically bonded very strongly.

  - The reports from site survey helped to devise plans in a more comprehensive way.

- **Post-disaster situation (Reconstruction & Recovery)**

  - Since, Banda Aceh did not make a move, land-use planning according to the danger zones were done and other parts of the urban system such a road network, public buildings were targeted and not only individual households.

  - The plan was to re-build around a central mosque and the two-storey housing units would be composite in nature. This clever integration of RC structure with wooden framework was a success as this kind of houses resists the two types of forces from tsunami and earthquake together in a composite manner.

- The houses were multi purpose in nature meaning people could generate income from small businesses in the ground floor or use the space for storing equipments and so on. The upper floor is obviously occupied as the living space.

- Banda Aceh was a quite community almost dying out, the re-settlement project rejuvenated the area through urban planning and created opportunities for people in the form of better living and income. This project can be considered as a "window of opportunity" into ongoing struggle for urban resilience. It has not been realized fully but is in its evolutionary state which may lead to sustainability at one point.

b. Individual houses—Settlements & Landscaping (Kirinda, Sri Lanka)

➢ ***ANALYSIS : Pros & Cons / Comments***

- **Pre-disaster situation (Preparedness)**

- No notable actions were taken by architects.

- **During/ Immediately after Impact (Response)**

- The project team immediately readied documents and site survey reports through consultation with the beneficiaries. Several town hall meetings at the local school amongst the locals and architects were held to discuss the design concept and the ideas of the commoners were articulated within the master plan. However on the downside, some claim that they were simply presented with a concept probably because all their demands were not met.

- It is not necessary of a design concept to accommodate all the demands of the users but to keep provisions and flexibility within the module or plan so that it can be manipulated according to the users' needs and such was the concept of the design here- adjustable and sustainable.

Figure 105. The architect in discussion with villagers (Left) & exchange of ideas at a town hall meetings (Right) (Source: AIA report, 2006)

- The survey revealed that the community had very strong bonding and is culturally very rich having lot of traditional values and hence in response Ban decided to touch upon not only the houses but view the project as one single unit (one settlement) to maintain that bondage.

- Immediate student participation in construction and tree planting helped to enhance the skills and knowledge of the beneficiaries and the students. Such activities of planting enhance the beauty of the landscape and also help to cut the force of the waves as well.

- **Post-disaster situation (Reconstruction & Recovery)**

- The master plan was devised to maintain economical, structural and cultural environments.
- All the materials used for household construction were sourced from Sri Lanka. This way the cost of construction was minimized.

- The plan was viewed by Ban as two houses, separated by the roof court with the kitchen and toilet housed under one structure. Conversely, the beneficiaries interpret the design as one house and consider the roofed court as an important structure. They wanted the bathroom and the kitchen to be separated from the main house as they did not want the women of the house to be seen by guests from outside.

- The roofed court was conceived as a means of ventilation and space for chores separated by a curtain but beneficiaries wanted more privacy for women as it was a Muslim conservative community. Some of the houses in the master plan are arranged in rows hampering privacy as one court overlooks another. However, these units were modified by the users by sealing it up and making an extra room for more privacy. Some may say that cultural values were not maintained whereas other may view the unit as a flexible, modifiable entity. The courts were actually like the shades of trees for socializing, mending fishing nets and so on and the families who decided to block it up was their own choice but there was no flaws regarding human comfort.

Figure106. Sealed court for privacy & using old bathrooms (Source: AIA report, 2006)

- Some residents resorted to using their old bathrooms because the septic tanks would fill up quickly because of the rain water meaning the drainage system was not designed thoroughly and integrated well enough with the master plan. However, provisions remain and can be rectified with time.

- The concrete blocks used to block the court were also meant to keep the air cool and so was the court itself. However, in both the interventions (one by the architect and the other by the user) the house remains cool either ways.

- The slatted roof at the gable end allows rain to come in during heavy precipitation. Hence, the users adapted to it by placing cardboard or plastic sheeting.

- The primary material CEB(compressed earth blocks) was used for walls and wooden roof trusses as structural frame for roof. These materials were structurally robust and sufficiently sturdy and heavy to withstand high winds and earthquakes. Dissatisfaction shown by residents was not related with the structural system but with quality of the material. The timber was changing color due to age and blending well with the environment whereas on the downside woodworm started to affect much of the timber.

- The cement used for CEB garnered complaints but the upside is that the interlocking nature of these blocks allow for extension of walls as the plots have an extra chunk of land. Also, the CEB is cheap and easy to construct and does not require experts to build it. Nonetheless, some beneficiaries complain that the skills have not been passed to them as hence they used concrete blocks to block the court space rather than CEB'S for ease of construction.

- The furniture in the interior (such as built-in storage shelves) was from rubber trees and was appreciated by almost all villagers as people lost everything to the tsunami.

- It was observed that the other projects undertaken by NGO's had failed but Ban's new material and method of construction corresponded to the circumstances and widely accepted by the people. The nearby villages decided to adopt the same plan because the materials and construction methods embraced the labor and brought income to the households. At the same time, addressed human comfort and needs through proper planning.

- A project that is acceptable and comfortable is a project that's sustainable.

- Integration of other forms of urban systems such as access routes, drainage systems, infrastructure, communal facilities, landscaping is yet to be done at full length but it is a slow process-rehabilitation, but it has begun.

c. Coastal/ Shoreline development & Landscaping --Individual houses & civic facilities (Majority of southeast and south west coastal communities of Sri Lanka)

➢ ***ANALYSIS : Pros & Cons / Comments***

- **Pre-disaster situation (Preparedness)**

- No notable actions were taken by architects.

- **During/ Immediately after Impact (Response)**

  - The design team performed risk assessment and surveyed the site and the surroundings to come up with a plan of working with the broader context –the shoreline and not just individual houses and facilities.

  - The assessments helped to outline some key characteristics about coasts and its inhabitants resulting in building upon them and rather not disregarding them completely.

- **Post-disaster situation (Reconstruction & Recovery)**

  - Coastal development is hardly regarded during the reconstruction phase of any project. Either the population is relocated inland or the individual structures and infrastructure made strong. Thus, initiatives such as coral reef retention, landscaping on steep beach, creating pathways over sand dunes to protect them were new ways of addressing future threats.
  - Since, the coastline always attracts a host of people and is prone to hazards always, these could be further developed in a natural way through planting trees and grasses that retain the soil and designing pathways and walk ups to retain the dunes. Escape hills and evacuation routes can be integrated by means of proper planning and the hills could be terraced in a way so that it is a means of refuge as well as a public gathering spot.

  - Developing the coastline would minimize the impact before the force of water comes inland through such interventions. Through beautification an approach can be said to serve the purpose of sustainability

  - Some basic innovations in house design were incorporated by grading the level of danger zones. Break-away walls, holes on the plinth were innovations integrated to drive away water from the structure and reduce the tsunami impact. These walls are decorative, cheap, easy to construct and functional at the same time.

  - Elevated structures need to consider wind-loading and should be secured from foundation to floor beam to the wall to the roof. Different materials act differently depending on the danger zone and this was well established in the different types of building described in section 3.4.

4.5. LANDSLIDE

A. *Peradeniya landslide – 2009*

a. Resettlement of Urban center (Peradeniya, Sri Lanka)

➢ ***ANALYSIS : Pros & Cons / Comments***

- **Pre-disaster situation (Preparedness)**

  - No notable actions were taken by architects.

- **During/ Immediately after impact(Response)**

  - Hardly any actions are seen to be performed by architects, planners in this particular phase.

- **Post-disaster situation (Reconstruction & recovery)**

  - The architectural intervention was with the focus to re-settle the commercial activities taking place within the reservation area thus maintaining the spirit of the town and as well as boost up more activities with economic value in different layers. Such as the top levels will be for high-end shopping for tourists and the bottom levels for local vendors.

  - The stepped land plots will provide arena for safer constructions on the sloping arena in the future and the mass need not relocate to a completely new area.

  - The removing of top layer of soil and the construction's surface being bed rock was a wise decision as the top layer prone to landslide had already been removed. The retaining walls add to the structural stability and as well as add to the beauty of the landscape as it acts as a decorative barrier.

B. Ratnapura town landslide – May 2003

a. Resettlement of houses (Ratnapur, Sri Lanka)

➢ ***ANALYSIS : Pros & Cons / Comments***

- **Pre-disaster situation (Preparedness)**
  - No notable actions were taken by architects.
- **During/ Immediately after impact(Response)**
  - Hardly any actions are seen to be performed by architects, planners in this particular phase.
- **Post-disaster situation (Reconstruction & recovery)**
  - Split-level construction respected the topography and hence less disturbance of soil beneath.
  - Sewage was pumped out to sewer and the leakages maintained by sub-soil drains. Engineered retaining walls were constructed with both surface and sub-surface drainage.
  - The roads and off-street parking streets were protected and stabilized by retaining walls.
  - Local materials which were available was used such as brick and concrete. However, more flexible and light structures can be made which can also move with the movement of the landslide.
  - Here, the control works such as topography geology and other conditions are not modified too much but the restraint works such as construction of structural elements is emphasized more. However, on a broader scale the control works should be taken into account as well for an integrated and comprehensive approach.

Examples of Houses and structures in Peradeniya and Ratnapur followed most of the good practices as illustrated in Fig.107 and 108 in the next page.

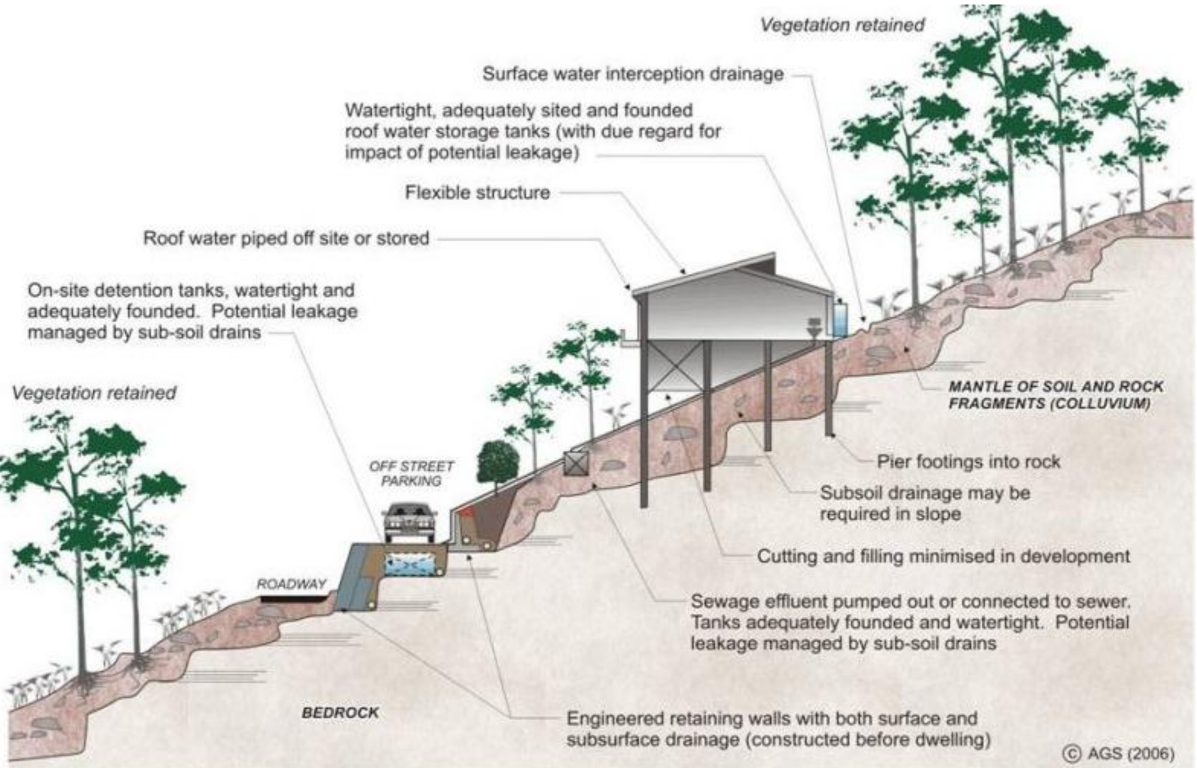


Figure 107. Examples of GOOD Hillside practice. (Source: http://lrm.australiangeomechanics.org/wp-content/uploads/2012/04/GeoGuide_LR08_Construction1.pdf)

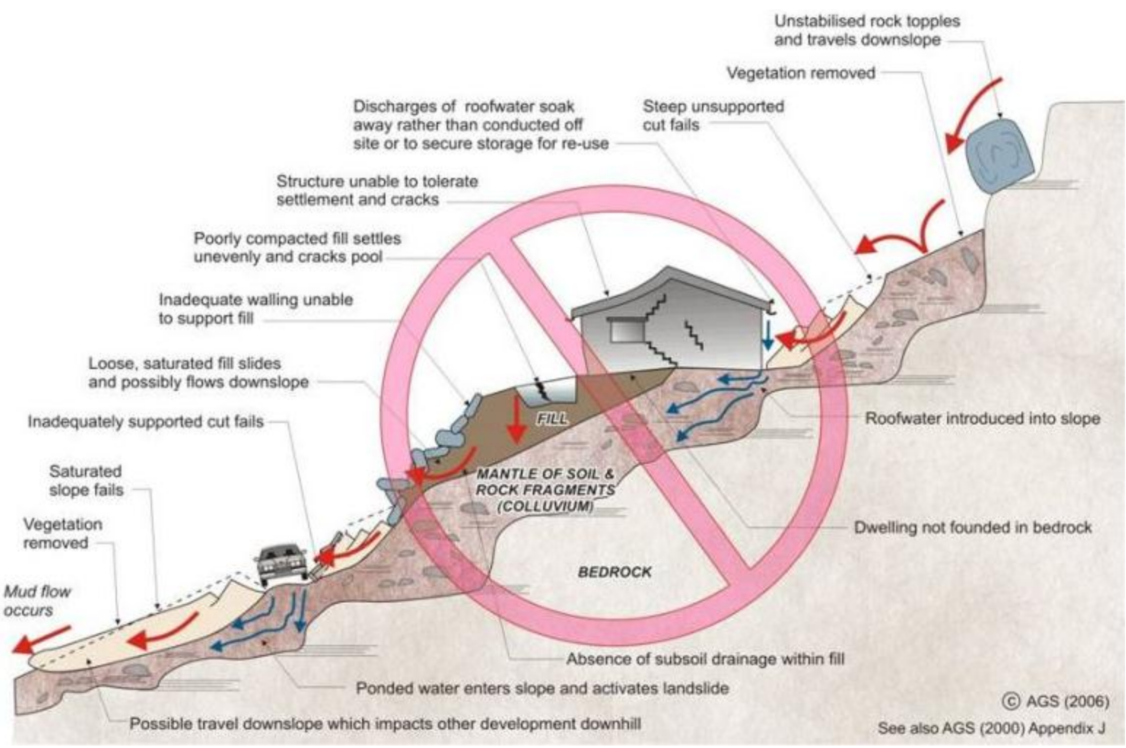


Figure 108. Examples of BAD hillside practice. (Source: http://lrm.australiangeomechanics.org/wp-content/uploads/2012/04/GeoGuide_LR08_Construction1.pdf)

C. California , Rancho de Palos Verdes– 2012

a. Landslide Mitigation Houses (Rancho de Palos Verdes, USA)

➢ ***ANALYSIS : Pros & Cons / Comments***

- **Pre-disaster situation (Preparedness)**

  - Anchors attached to the cables that are inserted in the bedrock shall move as landslide happens, and so extra protection for anchors is needed.

  - Providing water and sewerage lines maybe very difficult in an active landslide area and also the cables may snap due to the large forces of landslide. The possibility of a cable under tension snapping is potentially serious for both the landslide and any people in the vicinity.

  - Such ideas need to be developed with inexpensive techniques as it cannot be afforded by many due to its high-tech and elaborate structural system.

  - Keeping the floors level when a landslide moves can be very challenging in this case but then again the flexibility of structure and the ability of the house to change shape with the movement can be explored as an idea.

Figure 109. 3D representation of landslide mitigation housing (http:// blogs.agu.org/landslides)

- **During/ Immediately after impact(Response)**

  - Hardly any actions are seen to be performed by architects, planners in this particular phase till this intervention described above was conceptualized.

- **Post-disaster situation (Reconstruction & recovery)**

  - The concept is still at an evolutionary stage and hence had not been implemented yet to check for sustainability in real time. Nonetheless, sustainable approach was followed.

CHAPTER 05

CONCLUSION

5.1. Summary of Analysis

Through the analysis of different projects some “realized” and some “conceptualized” at home and away, it can be concluded that intervention techniques be it (structural or non-structural) is a way forward to the future. How? In the previous chapter, it can be seen that every project and every practice has been viewed as a “window of opportunity”. Every context is different and so is every disastrous situation. Hence, if every project is viewed in a positive light projecting towards the future, then sustainability and resilience can be achieved by evolving and molding ideas according to what the situation demands. In these case studies, likewise have been observed as ideas and concepts were presented that would cater to needs of the people and their surroundings and not visualized as only a mere project to respond to the immediate demands and needs only.

Every individual, every household, every nook and corner of the neighborhood that connect to the greater whole to form a community that would eventually expand to greater nations should be the matter of concern; not just an individual entity. Development activities should be a continuous process of tasks that should hatch a solution-“a robust-sustainable solution” and not just a “product”. Repetition of previous fixed set of concepts for housing solutions should be discarded and innovative concepts should be accepted and absorbed by the power leaders to the grass root levels. This should in turn, give rise to dynamism (especially in the preparedness and reconstruction sectors) in the activities of the DRMC and architectural practices rather than sticking to a stereo-typed nature of practice. Also, this should help to open up a completely new trend and style in architecture and produce a completely new set of architects who would learn to re-orient themselves in a different order, in a different manner and lead the way to a more humanitarian architecture.

That architecture and disaster management is overlapping, the previous chapter bears proof. It has been observed that people tend to abandon their homes, their shelters and eventually their lives because they fall prey to the system delivering “the hurried product”. The system often identifies survival to be the vital most need for humanity and yet it is addressed through temporary solutions that may not sustain in the long run. If apt professionals (such as architects and planners) were recognized in the reconstruction and preparedness phases, then a community ready for the future adversity would arise and it would solve un-coordinated and inappropriate planning usually performed by unspecialized and unaware task forces.

The overall idea is not to house an “entity” but an entire “habitat” that should comprise of the humans and the whole system around them. An idea that would solve problems in terms of social, cultural, environmental, economical and physical aspects- everything required to make a habitat stable and function as “one unit” and not just “one entity”. The ideas should be able to think “beyond shelter” and incorporate other elements around it. A house is a “home” when it can sustain itself on its own and this is only possible if everybody starts “re-building” rather than only building because rebuilding “builds back better homes to better lives”.

5.2. Conclusion

With the advent of civilization in terms of technology, lifestyle, economic growth, population expansion,and urbanization; the world has seen a series of dangerous events over the recent years. These events or more notoriously known as “natural hazards” expose countries, towns and villages; people, homes and their livelihoods to immense destruction causing loss of lives and property. Restoring and Reconstruction of such immense destruction can take ages or be completely unsuccessful if not managed well which is often the case of post-disaster scenes. The reconstruction works are speedy processes that follow a given set of fixed rules and typologies inappropriate to context and culture without the supervision or involvement of apt professionals. The “who” does “what” aspect should be clear within the system and the approach of activities need to be a continuous process and not just a hurried “product”. Once this process of interventions and techniques is explored by fitting professionals, an environment of sustainability and resilience will arise after any calamity and this laid the foundations to form the basis of thethesis research.

This thesis paper helps to gather the idea that “architects” and “architectural interventions” can contribute greatly to the resilience and sustainability of a community. It is expected of architects to realize people-oriented projects that are an amalgamation of architecture that responds to humanitarian beliefs as well deals with the technical issues and the environment. The restoration and the reconstruction phases being the crucial stage of the DM cycle follows through the fact that if a disaster (small to magnanimous in proportion)should take place, then the community should be resilient or prepared enough to fight the situation successfully and spring back to normalcy in a short period of time without much ado. A “community” and not just an “individual” should be able to contain and at the same time resist the effects of the calamity which would otherwise wreck terror and havoc amongst nations. This paper hence, sheds light on those exemplary works by architects that have made a significant contribution towards the society and had helped people/ can help to get back to their feet after a disaster.

The show-casing of innovative works and interventions from all over the world can act as a platform of a new set of emerging architects, designers and planners having the capacity to “build” ,“re-build” and most importantly “build back better” (BBB) resilient “homes” to “sustainable nations”. The global context is ever-changing due to climate change and urbanization and hence the dynamics of our surroundings have become rather unpredictable posing greater challenges to professionals. Just like the context is in a constant process of change and so is the disaster that is constantly evolving. Hence, this paper realizes the fact that mainstreaming of a certain profession or practice is a draw-back and that it should be able to change and evolve with time and open a window for architects and designers in the world DRM platform.

Since, the topic of architectural practice in DRMC is seldom discussed in literature or policy-making; this paper highlights the need for good architectural interventions for future sustainability of an individual and his home that will eventually extend to an entire community. The skills of an architect and her innovations are very much vital in the system and so the works done in the preparedness and reconstruction phases are highlighted in the case studies in this dissertation. Also, the case studies have been scrutinized in the final chapter and the strengths, weaknesses, opportunities and threats have been presented to generate a conceptual idea about the projects whether the designs were sustainable and resilient or not.The solutions outlined can re-orient the general thinking about architecture as a profession and the welcoming of such practices can lead the way to a renewed and newer world.

The innovative ways presented in the dissertation represents the architectural practice ina different light and introduces it as one of the most vital branches of the disaster management system. The urban system is a complex system that connects the community along with its different entities. A shelter alone or a physical attribute only is never the answer to a post-disaster reconstruction scheme but other integrated components such as economic, social, cultural, political and environmental elements also play along with it.The architects and interventions are viewed here as agents of “change” and development to an evolving context which is in turn should lead the way of sustainability and resilience. It is said that the architect only possesses enough knowledge as to how to structure the human habitat appropriately and can envision creative, transformative spaces that can evolve with the situation in demand. Through this research, it is realized that a “house” should not be viewed a separate entity but it should be given the attributes of a “home”, a place of identity, by connecting all the components holistically in an integrated, participatory approach through interventions. This not only targets the physical environment but the socio-cultural, environmental and economic elements as well. When these elements are improved through interventions during the preparedness and the post-disaster reconstruction phases, and not only restored temporarily, then resilience and sustainability can be said to be achieved as is the essence of this entire dissertation paper.

5.3. Recommendations

The reconstruction and preparedness phases in the disaster risk management cycle (DRMC) often overlook the "community" and the "designers" who bear the optimum skills and knowledge of re-building. This maybe because of bad governance, unethical, unprofessional bureaucratic approaches or just maybe because of the lack of awareness and understanding. However, the instillation of the concept of architectural innovations may solve the problem of un-coordinated and inappropriate housing solutions before and after a disaster. The idea of comprehensive, innovative design solutions need to be brought to attention of the GO's ,NGO's and people alike through projects that have been "realized" or "conceptualized" to be a successful example of sustainability and resilience.

The new interventions and solutions need to be introduced and accepted by the key professionals and administration in the disaster management system. This practice will not only highlight the profession of architects in a new light but also will improve the activities before and after the implementation process. The "build back better" principle can be achieved if solutions are provided by experts namely architects and planners who possess adequate knowledge about reconstruction and re-building and not just temporary restoration. This will result in development activities that will follow a process through trial and error and participation and the result shall be fruitful for the future thriving of communities from disasters.

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