REDUCING COMMUNITY RISK THROUGH DISASTER RESILIENT HOUSING IN BANGLADESH

A Dissertation for the Degree of Master in Disaster Management

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ABSTRACT

Bangladesh is a multi-hazardous and disaster prone country due to its geographic location and socio-economic condition of the people. Every year natural disasters disrupt the lives of people in some parts of the country. The housing sector is mostly damaged due to disasters on a regular basis and is the cause of most economic losses of the country. Houses and settlements are facing greater challenges triggered by natural hazards and uncontrolled urbanization in Bangladesh. Till date, there seems to be a lack of overall housing solutions for building of resilient rural structures that address future disaster risks posed to housing in the hazard exposed areas. Inappropriate housing solutions together with poorly constructed houses are considered as one of the main sources of risks to disasters.

Hazards in nature do not constitute disaster risk, however, the underlying vulnerabilities to hazards and external drivers construct disaster risk and resulting losses. These vulnerability factors are not addressed. The housing sector of the country tends to focus more on the physical improvements with limited attention to other aspects such as the social and administrative issues. From literature review in the context of Bangladesh, five significant findings have been considered that would ensure a resilient housing system; (i) local knowledge and construction practice to develop long term disaster resilient housing, (ii) improving local awareness and supporting local economy to raise resilience, (iii) improving communication between the local masons and the professional expertise, (iv) application of planning codes and construction regulation and (v) enhancing the local governance. This paper addresses such factors that may generate several policy implications for local authority to issue appropriate legal frameworks and supportive programs in order to improve local construction and to build safer and more resilient communities. Furthermore, it also addresses some approaches that may be crucial for disaster risk reduction which can be achieved through appropriate housing practices in Bangladesh.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 01: INTRODUCTION

1.1 Background

Bangladesh is most vulnerable to various natural disasters and is a known cause of distress among its people. The major disasters concerned here are the occurrences of flood, cyclone and storm surge, flash flood, drought, tornado, riverbank erosion, and landslide. These extreme natural events are termed disasters when they adversely affect the whole environment, including human beings, their shelters and the resources essential for their livelihoods. The communities in the disaster prone areas of the country, especially the poor are the most affected by it and suffer great loss as they cannot easily go back to the pre-disaster condition. Hence, it becomes important to build communities resilient to disasters to reduce their vulnerability and risk. As stated in DEPICHO:

> "Bangladesh is one of the most disaster-prone countries in the world, suffering from regular floods, cyclones, earthquakes and drought. It is estimated that in the past 20 years, 135 million people in Bangladesh have been affected by natural disasters, and while many have lost their lives or been injured, millions of others have also lost their homes, land and livelihoods" (DEPICHO, 2012, p.1).

Although disasters have a huge impact on people's lives, it has larger impact on their shelter. Disaster events disrupt day to day life and leave the families without proper housing and results in lack of access to basic services such as water and sanitation. Since this is one of the key assets to the community people, the damage makes it difficult for them to recover from the loss.

Housing or shelter is considered one among three basic human needs next to food and clothing. The importance of housing should not be understated since it is a key aspect of a person's health, wellbeing, and prospects in life. "Housing cannot be merely seen as a living and infrastructure/facilities function, but also as settlement process and as facilities for people to communicate with the environment (neighborhood, society, nature surroundings)" (ADPC, 2011).

Disaster risk reduction (DRR) offers a major contribution to the building of safer, resilient communities. Central to this is the focus on communities and specific zones that are at risk from frequent disaster impacts. The UNISDR defines resilience as:

> "The ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions" (UNISDR, 2009, p.24).

Resilience and the building of resilience should therefore be seen as an integral part of disaster risk reduction activities.

"Resilient Housing" is an alternative approach in disaster risk reduction targeting the most vulnerable communities. "It has been argued that designing and constructing a resilient built environment demands an in-depth understanding of the expertise and knowledge of avoiding and mitigating the effects of threats and hazards" (Little, 2004; Hamelin and Hauke, 2005) "and that the most influential disciplines that can affect the resilience of the built environment are the design, engineering and construction discipline" (Bosher et al., 2007). Therefore through careful architectural planning and construction practices we can develop resilient housing in the disaster prone areas where the communities are most at risk of losing their homes. The use of disaster resilient materials and structures should be considered which can help minimize severe damage and loss.

This study focuses on exploring the means and methods through which risk to communities can be reduced through disaster resilient housing which will eventually reduce the severe impact of the disasters as well. Through this study some basic design considerations, construction practices, social and administrative issues are laid out to be considered for construction practice in Bangladesh.

1.2 Statement of Problem

Bangladesh is a multi-hazardous and disaster prone country. Every year, recurring disasters like flood, cyclone and landslides upset lives of the rural community people and adversely affect the environment (DEPICHO, 2012). Housing among the others is facing greater challenges due to natural hazards and uncontrolled urbanization in Bangladesh. However, there seems to be a lack of overall housing solutions for building disaster resilient structures in the hazard exposed areas that address future disaster risks. Inappropriate housing solutions together with poorly constructed houses are considered as one of the main sources of risks to disasters (Tran et al., 2012). The housing sector of the country tends to focus more on the physical improvement with little attention to the administrative and social issues. Shelter is one of the basic needs of human

survival (Newaz, 2004). Having a home safe from natural hazards is very important in the disaster prone areas. Therefore exploring means to reduce community risk through a resilient housing system is now a vital issue.

Analyzing existing literature, I was convinced that there needs to be appropriate legal frameworks and supportive programs in order to improve local construction and to build safer and more resilient communities. Through the integration of disaster risk reduction (DRR) in the housing system, community resilience can be achieved and damage minimized. This was the motivation behind conducting a study to explore different approaches for mainstreaming DRR in the housing practice in Bangladesh.

1.3 Objectives of the Research

- To identify how the existing separation between risk reduction and housing can be overcome, and integration achieved.
- To explore ways in which resilience can be achieved through housing practices in the disaster prone areas.
- To explore different disaster resilient design approaches and structures that could be used in housing practices to reduce community risk in the disaster prone areas.

1.4 Research Questions

1. Will mainstreaming disaster risk reduction into housing practices in the disaster prone areas build a resilient community to disaster in the Bangladesh context?
2. How can disaster resilient housing contribute to reduce the vulnerability of the community people?

1.5 Methodology

The study is based on a qualitative research. In this study, information and relevant data is mainly extracted from extensive study of the concerning area from the secondary sources which includes published articles, journals, various websites and books. In addition, the current scenario of housing in the disaster prone areas of Bangladesh is studied and analysed through secondary information to understand the housing patterns and the problems that the community face during disasters. This information is used to formulate ways in which their housing can be improved and made more resilient so that they don't suffer severe damage in the aftermath of a disaster. After

collecting the information, different solutions to reduce the community risk through disaster resilient housing are presented on understanding of the major problems that the communities face.

1.6 Limitations and Scopes

Since this study is conducted for an academic purpose, time constrain was a big limitation. The study had to be completed within the given timeframe. The availability of relevant literature was also a constraint since the only information available was from the pool of secondary resources from websites since field work and site visit were not viable as a result of the political unrest in the country. In addition, at times relevant information to the topic was inaccessible or unavailable from the websites.

In this study, the major hazards and disasters of Bangladesh; cyclone, flood, landslide and earthquake have been discussed, however, the study focuses only on the disasters that impact the housing of the rural areas of the country. The impact of earthquake on housing usually occurs in the urban areas and the design concept of resilience goes to a different dimension that is beyond the capacity of this study. Therefore, earthquake has been excluded from the study of disaster resilient housing.

CHAPTER 02: LITERATURE REVIEW

2.1 Community, Community Risks and Vulnerabilities

The word "community" is derived from the old French *communité*, a broad term for fellowship or organized society. The term community has two distinct meanings; one is a group of interacting people, living in some proximity (i.e., in space, time, or relationship) and the other usually refers to a social unit larger than a household that shares common values and has social cohesion. In conventional emergency management, communities are viewed in spatial terms: groups of people living in the same area or close to the same risks (Twigg, 2007).

It is common that the people at the community level have more to lose because they are the ones directly hit by disasters, whether on a big scale or on a small scale. They are the first ones to become vulnerable to the effects of such hazardous events. The community, therefore, has a lot to lose if they do not address their own vulnerability. On the contrary, they have the most to gain if they can reduce the impact of disasters on their community. The local people of a disaster prone area, due to exposure and proximity, are the victims and assume most of the responsibilities in coping with effects of disasters. They have local knowledge of vulnerabilities and are repositories of any traditional coping mechanisms suited to their own environment. In addition, these people are the first responders in times of crisis whereas the last remaining participants as stricken communities strive to rebuild after a disaster.

People with vulnerabilities are more susceptible to the immediate, medium and long- term effects of disasters such as loss, injury, social dislocation and economic hardship. Vulnerability may depend on a number of factors, such as personal health, location or socioeconomic situation. People who require special or significant assistance to mitigate against, prepare for, respond to and recover from a disaster should be considered vulnerable. Vulnerability diminishes the capacity of an individual or group to anticipate, cope with, resist and recover from the impact of a natural or man-made hazard. Vulnerable groups are also those that also find it hardest to reconstruct their livelihoods following disaster, and this in turn makes them more vulnerable to the effects of subsequent hazard events (Sadeka et al., 2013). Being poor contribute a lot to being vulnerable because they face many risks and pressures that limit their ability to improve their livelihoods and wellbeing. Though disasters affect everyone, often the impact disproportionately falls on poor communities and the poor and marginalized people within. The effects of natural

disasters can be persistent for the poor, especially when they lose both of income and assets (Noy, 2009). Poverty restricts these community people from having alternate or diversified livelihood options. They have limited or almost no access to funding or financial assistance for which they are usually dependent on one kind of livelihood which when damaged by a disaster event becomes difficult to recover.

Household assets are the important assets which include land, livestock, productive assets, appliances, and non-productive assets. The poor and vulnerable do not have the assets necessary to generate stable income and maintain a healthy quality of life. Only very few rural households own agricultural land. Vulnerable and highly vulnerable households are overwhelmingly landless. Therefore their household assets are vulnerable to any natural hazard and once they are damaged, they can hardly recover the loss.

2.2 Concept of Resilience

The term resilience is often used in the same manner as the notion of "bouncing back" that reflects its Latin root *"resiliere"* which means "to jump back" (Klein et al., 2003; Paton & Johnston, 2006). Different scholars/organizations have defined resilience by different perspective. Here resilience is considered with the perspective of disaster or hazard event. International Strategy for Disaster Reduction (ISDR) defines resilience as "the capacity of a system, community or society that is potentially exposed to a hazard, to adapt to it by resisting changing so that it reach and maintain an acceptable level of functioning and structure" (Sadeka et al., 2013). UNISDR also define as "the ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner" (UNISDR, 2007).

'Resilience' is generally seen as a broader concept than 'capacity' because it goes beyond the specific behavior, strategies and measures for risk reduction and management that are normally understood as capacities. However, it is difficult to separate the concepts clearly. In everyday usage, 'capacity' and 'coping capacity' often mean the same as 'resilience'. A focus on resilience means putting greater emphasis on what communities can do for themselves and how to strengthen their capacities, rather than concentrating on their vulnerability to disaster or their needs in an emergency. The terms 'resilience' and 'vulnerability' are opposite sides of the same coin, but both are relative terms as argued by Manyena (2006). One has to ask what individuals, communities and systems are vulnerable or resilient to, and to what extent. Like vulnerability,

resilience is complex and multifaceted. Different features or layers of resilience are needed to deal with different kinds and severity of stress.

As defined by Chandra et al. (2011), Community resilience involves enhancing the capacity of the community to account for its vulnerabilities and grow capabilities that support the community in preventing, withstanding, and mitigating the stress of a hazard incident; recovering in a way that restores the community to a state of self-sufficiency and using knowledge from a past response to strengthen the community's ability to withstand the next hazard incident.

The 'disaster-resilient community' is an ideal. Communities can never be completely safe from natural and man-made hazards. It may be helpful to think of a disaster-resilient or disaster-resistant community as 'the safest possible community that we have the knowledge to design and build in a natural hazard context', minimizing its vulnerability by maximizing the application of DRR measures. DRR is therefore the collection of actions, or process, undertaken towards achieving resilience.

The component of resilience is a broad concept and hence is divided into five thematic areas relating to resilience and DRR. The five thematic areas are based on those in the Hyogo Framework for Action and are intended to cover all aspects of resilience (Twigg, 2007).

Table 2.1: Components of Resilience

Thematic Area	**Components of Resilience**
Governance	• Policy, planning, priorities and political commitment. • Legal and regulatory systems • Integration with development policies and planning • Integration with emergency response and recovery • Institutional mechanisms, capacities and structures; allocation of • responsibilities • Partnerships • Accountability and community participation
Risk Assessment	• Hazards/risk data and assessment • Vulnerability and impact data and assessment • Scientific and technical capacities and innovation
Knowledge and Education	• Public awareness, knowledge and skills • Information management and sharing

	• Education and training • Cultures, attitudes, motivation • Learning and research
Risk management and vulnerability reduction	• Environmental and natural resource management • Health and well being • Sustainable livelihoods • Social protection • Financial instruments • Physical protection; structural and technical measures • Planning regimes
Disaster preparedness and response	• Organizational capacities and coordination • Early warning systems • Preparedness and contingency planning • Emergency resources and infrastructure • Emergency response and recovery • Participation, voluntarism, accountability

Source: Twigg, 2007 modified by author

2.3 Concept of Disaster Risk Reduction (DRR)

The Evolution of Disaster Risk Reduction:

The concept of Disaster Risk Reduction (DRR) has evolved in the last decade to a widely adapted framework to reduce the risks of natural hazards. Over the past decades, the UN International Decade for Natural Disaster, the Yokohama Conference (1994) and the World Conference on Disaster Risk Reduction (WCDR) in 2004 have contributed to a significant shift in the understanding of disaster management towards a more comprehensive understanding of the underlying causes of hazards and vulnerability and towards the development of a forward looking and longer term strategy for anticipating and managing risk; in other words, a change of the concept of vulnerability and hazards by drawing more attention to the underlying causes of increased social vulnerability to hazards. During this time, the today used concept of Disaster Risk Reduction was developed giving particular emphasis on proactive measures (prevention and preparedness) instead of being reactive to disasters.

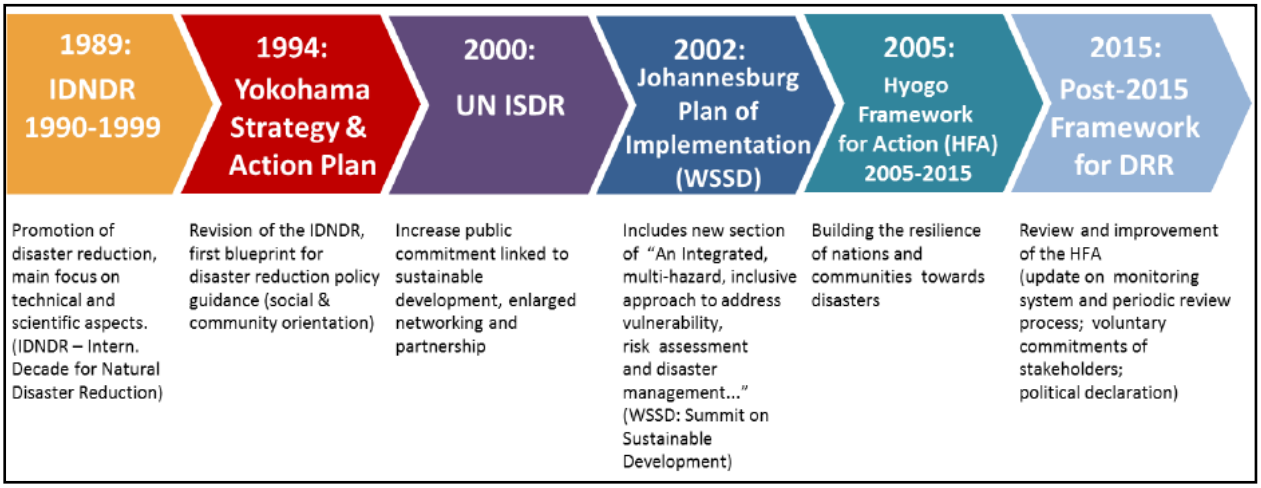

Fig 2. 1: DRR agenda in progress
Source: ISDR, 2009; modified by HELVETAS Swiss Intercooperation and GRF Davos

Yokohama Strategy and Plan of Action:

On the occasion of the 1994 mid-term review of the IDNDR (International Decade for Natural Disaster Reduction), the World Conference on Natural Disaster Reduction was held in Yokohama. Since then, the Yokohama Strategy for a Safer World: Guidelines for Natural Disaster Prevention, Preparedness and Mitigation and its Plan of Action, unanimously adopted by the participants of the Conference, has served as the international blueprint for disaster reduction. Since 1994 the human and economic losses due to natural disasters have continued to increase despite efforts undertaken during the IDNDR and, later, under the umbrella of the International Strategy for Disaster Reduction (ISDR), the United Nations programme established in 2000 to follow on the IDNDR achievements.

Hyogo Framework for Action (HFA):

A cornerstone of DRR is the Hyogo Framework for Action (HFA) (2005-2015) elaborated at the World Conference on Disaster Reduction in Kobe, Hyogo (Japan). Adopted by 168 countries, its overarching goal is to build the resilience of nations and communities to disasters by achieving substantive reduction of disaster losses by 2015. The framework is organized according to five priorities for action (UNISDR, 2005)

Table 2.2: Priorities for Action

1. Make Disaster Reduction a Priority
Ensure that disaster risk reduction is a national and local priority with strong institutional basis for implementation.
2. Know the Risks and Take Action
Identify, assess and monitor disaster risks – and enhance early warning.
3. Build Understanding and Awareness
Use knowledge, innovation and education to build a culture of safety and resilience at all levels.
4. Reduce Risk
Reduce the underlying risk factors
5. Be Prepared and Ready to Act
Strengthen disaster preparedness for effective response at all levels

Source: UNISDR, 2005; modified by the author

With the HFA coming to an end in 2015, the United Nations General Assembly Resolution 66/199 requested UNISDR to facilitate the development of a post-2015 framework for disaster risk reduction. This new framework aims at reviewing and improving the HFA.

Preparatory meetings indicate a three-fold outcome composed of:

A) The post-2015 framework for disaster risk reduction with its monitoring system and period review process (HFA2),

B) The voluntary commitments of stakeholders, as leading examples of assumption of responsibility, vision and readiness to act, and

C) The political declaration.

The concept:

Disaster risk reduction (DRR) is a broad and relatively new concept. There are different definitions of the term in the technical literature but it is generally understood to mean the broad development and application of policies, strategies and practices to minimize vulnerabilities and disaster risks throughout society. As per UNISDR disaster risk reduction is defined as:

> "The concept and practice of reducing disaster risks through systematic efforts to analyze and manage the causal factors of disasters, including through reduced exposure to hazards, lessened vulnerability of people and property, wise management of land and the environment, and improved preparedness for adverse events" (UNISDR, 2009, p.12).

As argued by Twigg (2007), DRR is a systematic approach to identifying, assessing and reducing the risks of disaster. It aims to reduce socio-economic vulnerabilities to disaster as well as dealing with the environmental and other hazards that trigger them. It is the responsibility of development and relief agencies alike and it should be an integral part of the way such organizations do their work, not an add-on or one-off action. DRR is very wide-ranging, therefore, there is potential for DRR initiatives in just about every sector of development and humanitarian work (Twigg, 2007).

Disaster risk reduction (DRR) can be accelerated through using the potentials of the community people where they join hands together. So community based DRR approach could be useful to reduce disaster risk and enhance resilience of the livelihood. Establishing social organizations such as community based organizations (CBOs) are important tool to conduct DRR measures at local level which enhance the resilience of the community people (Pelling, 2003). Several countries have already adopted community based DRR approaches that have increased the capability of the community to deal with disaster event (UNISDR, 2007).

2.4 Disaster Resilient Housing

Like food and clothing, shelter is one of the basic needs of human survival. Everyone has the right to adequate housing for health and well-being. Housing has close relationship to a person's life, livelihood, health and overall well-being and therefore directly includes the social themes of vulnerability, social protection and livelihoods. Adequate housing is not just limited to physical structure. Adequate housing means adequate privacy; adequate space; physical accessibility; adequate security; security of tenure; structural stability and durability; adequate lighting, heating and ventilation; adequate basic infrastructure, such as water-supply, sanitation and waste-management facilities; suitable environmental quality and health-related factors; and adequate and accessible location with regard to work and basic facilities: all of which should be available at an affordable cost. Adequacy should be determined together with the people concerned, bearing in mind the prospect for gradual development (Newaz, 2004).

Having a home safe from natural hazards is something that is very important in the disaster prone areas. However communities living in these areas do not have this luxury. The communities are faced with multiple cases of disasters every year. Because these communities are usually marginalized and fall under the poverty line, affording disaster resilient housing becomes a great issue to them and thus they are tremendously vulnerable to any hazard. Even without disasters, these communities have to be prepared in terms of structures. And with disasters it is of utmost importance. Over a million houses are severely damaged by disasters every year, half of them totally destroyed. The loss of shelter and household assets makes the poor even more vulnerable to future disasters. They cannot build back better by themselves due to their financial inadequacy. Although policy and governance play a huge role in tackling these issues, giving people resilient homes against earthquakes, seasonal floods, cyclones and landslides, engaging the community people in building disaster resilient housing could also be a good initiative towards a disaster resilient community and reduce disaster risks.

Disaster resilient housing concept refers to those structures that is expected to not collapse or be destroyed, but may still suffer some damage which however, can be repaired. Disaster resilient housing means to build structures and a community considering the disaster resiliency strategies and integrating the disaster risk reduction measures so that the houses can withstand the impact of any natural hazard i.e. cyclone, flood, earthquake, landslide etc. A disaster resilient housing does not only depend on the structure, material, design and construction of the houses but also depends on the socio-economic conditions, administrative and local governance of the community.

2.5 Impacts of Disasters on Housing

From the recent disaster occurrences we can assume that the effects of climate change are inevitable and will only get worse in the near future giving rise to even frequent natural hazards, the government's lack of sufficient disaster-preparation efforts will result to more calamity-related deaths and people will continue to struggle in the vicious cycle of poverty, rebuilding their lives only for them to be destroyed again by the next calamity. Often housing is the sector severely impacted by disasters. Damage to housing sector includes both private and government and in most cases governments have to provide assistance for the damages associated with private sector housing damages.

Disaster event disrupts day to day life and leaves the families without shelter and results in lack of access to basic services such as water and sanitation. In addition, micro, small and medium-sized businesses located in those homes are similarly affected indirectly and the family could also be bereaved of the chance to be eligible for loans since one of the key assets or collateral is demolished, making it difficult for them to recover from the loss. Lessons from past events have shown vulnerable groups face various protection related problems aftermath of disaster events. With limited resources and options, recovery processes of individual households are contingent upon their coping capacity and the external support. Further, the community as a whole also suffers as the local economy is hard hit and the responsibility to support those made homeless by the natural disasters can place extra burden on the dwindling economy (ADPC, 2011). Disasters have adverse impact on housing as the financial inadequacy of the marginalized community people make them incapable of building back better by themselves.

2.6 Vulnerabilities of Housing to Disasters

Hazards in nature do not constitute disaster risk, however, the underlying vulnerabilities to hazards and external drivers construct disaster risk and resulting losses.

Factors contributing to the vulnerabilities of housing as stated in ADPC (2011):

- Poor land use planning/with poor understanding on hazards/without risk based planning
- Lack of knowledge and incorporation of appropriate disaster resistant features during planning and construction process
- Lack of regulatory mechanism to enforce land use/building regulations
- Limited or no mechanism for accountability in case of violation of regulations
- Lack of skilled human resources in planning and execution
- Poor quality and sub-standard building materials
- Poor maintenance of structures
- Poor governance-corruption

The variety of factors, which contributes to the vulnerability of the housing stock ranges from having systems in place for proper settlement planning, appropriate technical guidance in forms of building codes, suitable enforcement mechanisms, capacity for implementation, and skilled labor as well as enabling factors such as good governance.

“Inappropriate housing solutions together with poorly constructed houses have been known as one of the main sources of risks to climate hazards” (Tran et al., 2012). If the houses are not well built using appropriate structures, materials, proper design and construction methods catering to the need to reduce disaster risk then, the houses will be highly vulnerable to adverse impacts of natural hazards.

“Socio-economic situation of households translates to differing levels of housing vulnerability” (Tran et al., 2012). For example high income households can afford to buy expensive land in the urban areas with adequate basic services and infrastructures, also their houses are constructed with skilled professionals, therefore they are situated in safe and less vulnerable places. However, low income households are the most vulnerable because they cannot afford such provisions and tend to locate themselves in the disaster prone areas without any construction assistance.

Lack of knowledge and awareness of the local people regarding climate risk and disaster risk reduction is another underlying cause of vulnerability (Tran and Tran, 2013). Due to this ignorance they are not integrating or mainstreaming disaster risk reduction in their housing practices or giving due importance to it.

2.7 Importance of Mainstreaming DRR in Housing Practices

As stated by Bosher and Dainty in 2011:

> “Arguably a diverse range of hazards are likely to become more significant in future years and so it has become incumbent upon those responsible for planning, designing and constructing the built environment to take account of these threats as a core part of their professional activity” (Bosher and Dainty, 2011, p.7).

Housing located near to the disaster prone areas are under great threat of multiple hazards. Often these communities are the poorest and the most socially marginalized and they are likely to suffer great damage from disasters associated with natural hazards (Morrow, 1999). They are more susceptible to disasters because of their housing vulnerability. Therefore, it is necessary to retrofit the existing housing for reducing the threats of impending disasters and incorporate disaster risk reduction in the planning and construction of new housing practices. Argued by Benson et al. in their paper;

> "Mainstreaming DRR into development means to consider and address risks emanating from natural hazards in medium-term strategic frameworks, institutional structures, country and sectoral strategies, and policies in the design of individual projects in hazard-prone countries" (Benson., 2007, p.7).

It requires analysis of how potential hazard events could affect those policies and projects, which should lead to the adoption of related measures to reduce vulnerability, treating risk reduction as an integral part of the development process. "The lack of consideration of DRR into development process leads to bearing extra costs in reconstruction which perpetuates the conditions for unsustainable development and shifts the scarce resources originally programmed for development into relief and response" (Bakhtiari, 2014).

With this understanding, Mainstreaming DRR in housing would mean that all housing related interventions have considered the effect of natural hazards (current as well as future risks magnified by climate change) and of the impact of those interventions in turn, on vulnerability to natural hazards, and accordingly have adopted risk reduction measures. This would require understanding the typical vulnerabilities to hazards, analyze how these vulnerabilities interact with the existing processes of development of the sector and understanding of the actors involved in each of the processes. At a strategic level mainstreaming entails addressing or incorporating DRR measures in policies, regulations while at operational level, undertaking specific measures such as evaluation of hazards, vulnerability and risks and addressing it through appropriate mitigation measures. In case of housing it would be important to design the structure to a minimum service level of operational or of higher order to life safety performance level (ADPC, 2011).

On the aftermath of a disaster, it is of utmost importance at the policy level for mainstreaming DRR in the reconstruction strategies to enable safe built environment and build back better. Housing reconstruction is a unique challenge and provides a window of opportunity to reduce underlying risk factors and build back better. Mainstreaming can be undertaken by enhancing safety standards, review of regulatory and planning framework such as land-use and by incorporating DRR.

Objectives of Disaster Risk Reduction Initiatives in Housing Construction:

- Ensure adherence to guidelines on hazard resilient construction in hazard prone areas.

- For successful implementation of housing, usage of land use zoning plans which takes into consideration information on risk from natural hazards.
- Introducing amendments and revisions for land sub-division process considering the natural surface drainage path, contour plans and its approval procedure.
- Utilization of national building codes that have special provisions for enhanced design standards for buildings in areas affected by natural disasters.
- Compliance and enforcement of local building laws requiring prescribed standards under natural building codes in urban hazard-prone areas.

2.8 Challenges of Mainstreaming DRR in Resilient Housing Practices

For resilient housing in disaster prone areas it is very important that housing practices integrate disaster risk reduction measures to reduce threats of impending disasters. However, there are many challenges that need to be addressed for mainstreaming disaster risk reduction into housing practices, some of which are described below.

2.8.1 Socio-Economic Situation of the Households

Often the communities located in hazard prone areas are the poorest and most marginalized. The concept of resilience is beyond their understanding and capacity as survival is the biggest challenge to them. Economic difficulties generated by the unstable livelihood, unemployment and low paid jobs are one of the biggest obstacles to achieving resilience. It undermines the effort of housing risk reduction (Tran and Tran, 2013). Due to very limited financial capacity, houses of low income households are the most vulnerable. The owners tend to buy the cheapest plots in hazard prone areas. In addition, their houses are very vulnerable without strong connections or bracings and often built based upon experiences of local masons without technical designs and construction supervision. Economic difficulties make them put DRR as the secondary priority behind basic needs of living such as food, healthcare, or school fees for children.

2.8.2 Lack of Climate-Risk Knowledge

Limited awareness of local people on climate change and the importance of climate risk reduction for a long-term development is another big challenge addressed (Thang et al., 2013). This has made them underestimate the actual danger of climate hazards and prefer immediate or short-term responses. These people often think of disaster preparedness and risk reduction when they receive announcements of a coming hazard on mass media, and then rush to using quick and

simple measures to respond (e.g. putting sandbags on roofs, moving valuable items to safe places in house, and evacuation). They can hardly think of a permanent solution to their housing problems which would provide them with safety from the multiple hazards.

2.8.3 Skills and Communication of the Local Builders

The safety techniques of local builders seem inadequate, and are likely to re-produce risks to future hazard in new construction (Thang et al., 2013). These builders lack proper knowledge on safe construction methods and are poorly equipped with construction techniques, equipment and materials. Another challenge for these builders and the local people is the lack of awareness and understanding on how to properly create safe buildings with new materials (e.g. cement, brick, or steel) and new construction methods (Chantry and Norton, 2008). Therefore, in an era of climate change with the estimated increasing occurrence of climate events improper construction of houses and inappropriate material use will not help local communities avoid disaster damage and losses. Lack of communication and consultation with in-field experts and professionals (i.e. local architects and engineers) about building resilient shelters also become an issue. Currently, poor and low-income groups pursue construction on their own and lack technical guidelines or instruction for disaster resilient construction (Tran and Tran, 2013).

2.8.4 Applying Planning and Construction Regulations

Application of building codes and construction regulations related to DRR is another challenge. Usually building permits are not required for most local practices of housing construction in hazard prone or rural areas. Local people decide on their housing forms and construction freely based on their needs and financial capacity (Thang et al., 2013). As for poor and low-income groups, as there are neither technical supports nor regulatory requirements for safe construction given to them, many unsafe conditions can be found in their houses. DRR is faced with challenges from a lack of building codes, zoning, and planning criteria for climate risk reduction in hazard prone areas (Tran and Tran, 2013).

2.8.5 Lack of Local Governance

Lack of local governance is also a challenge for an environment of safe construction. This limited or no governance strongly influences housing vulnerability and may undermine efforts of building a resilient housing system to climate change. Limited governance and management is a complementary catalyst to the increase of climate risks in human society (Tran and Tran, 2013). Usually governance mechanisms for civil construction (i.e. residential houses) tend to focus on central urban districts. However, more consideration should be given to peri-urban and rural

areas, the places that are more vulnerable to climate risks and natural hazards. There is no system in place that will overlook the housing system and construction methods, at the same time, the local people and the builders are not accountable to any administrative system for their housing construction. This makes the integration of DRR a challenge as the whole management process is absent.

CHAPTER 03: DISASTER AND HOUSING IN BANGLADESH

3.1 Major Hazards and Disasters in Bangladesh

Bangladesh is a disaster risk hotspot, ranked with the highest disaster risks. This reflects the very profound, multi-layered challenges that the country face. Bangladesh is prone to floods and cyclones, and the risk of other disasters such as drought, earthquakes, landslides and tornados is increasing. The impacts are becoming more visible at the local level, with greater impacts on poor and vulnerable communities. Population density and poverty run hand in hand to increase vulnerability. Poor people in a crowded country like Bangladesh have limited options: they live in areas prone to cyclones, flooding or landslides, with their homes, life and livelihood against the forces of nature. Some of the frequent natural hazards are discussed in this chapter.

3.1.1 Cyclone

The Bay of Bengal is called a breeding ground for tropical cyclones and in terms of fatalities and economic losses; Bangladesh is one of the worst victims. The funnel shaped coast line and particularly the low topography make the coastal area subject to high surge associated with cyclones. The global distribution of cyclones shows that only 1 % of all cyclones that form every year strike Bangladesh; but unfortunately the fatalities they cause account for 53 % of the global total (Ali, 1999). Records show that 16 out of 35 of the tropical cyclones worldwide that caused deaths of more than 5,000, occurred in Bangladesh (SMRC, 1998). According to the Multipurpose Cyclone Shelter Programme report, 6.4 % of the country is considered High Risk Area where the surge height may exceed 1 m.

A number of cyclones have devastated Bangladesh causing hundreds of thousands of human deaths. Apart from the human casualties, cyclones have caused substantial damage to properties, which include physical infrastructure, livelihoods means and various direct tangible/intangible and indirect tangible/intangible items. It is very difficult to frame the continuum of loss and damage caused by these disaster events; it transcends the spatial and temporal boundaries. Since the livelihood activities of the poor people are localized, the population exposed to the risk of cyclones cannot afford shifting their settlements to a safer location. Thus, after every cyclone the people, as if, “rise from the ashes” to get ready to face another. They only become more vulnerable to the upcoming disaster (Mallick and Rahman, 2013).

3.1.2 Flood

In Bangladesh, flood is a recurring problem because of its flat and riverine feature. Almost every year some parts of India and Bangladesh experience flood with considerable damage. The floods of 1954, 1955, 1974, 1987, 1988 all caused enormous damage to properties and considerable loss of life. Bangladesh experienced the most devastating and prolonged flood in its history during the middle of 1998, which caused enormous damage to the economy of the country (Alam and Ali, 2000). The extent of damage caused by the flood is estimated to be around 3.0 billion US dollars (Annual Flood Report, 1998).

Bangladesh is well known as one of the most flood prone areas of the world because of its unique geographical setting and physiographic features together with a massive and unique hydraulic system. Bangladesh is a deltaic country located at the lower part of the basins of the three mighty rivers—the Ganges, the Brahmaputra and the Meghna. Heavy rainfall in the upstream of these rivers flowing through the country is the prime reason of flood in Bangladesh. More than 60 % of the country is inundated in large flood events. Heavy rainfall over the catchments of these rivers could produce an average runoff of about 1,009,000 million cubic meters. If the whole water were stored, the country would have been flooded to a depth of 8 to 10 meters.

Flood disasters have become larger and more frequent in recent times due to the ever increasing population, ill-planned infrastructural development and massive flood control interventions in a floodplain environment. Socio-economic impact of floods is profound; the flood prone zones represent areas with the highest incidence of the extreme poor, and the number of poor living in high flood risk areas is on the rise. Major proportion of the economic loss resulting from floods is constituted by the damage to infrastructures (Rahman and Salehin, 2013).

3.1.3 Landslide

Bangladesh is a disaster prone country. The physiography, morphology and other natural condition have made her vulnerable to various disaster and environmental hazards. Besides Flood, cyclone induced storm surges, droughts, earthquakes and river bank erosion, landslide has become newly a burning issue. Landslide and avalanches, while historically not renowned for causing as large a death toll as other natural disasters such as tropical cyclone or earthquakes, have had just as dramatic an impact on property and lives (Bryant, 1991). Landslide is an inveterate problem for south eastern part of Bangladesh and Chittagong city is particularly highly vulnerable to this hazard with an increasing trend of frequency and demand. During the last five decades, Chittagong suffered about 12 times landslides (BWDB, 2005). The landslide of 11 June,

2007 in Chittagong is the most devastation case of landfall in the history of landslide in Bangladesh (Haque, 2008). The physiographic characteristics of Bangladesh make the country more susceptible to landslide. Physiographically, most of the area of Bangladesh is floodplain and only 18 % is hilly and tract area (Islam and Uddin, 2002).

Landslide is a natural phenomenon and accelerated by human interventions. Landslides occur as a result of changes on a slope, sudden or gradual, either in its composition, structure or in its hydrology, vegetation. The change can be due to geology, climate, weathering, land use and earthquakes (Sahni et al., 2001). Two major factors that aggravated the landslide vulnerability in the hilly areas of Bangladesh are the unsustainable lands use and alteration in the hills including indiscriminate deforestation and hill cutting. Landslide not only contributes to death tolls besides other natural disasters but also causes enormous property and economic loss.

3.1.4 Earthquake

Bangladesh is located in the north eastern part of the Indian subcontinent at the head of the Bay of Bengal. The Geographical location of Bangladesh makes it susceptible to earthquakes. The country's position adjacent to the very active Himalayan front and on-going deformation in nearby parts of south-east Asia expose it to strong shaking from a variety of earthquake sources that can produce tremors of magnitude 8 or greater. It is also the site of the Dauki Fault system along with numerous subsurface active faults. As indicated by the tectonic framework of Bangladesh and adjoining areas, Bangladesh is situated adjacent to the plate margins of India and Eurasia where devastating earthquakes have occurred in the past. A number of tectonic blocks surrounding Bangladesh have also produced earthquakes in recent times. Any future earthquake in Bangladesh shall affect more people per unit area, since it is the most densely populated country, than any other seismically active regions of the world (Sultana et al., 2013). Bangladesh has experienced damages of five earthquakes having magnitude over 7.0 (Richter Scale), in the last 150 years that caused extensive damages to masonry buildings in many parts of Bangladesh including Dhaka. There are three major active faults studied so far having potential to generate 7.0–8.5 magnitude earthquakes (Kamal, 2013).

As Bangladesh is located in technically active faults, much of the country including Chittagong, Sylhet, Dhaka, Rangpur, Bogra, Mymenshing, Comilla, Rajshahi are very much vulnerable to major earthquake disaster. Considering geology and tectonics of Bangladesh and the neighbourhood, five tectonic blocks have been identified to be active in producing damaging

earthquakes. These are Bogra fault zone, Tripura fault zone, Sub Dauki fault zone, Shillong fault zone and Assam fault zone.

Severe damaging earthquakes have occurred in the history of Bangladesh and moderate damaging earthquakes occur every few years. These earthquakes have the possibility of sinking many of the buildings on filled earth with shallow foundations due to the liquefaction effect. It may also cause large scale damage and some collapse of poorly constructed and old buildings. Possible outbreak of fire may also occur in most of the buildings from the gas lines (the residential ovens are mostly in burning condition from morning to mid-night). Earthquake cannot be prevented. But in order to minimize the loss of lives and property in national interest, certainly it is high time to be much more concerned about the probable impending earthquake in Bangladesh (Sultana et al., 2013).

3.2 Types of Rural Housing

3.2.1 *Kutcha* House

Foundation: Earthen plinth with bamboo (sometimes timber) posts.

Walls: Organic materials – jute stick, catkin grass, straw, bamboo mats, etc. Split bamboo framing. Earthen walls in some areas.

Roof: Thatch - rice or wheat or maize straw, catkin grass, etc. with split bamboo or sometimes reed stalk framing.

Fig 3. 2: *Kutcha* house

3.2.2 Semi-*Pucca* House

Foundation: Earthen plinth; Brick perimeter wall with earth infill; Brick and concrete.

Walls: Bamboo mats; CI sheet; Timber (sometimes split bamboo) framing. Earthen walls in some areas. Sometimes part or full brick.

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

Fig 3. 3: Semi-*Pucca* house

3.2.3 *Pucca* House

Foundation: Brick and concrete.

Walls: Brick.

Roof: Reinforced concrete (RC).

Fig 3. 4: *Pucca* house

3.3 Problems of Rural Housing

The rural houses are mostly built with the locally available materials like mud, bamboo, tiles and thatches that are not durable and easily get damaged due to heavy rain and wind blows. Due to the heavy wind velocity and the uplift forces developed by cyclone the pyramidal shaped roofs and the projected eaves of the roof are also damaged. The light roof structures having inadequate "J" bolts, absence of wind bracing and lack of ties, inadequate sheet thickness, fastening and insufficient frequency of the fasteners contribute to the damages, even the permanent houses constructed with RCC and brick walls are also affected due to the excessive corrosion of steel in the structures. The roof slab having inadequate thickness of roof concrete and low self-weight which causes tension at the top due to the suction effect of the wind where hair line cracks develop, these RC concrete exposed to the atmosphere gets rusted and ultimately causes the roof to collapse. Heavy damages occur to the unsymmetrical houses compared to symmetrical plan about its both axis. Factors to decide the level of damage during disasters are the effects of wind tunnel on the streets and housing plan arrangements. The unreinforced masonry walls also fail due to excessive tension. Sometimes the timber rafter are destroyed by the white ants and losses its section and leads to collapse at the time of disasters. The unscientific installation of roof tiles, doors and window latches, hinges and bolts, are vulnerable hardware and fasteners during the disaster. The cantilever parapets and the light weight verandah roof, improper connections of walls with footings are the most susceptible to high speed wind. The siting of building on the terrain conditions like hills, valley, ridges in the windward side, leeward side are the factors influencing the damage level of structure (Mahendran and Hussain, 2010).

3.4 Risks and Vulnerabilities of Housing in Bangladesh

Any given risk or disaster event is distinguished by its geographic location and setting. These are important keys to the origins of danger, the forms of damage and whom they most affect. They are critical for the appropriateness and deployment of organized response (Hewitt, 1997).

3.4.1 Cyclone Prone Communities

For generations, cyclones and tidal surges have frequently devastated lives and property in coastal areas of Bangladesh. Rural communities that are located on lowlands or in unprotected and unsheltered, low-lying coastal areas or river floodplains are mostly considered to be vulnerable to cyclones. The vulnerability of a human settlement to a cyclone is determined by its siting, the probability that a cyclone will occur, and the degree to which its structures can be

damaged by it. Generally, the poor and the marginalized, who cannot afford to obtain a land in a safe area, to build a house with proper guidance and building materials and to have an alternate source of livelihood are forced to settle down in these vulnerable areas that pose serious threat to cyclones. Houses are considered vulnerable if they cannot withstand the forces of high winds. Generally, lightweight structures with wood frames, especially older buildings where wood has deteriorated and weakened the walls, houses built with temporary materials, poor joints and bracings, without any design guidance and construction assistance are those most vulnerable to cyclones. Houses made of unreinforced or poorly-constructed concrete block are also vulnerable unless they are anchored properly to the ground. The degree of exposure of land and buildings will affect the velocity of the cyclone wind at ground level, with open country, seashore areas and rolling plains being the most vulnerable. Certain settlement patterns may create a "funnel effect" that increases the wind speed between houses, leading to even greater damage (Agarwal, 2007).

a. **b.**

Fig 3. 5 (a &b): Cyclone affected community

3.4.2 Flood Prone Communities

Human being exists in this world in an adopted ecological relationship with the surrounding environment and has to live with a variety of natural hazards which threaten life and property. Flood is the most common type of hazards and the cause of most natural disasters affecting society. Flood is the perennial problem for Bangladesh. Every year flood causes enormous damage to the people and property of the country. Particularly in the rural areas of Bangladesh, the housing for the majority of the population is very weak and incapable of withstanding the extreme loads generated during these natural calamities (Al-Hussaini et al., 1999). As the

population in the rural areas is increasing, people are moving towards the floodplains for settlement that makes them more exposed to damage due to recurrent flooding. To fulfil the requirement of accommodation, agricultural and marshy lands are used for housing; more houses are built neglecting water drainage system and proper sanitation. This makes the settlement more and more vulnerable.

The impact of floods to housing is due to several reasons:

a) Flood depth,

b) Flood duration,

c) Uplift due to soil saturation and

d) Horizontal force created by flood waves or currents.

Direct flood hazard is associated with other types of secondary hazards such as high winds or storms, lightning, slope instability, ground settlement, etc. Floodwater can submerge buildings and cause various degrees of damage from staining of walls to structural collapse depending on flood depth and/ or duration and type of building (ADPC, 2005).

a. **b.**

Fig 3. 6 (a & b): Flood affected community

3.4.3 Landslide Prone Communities

Landslide is one of the neglected disasters in Bangladesh, as these take place in isolated and dispersed locations and do not create big headlines as earthquake, flood or cyclone does. The cumulative effects of landslides, however, in terms of lives, properties and infrastructure have been quiet substantial. There have been instances when many settlements in hilly slopes have

gone into complete oblivion and many rural and urban settlements have been very severely affected due to landslides.

Common attribution of vulnerability of mountain people in Bangladesh are poverty, landlessness, inaccessibility to natural resource base, illiteracy, isolation, backwardness and fragility stemming from rugged terrain and harsh climates; in turn, risks are linked with greater proneness to geophysical extremes, unfriendly agricultural practice, increasing population and scarce resources (Sarkar and Rashid, 2013). Due to population increase the rural poor are unable to afford proper housing and live in informal settlements. These informal settlements are built on vacant government land or private vacant land located in low-lying areas, river banks, foothills and valleys vulnerable to natural disasters. Specially, from 1990 rural people started to migrate from different parts of the country to the hilly region as abundant land and natural resources are available there and migrated people face less struggles for livelihood and living space. As these people from flat plain do not have any understanding about living in the hills and hill ecosystem, they unknowingly welcome threats of landslide by unsustainable land use, vegetation, disrupting natural drainage of a hill etc. In areas prone to seismic hazards, the large number of building of variable quality, many of which poorly constructed or badly maintained, will pose high risk to lives. The vulnerability of people living or working in such structures is bound to be high. A growing population can likewise put pressure on natural resources such as agricultural lands and forests. With the limited land for food production, it may result in the opening or encroachment of forestlands, not only for food production but for settlements as well. Deforestation can result to increase in landslide hazard intensity or frequency in the long run (Sarkar and Rashid, 2013).

a. **b.**

Fig 3. 7 (a & b): Landslide affected community

CHAPTER 04: APPROACHES TO MAINSTREAM DRR FOR RESILIENT HOUSING PRACTICE IN BANGLADESH

4.1 Land Use Planning

The urban population of Bangladesh is growing twice as fast at the total population. This is due to both natural population growth in towns and cities, and high rates of rural-to-urban migration. By 2025, it is estimated that 50 per cent of the total population will be living in urban areas. Within this content, towns and cities in Bangladesh need to improve their capacity to plan and manage current growth in order to ensure adequate living standards for urban residents as well as to facilitate longer-term growth. However, many urban areas in Bangladesh do not have land use plans in place, leading to activities being uncontrolled, unplanned and uncoordinated. As a result, urban development in these areas is largely unsustainable and characterized by inadequate provision of municipal services, expanding informal settlements, fragmentation of peri-urban areas, inefficient land use and poorly functioning land markets (ADPC, 2013)

Land use planning is prepared to identify, adopt the best land use options for housing and also to identify alternatives. While good land use and planning can either eliminate disaster risk or minimize disaster risk by adapting appropriate mitigation measures it also reduces overall land vulnerability to disaster risks. Risk based land use planning can be an effective tool for managing disaster risks and protect development gains. Knowledge of the relationships of development, land use and disaster risks provide planners a deeper understanding of what drives people to locate themselves in high risk areas. The location of residential areas, industries, critical public facilities and services are important parameters that define the vulnerability of communities to hazards. In this context, land use planning is instrumental in addressing the challenges posed by natural hazards on built environment. Through land use planning, vulnerability parameters can be modified to reduce risks. With its array of regulatory and non-regulatory techniques and mechanisms, land use planning can become an effective tool for disaster risk reduction (ADPC, 2011).

To generate disaster risk information relevant to land use planning, disaster risk assessment or DRA is undertaken. DRA can be done using formal analytical quantitative methods or through qualitative risk perception. Whatever approach is used, a disaster risk assessment process involves four steps; (1) hazard characterization; (2) consequence analysis; (3) risk estimation; and (4) risk evaluation.

As stated in ADPC (2011), through the use of disaster risk information in land use planning, planning units would be able to:

- Identify areas
  - Those are of high risk from impacts of hazards such as flood prone that need lessening of effects of hazardous events such as water retention.
  - Where it is necessary to ensure effectiveness of response activities such as escape routes
- This identification would help in restricting location of human settlements and housing suitable economic activities. For example, flood areas might be allowed for agricultural use but not for human settlements.
- Understand the area of land actually available for development (considering development is not allowed in areas prone to natural hazards) and thus find options of how to meet the demand over time and accordingly set developmental goals and objectives.
- Provide guidance in formulating suitable risk reduction policies and zoning regulations such as building codes.
- Provide guidance in adopting suitable risk reduction measures in the development projects in the area.

Mainstreaming DRR into land use planning aims:

- To make spatial development decisions based on a broad range of information, including disaster risk information;
- To reduce the exposure of communities and assets;
- To ensure that assets and communities are located in appropriate areas, from a disaster risk perspective;
- To reduce the vulnerability of communities and assets; and
- To avoid the creation of new hazards or risks through inappropriate spatial development.

A systematic approach is required to achieve the above objectives. The overall method is to systematically incorporate relevant disaster risk information (risk identification, risk assessment, risk evaluation) as well as disaster risk treatment measures into relevant stages of the Land Use Planning (LUP) process. This is the ‘mainstreaming approach’.

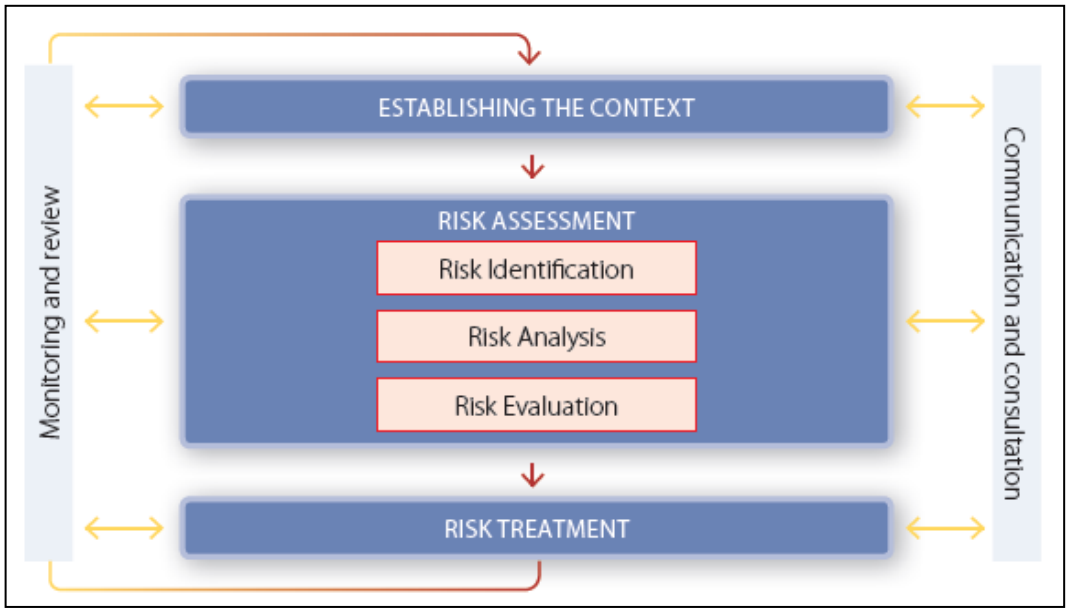

Fig 4. 8: The risk management process (ISO31000)
Source: ISO (2009)

Table 4.3: Summary of activities for mainstreaming DRR into land use planning

No.	LUP Preparation Step	Main DRR Activity	Enhanced Outcome
1.	Preparation	• The role of DRR in the planning proposal is defined • Shared vision of resilient spatial development is agreed	• Planning proposal becomes risk sensitive
2.	Data and Information Gathering	Hazard and vulnerability data and information is collected	• A more comprehensive range of data and information is collected
3.	Data and Information Analysis	• Risk assessment is undertaken • Specific disaster risks are prioritized	• A more comprehensive range of data and information is analysed • Disaster risk in the planning area is known
4.	Plan Formation	• Disaster risk is treated using different measures(zoning, regulation, policy)	• Future spatial development as described in the plan becomes risk-sensitive and

		• Indicators for monitoring disaster risk are established	resilient
5.	Plan Adoption and Gazetting	Advocacy for risk-sensitive LUP	• Risk-sensitive LUP becomes legally binding

Source: ISO (2009)

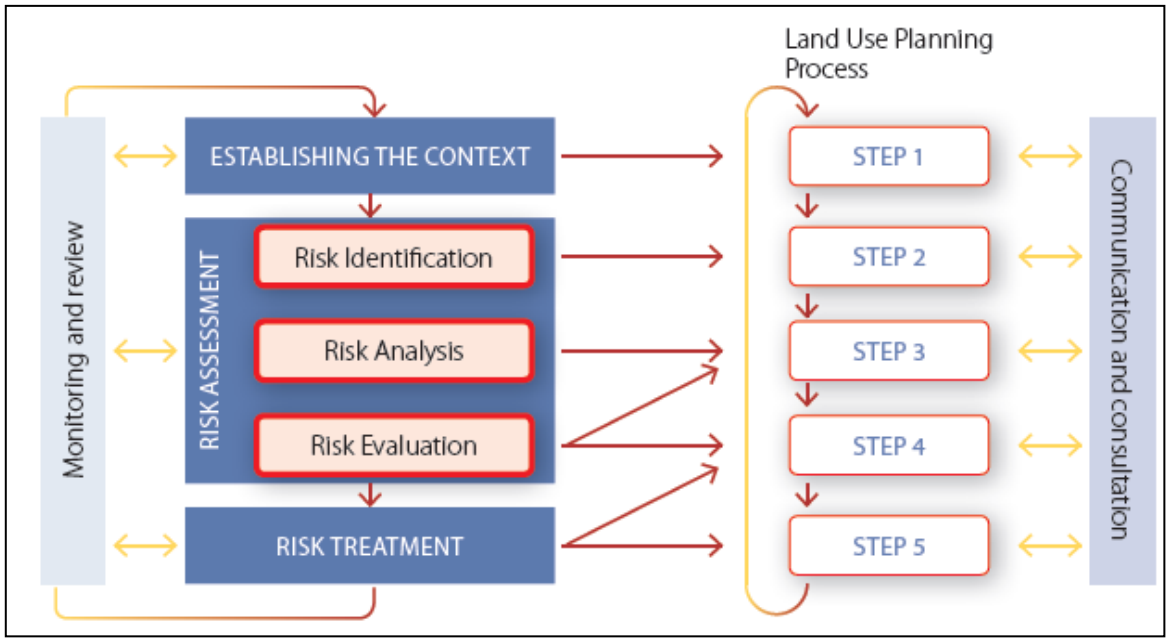

Fig 4. 9: Model for mainstreaming DRR into land use planning
Source: ISO (2009)

4.2 Housing Finance

As stated by Hafiz (2000), extensive damages to housing are mainly caused by natural disasters in Bangladesh, mainly attributed to building materials for construction. Houses are made of materials such as bamboo, thatch or mud which are extremely vulnerable. Anything durable than these materials are beyond the affordability of most rural residents. Improved quality and better condition of housing can cut down damages caused to housing and this improved quality can be achieved by better design and use of permanent materials such as bricks, cements, RCC etc. However, this improvement involves increasing cost which becomes difficult to afford (Hafiz, 2000)

Also, argued by Tran, et al. (2012), socio-economic situation of households lead to differing levels of housing vulnerability. Low income people buy the cheapest lands in the most vulnerable

places away from city centres, in the suburban, peripheral zones or disaster prone areas. Their houses are built with temporary materials that are extremely vulnerable and built upon experiences of local masons without technical designs and construction supervisions. Aftermath any disaster, these rural people would become more vulnerable due to very limited socio-economic ability for recovery. (Tran et al., 2012).

Therefore an approach to mainstream DRR in the housing practice could be to finance housing and increase affordability of the rural people in Bangladesh through the following ways:

4.2.1 Affordable Improvement of Housing

Improved housing design and use of more durable materials is assumed to significantly lower the extent of damages caused to housing. However it is financially difficult for the rural people to improvise it at one go. It was shown that about a loan of 600 Taka is what a poor family need in the first stage of graduation to improved housing. The financial institutions can lend their support by giving loans to these poor families for a hazard safe housing (Hafiz, 2000).

4.2.2 Lowering the Cost of Building Materials

Construction techniques with permanent materials like brick, concrete etc. are unknown to the rural people. The price of these permanent materials and the cost of construction are expensive and beyond the affordability of most rural people. In this regard, prefabricated building materials can partly provide solution to building improved and hazard safe houses. Prefabricated building material industry can provide job opportunities to the rural people as well as produce affordable home building materials. These materials can be bought in instalments expanding affordability of the people further (Hafiz, 2000).

4.2.3 Making Finance Available to the People

Rural people need small amount of money at varying times, however, there are no public sectors institutions in these rural areas that might help them finance and improve housing. On the other hand, the economic condition of the general rural people is not satisfactory to lend money to other people. The role of Grameen Bank and a few NGOs are commendable but their coverage is small compared to the number of people that need financing and material assistance. Therefore there is an urgent need to set up institutions for providing these rural people with home-building and home-improvement loans (Hafiz, 2000).

4.2.4 Creating Financing Institutions for the Rural Masses

According to Hafiz (2000), About 96 millions of people live in the rural areas of Bangladesh of which only 25% is covered by Grameen Bank and other NGOs, which is a plain evident that majority of the people are left out. Most of the formal financing institutions are located in the urban centers and hardly extend loan to rural people. House Building Finance Corporation is the only public center finance institution in Bangladesh and its service is limited to urban residents only, therefore there is an urgent need to create a Rural House Building Finance Corporation to provide loans to the rural residents.

The government cannot provide loans to all the people that require finance for building hazard safe homes at once. Therefore the hazard prone areas should be identified and categorized according to the intensity of hazard experienced by the areas, such as:

- Extremely hazard prone areas
- Moderately hazard prone areas
- Low hazard prone areas

The lending program can initially start with areas that are extremely hazard prone and subsequently move to other less hazard prone areas or two divisions can be formed, one for the extremely hazard prone areas and one for the less hazard prone areas. These institutions can also act like banks where people can deposit money and account holders get preference for loans (Hafiz, 2000).

4.2.5 Hazard Safe Housing through Government Initiatives

The government is constructing cyclone shelters with its own fund and with the help of foreign aid. Although these shelters provide temporary accommodation, they are very helpful when disasters strike giving accommodation to about 40-50 families. However, generally it is seen that people don't want to leave their houses during cyclone or flood until the situation becomes too critical for safety because they want to protect whatever belongings they have. If they abandon their belongings to move to the shelter, they are lost.

As stated by Hafiz (2000), shelters accommodating about 200-250 people, require about 4-5 million Taka. Therefore about 0.1 million Taka is spent for every family consisting of five members. Instead of constructing cyclone shelters, if the government spends this amount for each family to construct a cyclone and flood safe house, these people can stay within their houses with their belongings and livestock safe when disaster strike. The government can build a permanent,

hazard safe stilt house for every family that is equipped with basic amenities, very safe and comfortable for living. The rooftop of these houses can be designed to harvest rainwater during crisis (Hafiz, 2000).

State and local governments and related entities need access to sufficient financial resources in order to incorporate smarter and safer residential building and renovation methods, develop and enforce new building and zoning codes, implement enhanced land use planning strategies, and develop more cost-effective support programs for low- and moderate-income households. Maintaining and expanding financial resources for pre-disaster mitigation measures will not only save more lives, but also reduce the costs of disaster recovery.

4.3 Local Builders/Masons

Non availability of skilled work force leads to poor design and construction of houses and infrastructure. Lessons from past disaster events, points to factors such as faulty design, weak construction material and poor maintenance, non-compliance to safety regulations. From a DRR perspective, technological advances are made to improve the disaster resistant features and subsequent enactments through building codes, however adaption of the improvements in practice are limited. In a post disaster reconstruction setting non-availability of skilled work force is a major impediment in providing safe houses (ADPC, 2011).

The local masons or builders of the rural areas lack knowledge on building materials and construction methods. They construct the houses based on their limited skill and without any consultation or supervision with the in-field professionals such as architects and engineers. Professional expertise and skills are crucial to effectively assist at-risk communities (Tran and Tran, 2013). Therefore expert professionals should train and assist the local masons and builders, enlighten them regarding building materials, construction methods and integration of DRR in the process. Recognizing the needs to improve the skills, measures should be taken at various levels in improving the skill sets of local builders and masons, and training should be provided on climate risks and DRR for a hazard safe and resilient housing. Formal sector holds prospects for improving the skills to ensure the quality and incorporation of disaster resistant design through relevant trainings and capacity building (ADPC, 2011).

4.4 Resilient Building Materials

Locally available indigenous materials such as bamboo, straw, grass, jute stuck, golpata, mud and CI sheet are mainly used for houses in the rural areas. (Hasan et al., 2000). These materials are temporary and are extremely vulnerable. Therefore houses in these areas are exposed to damage caused by hazards due to the use of such materials. Material is an important factor that can make the construction of houses stronger and safer to hazards to a large extent and lessen the damage caused. Therefore the use of permanent materials like bricks, concrete etc. that are more durable will contribute to more resilient housing (Hafiz, 2000). Materials should not only be durable but also environmentally friendly which will not pose to any climate risk and are economically viable.

In general, choice of building materials for housing depends on various factors such as type, budget, culture, climatic condition and labor to name a few. Particularly in the context of low cost housing building materials need to be cost effective, environmentally friendly. However in practice, use of substandard materials, design and shoddy construction, poor maintenance are key reasons for structural failure. It is important to select appropriate building materials with designing process in order to reduce the structural vulnerability. In addition there is a need to strengthen existing building industries in terms of skills, technologies and production for them to provide quality and durable materials (ADPC, 2011).

DRR can be achieved through the use of resilient building materials. Improvising the existing houses step by step and constructing the new ones with the resilient materials as pre-disaster mitigation measures will not only save more lives, but also reduce the costs of disaster recovery.

4.5 Construction Regulations and Governance

The Building Codes are national instruments providing guidelines for regulating the building construction activities across the country. In general, the Code mainly contains administrative regulations, development control rules and general building requirements; structural design and construction (including safety); fire safety requirements; stipulations regarding materials and other services. DRR measures needs to be defined precisely and consistently in the existing building codes. The building codes are expected to have DRR integrated in respect to disaster resilient construction techniques; appropriate project planning for reducing risks and monitoring of process of mainstreaming DRR (ADPC, 2011).

Building codes related to DRR should be applied and building permits should be enforced for local practices of housing construction. The housing forms and construction should be approved by the codes before implementation and specific elements in different disaster prone zones should be made compulsory. The application of safety-related regulations in will help to create an enabling environment for resilience performances and enforce a future resilient housing system.

A governing body should be responsible for overseeing the whole process whether the building codes have been applied or building permits issued, whether the design, construction materials and methods have been approved by the respective bodies in concern. Governance mechanisms for civil construction should give more consideration to peri-urban and rural areas that are, in fact, more vulnerable than central urban districts. DRR can be mainstreamed through governance mechanism, enforcing and ensuring proper building codes related to DRR have been applied for construction.

4.6 Respecting and Integrating Local Knowledge with DRR

Rural areas are rich in indigenous and local knowledge. Even though vernacular houses lack technical adequacy there is a lot to learn from them. Design of houses should respect and focus on local practice. There is a gap in understanding the local knowledge for having effective design and technology for the construction. Bridging this gap is necessary by learning from the local people and then improving the housing design. It is important to take into account that each of the communities in the rural areas has their own materials and construction techniques for housing. Therefore inputs from the local people and local artisans, strong understanding of the local culture and general context should be taken into consideration for sustainability and to achieve better impact in local housing resilience.

It is more beneficial to adopt local technologies with little improvement in the housing construction than introducing alternative technologies (Mackay, 1978 and Maskrey, 1995). It is imperative to incorporate certain hazard mitigation mechanisms against future disasters in the housing planning and construction. In areas where natural disasters are frequent, indigenous building practices for disaster mitigation and coping mechanisms do exist and advocates incorporating those practices in the housing planning. These practices may be inadequate for coping with hazards of great magnitude or may have been ignored due to economic pressures or lack of knowledge in traditional craftsmanship (Schilderman, 2004).

Adopting local approaches to disaster response in housing preserves local knowledge, strengthens social capital, and makes the reconstruction more acceptable to the community in terms of culture, climate, technology and economy. Schilderman (2004) mentions that community-based planning for disaster mitigation has proven to be more successful than formal, institutional approaches imposed upon the community; since the new construction standards introduced by formal approaches usually tend to be alien and costly to local groups. Relatively small changes and improvements in traditional construction could make housing more disaster resistant, yet remain affordable and climatically and culturally acceptable. For example, in Bangladesh, a study led by the German Red Cross organization identified minor construction changes – using metal bracings for bamboo joints instead of usual nylon ropes, preservative treatment of traditional materials, and improvements to foundations – that would strengthen houses made predominantly out of bamboo against impact from cyclones (Haq, 1999).

Incorporating new materials and technology into a local building culture should be carried out in a careful and critical manner. Local technology should not be completely replaced by new technology. A good practice is to replace certain steps in the building process, material procurement, material processing, and stages of construction, rather than propose a total negation of the traditional method.

4.7 Disaster Resilient Structures and Design Approaches

Structures and design play a great role in the resilience of housing. Taking into consideration factors such as context, culture, environment, climate risks, DRR measures, materials and construction methods, adverse damage caused to housing by frequent hazards can be reduced to a large extent as well as reduce the difficulty of recovery and reconstruction aftermath of any disaster. Some important considerations and technical guidelines have to be followed to upgrade any existing shelter or to build new safe houses in order to reduce the risks of loss of lives, livelihood and assets caused by heavy rains, strong storms and high floods. In technical words this means: “DRR compliance of a shelter is its ability to retain its original characteristics after being subjected to natural elements and continue to provide safe shelter to its occupants and assets”.

4.7.1 Cyclone

4.7.1.1 Location and Siting

The site and location of the house is important. Often due to financial constraints we have little choice in the matter. Therefore, when a house is recognized to have been located in a more vulnerable area, the rational response would be to build a stronger-than-normal house.

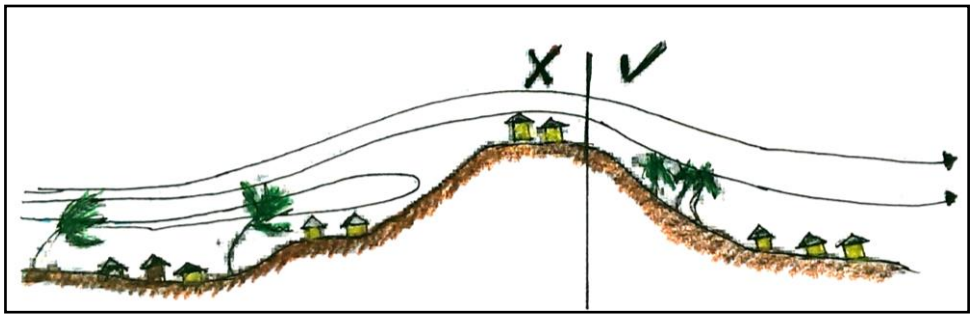

Fig 4. 10: Siting of the housing
Source: Prepared by author from IFRC (2011)

To protect the houses from strong winds, one of the most important ways is to build them in sheltered positions. The houses should be sheltered by the shape of the land or by windbreaks, to protect them from strong winds and also from tidal surges in coastal areas. They can also be shielded from the wind forces by vegetation barriers.

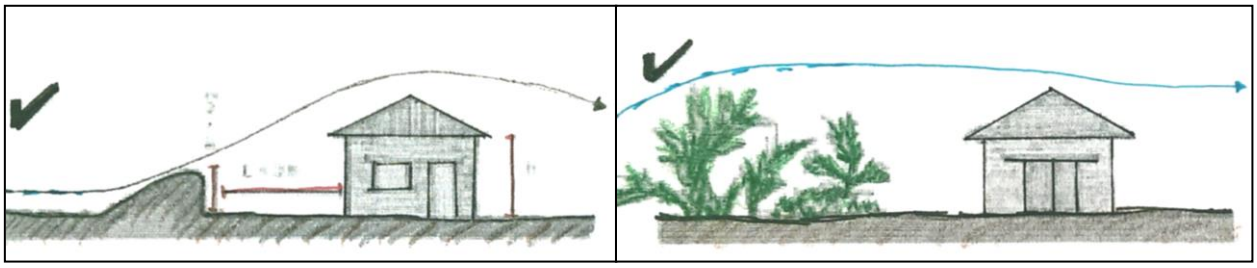

Fig 4. 11: Houses in sheltered location
Source: Prepared by author from IFRC (2011)

Small buildings should be far enough away from large trees that might fall over during strong winds.

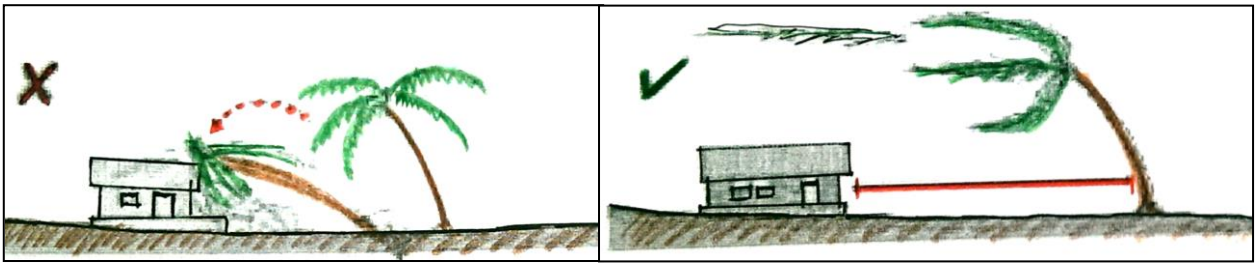

Fig 4. 12: Location of the houses from large trees
Source: Prepared by author from IFRC (2011)

4.7.1.2 House and Settlement Plan

Shape of the house is the most important single factor in determining the performance of houses in cyclones. Simple, compact, symmetrical shapes are best. The square plan is better than the rectangle since it allows high winds to go around them. The rectangle is better than the L-shaped plan. The best shape to resist high winds is a square. If other shapes are desired, the corners of the houses must be strengthened. If longer shapes are used, they must be designed to withstand the forces of the wind. Most houses are rectangular and the best layout is when the length is not more than three (3) times the width.

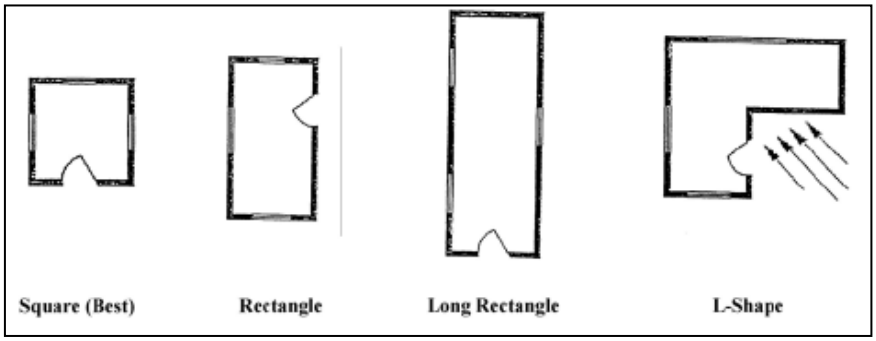

Fig 4. 13: House plans
Source: Agarwal, 2007

In case of construction of group of buildings, a cluster arrangement can be followed in preference to row type. This is because row type houses create a tunnel through which strong winds can pass at full speed. The cluster arrangement works like windbreakers. The planning of the settlement influences reduction of the wind forces.

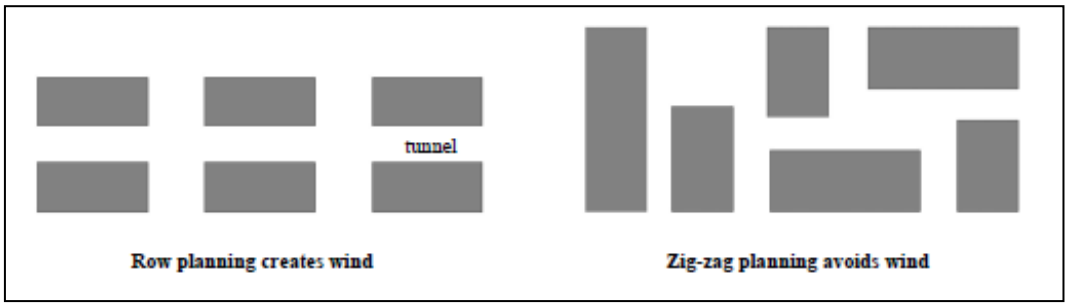

Fig 4. 14: Settlement planning
Source: Agarwal, 2007

The shorter elevation of a building should face towards the dominant direction of strong winds to reduce wind pressure on the construction.

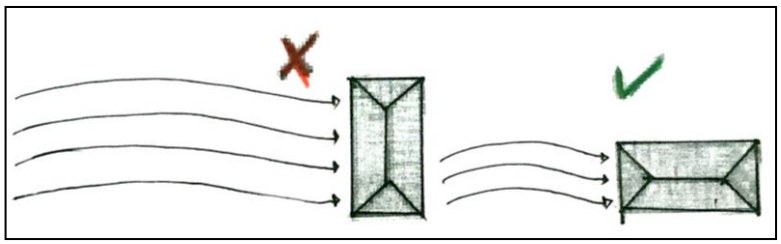

Fig 4. 15: Building elevation towards wind
Source: Prepared by author from IFRC (2011)

4.7.1.3 Elevating the House against Surge

In areas prone to cyclone and near to the coast, a site above the likely inundation level should be chosen. In case of non-availability of high level natural ground, houses should be constructed on stilts with no masonry or cross bracings up to maximum surge level, or on raised earthen mounds to avoid flooding/inundation, however, knee bracing may be used.

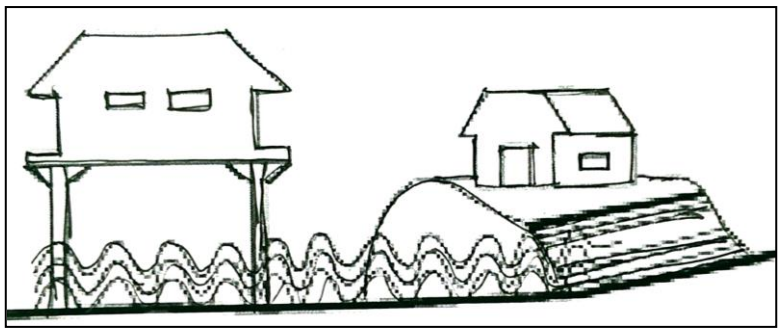

Fig 4. 16: Construction on silts or artificially raised earth mounds
Source: Prepared by author from IFRC (2011)

4.7.1.4 Construction

Houses need to be designed and built to withstand the forces created by the wind. Heavy buildings are naturally more resistant. Houses that are built with lightweight materials need strong anchors, fixings and bracing to resist strong winds. Below are some measures to reduce the vulnerability of shelter to wind forces

Foundations: Build the house on foundations or piling that rest on stable ground. Good-quality materials (masonry and mortar materials) should be used for bases and foundation walls. Foundations or piling should be sufficient to anchor light buildings firmly to the ground. The

wind forces can lift the wooden structure from the foundation if the connection between the two is not adequate.

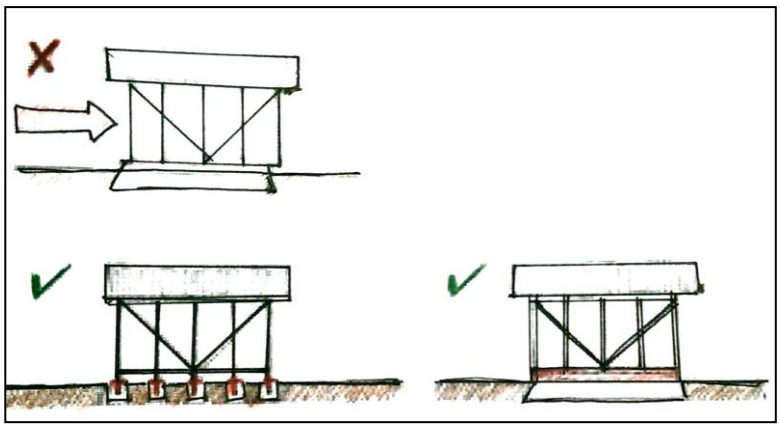

Fig 4. 17: Building foundation
Source: Prepared by author from IFRC (2011)

4.7.1.5 Walls and Openings

Masonry buildings: The walls should be of sufficient thickness and strongly bonded together for wind resistance. To prevent the structure lifting and moving off the ground, there should also be adequate weight on the foundations or piling.

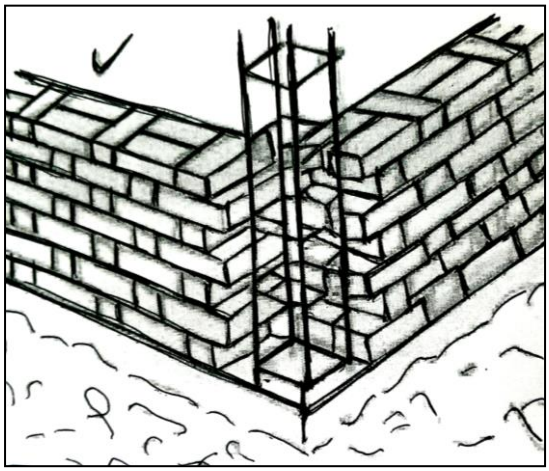

Fig 4. 18: Masonry walls
Source: Prepared by author from IFRC (2011)

Shutters or other protection should be provided on openings and resistant glass or plastic should be used for glazing. Shutters hinged along the top of window frames are preferred as these will not suddenly open and let in the wind, which could result in an increased internal pressure and cause the roof to blow off or the walls to collapse.

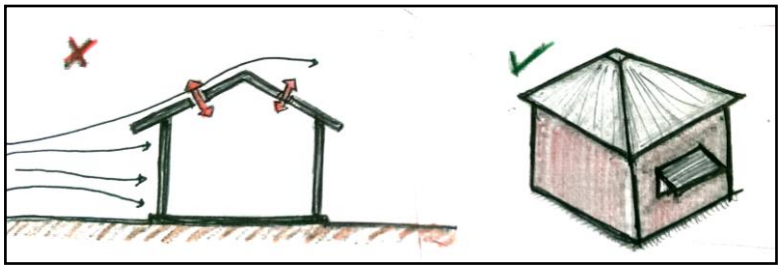

Fig 4. 19: House openings
Source: Prepared by author from IFRC (2011)

Timber-framed buildings: The timbers should be strongly fixed to each other and that the frame well anchored to foundations or piling to avoid the building lifting off the ground. To reduce the risk of the house from collapsing, the floor should be well braced and tied firmly into the walls to strengthen both walls and floors. The walls should be made strong with vertical and horizontal timbers and with sufficient bracing to resist wind pressure, water pressure and forces caused by earthquakes. All structural elements should be connected between each other by hurricane strap.

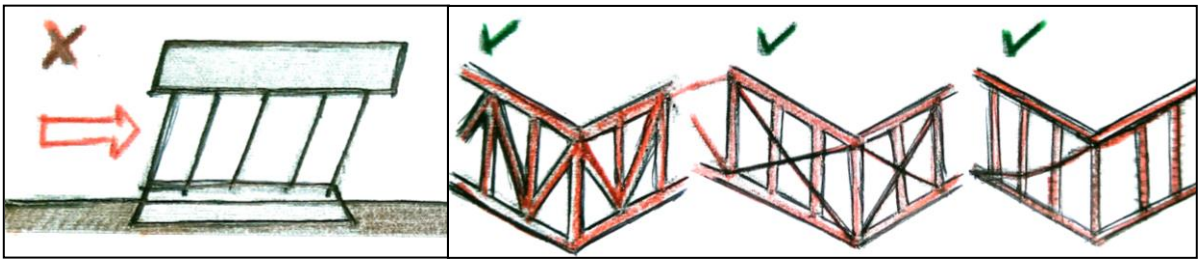

Fig 4. 20: Timber wall framing
Source: Prepared by author from IFRC (2011)

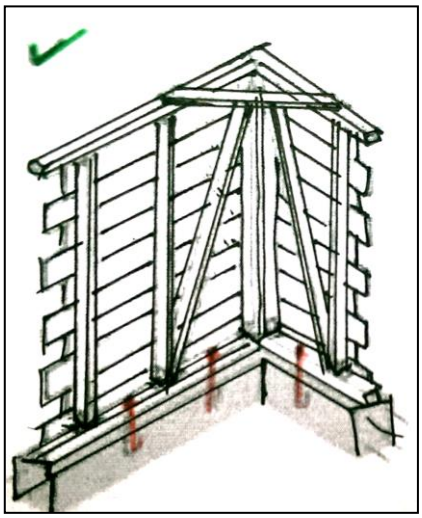

Fig 4. 21: Timbers anchored to the foundation
Source: Prepared by author from IFRC (2011)

Studs around windows and doors should be doubled as openings weaken the structure.

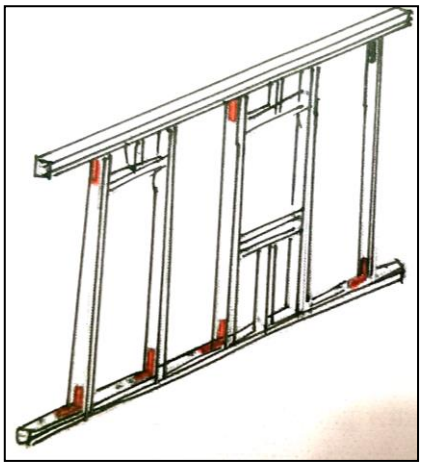

Fig 4. 22: Double stud openings
Source: Prepared by author from IFRC (2011)

4.7.1.6 Roofs

Strong winds easily blow off lightweight flat roofs. Therefore, the pitch of the roof should not be less than 22º in order to lessen the effect of the uplifting forces on the roof. Hip roofs are the best; they are more cyclone resistant than gable roofs.

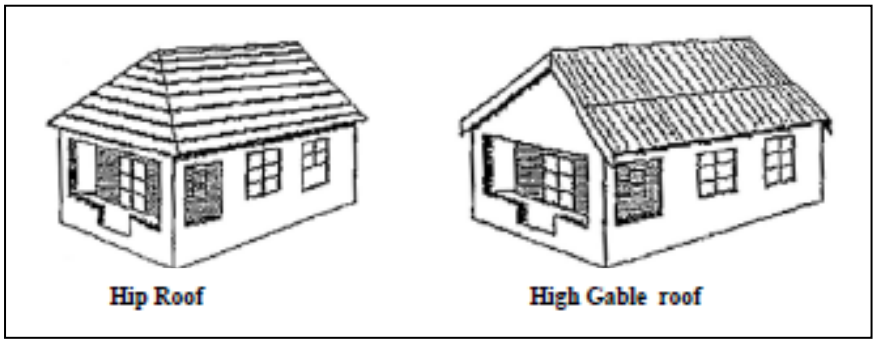

Fig 4. 23: Hip roof and high gable roof
Source: Agarwal, 2007

Overhanging roofs and canopies should be avoided, however, if they are desired, they should be braced by ties held to the main structures. When there is a portico or a verandah in front, overhangs should be structurally disconnected from the main structure because roof overhangs can cause uplifting of the roof structure due to strong winds, if they are connected to the main roof structure.

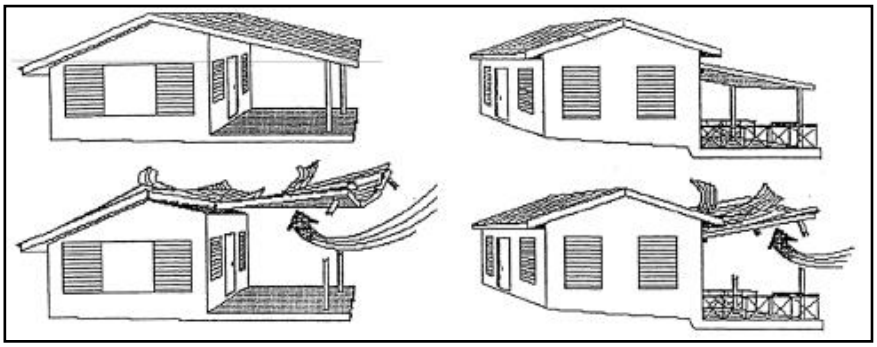

Fig 4. 24: Roof overhangs
Source: Agarwal, 2007

The roof elements should be tied together securely and be well fixed to the walls; the connections are most important. The rafters need to be connected directly to the ring beam with hurricane straps. Hurricane straps are used to connect the rafters to each other and to connect the rafters to the ridge beam.

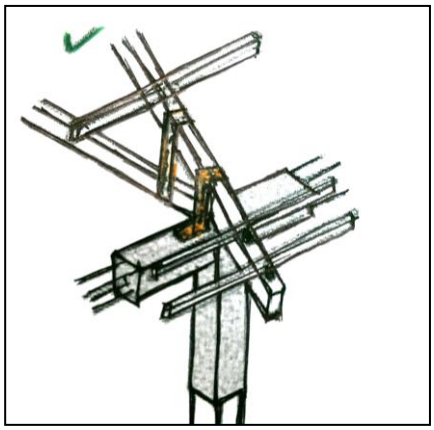

Fig 4. 25: Roof joints
Source: Prepared by author from IFRC (2011)

There should be sufficient fixing of cover material to the roof structure for adequate resistance to strong winds. The galvanized sheets should be fixed with galvanized roofing screws or large-cap roofing nails. These sheets should overlap two complete corrugations.

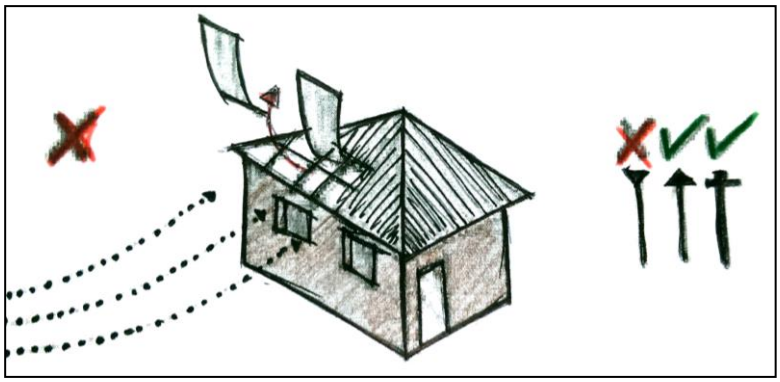

Fig 4. 26: Roof covering
Source: Prepared by author from IFRC (2011)

4.7.2 Flood

4.7.2.1 Location and Siting

Siting and location of housing is very important. Building a house in a place that is not likely to be flooded is the most important way to protect the house from floods. However, due to many unavoidable circumstances people have no option but settle down in flood prone areas. In such cases, houses and settlements should be sited above the highest recorded flood level, or should be protected by embankments that are sufficiently high and strong enough. Below are some measures for flood protection.

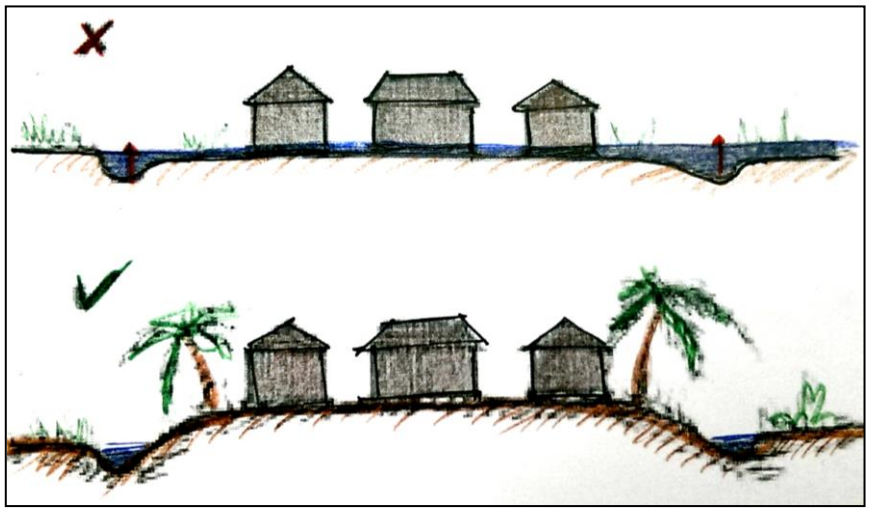

Fig 4. 27: Homesteads should be raised above the flood level
Source: Prepared by author from IFRC (2011)

Fig 4. 28: Houses and settlements should be sited away from locations at risk of landslides and rock falls during heavy rains
Source: Prepared by author from IFRC (2011)

Fig 4. 29: Houses and settlements should be sited well away from the likely path of flash flooding
Source: Prepared by author from IFRC (2011)

Fig 4. 30: Houses and settlements should be on stable ground to avoid the risk of collapse or landslides during flooding
Source: Prepared by author from IFRC (2011)

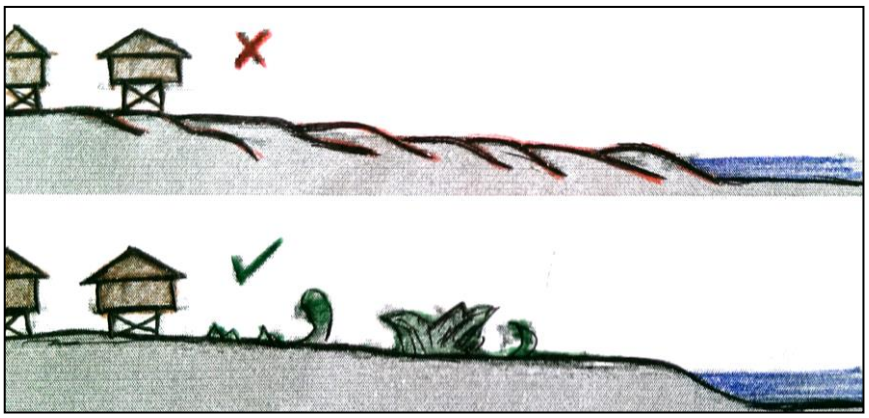

Fig 4. 31: Protect houses and settlements from erosion using ground-cover plants.
Source: Prepared by author from IFRC (2011)

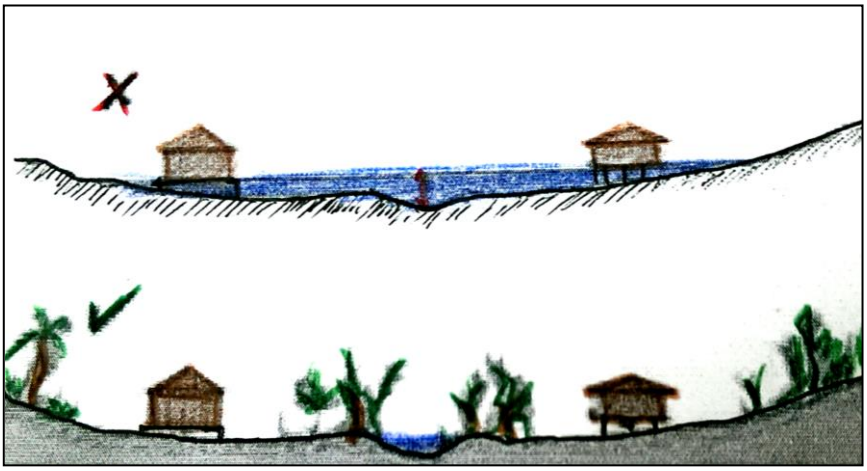

Fig 4. 32: Lines of trees and bushes should be planted to create barriers to river and tidal surges.
Source: Prepared by author from IFRC (2011)

4.7.2.2 Settlement Layout

The settlement should be laid out so that access is easy for evacuation and rescue. There should be an adequate and well-maintained drainage system in the settlement to carry away storm and flood water.

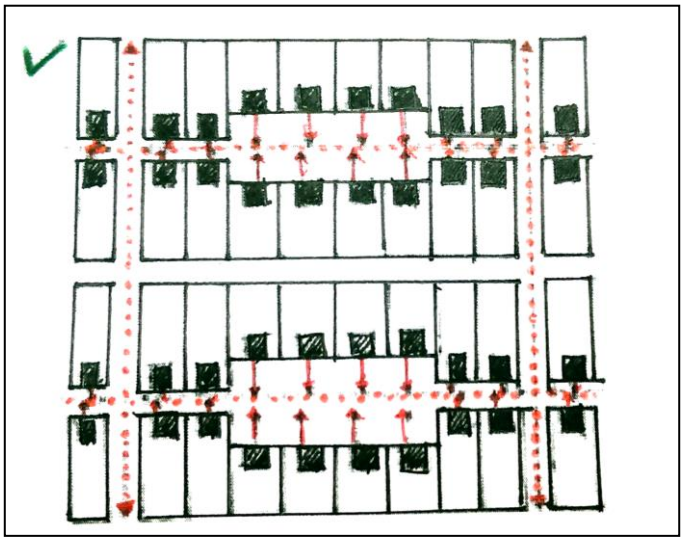

Fig 4. 33 :: Settlement layout
Source: Prepared by author from IFRC (2011)

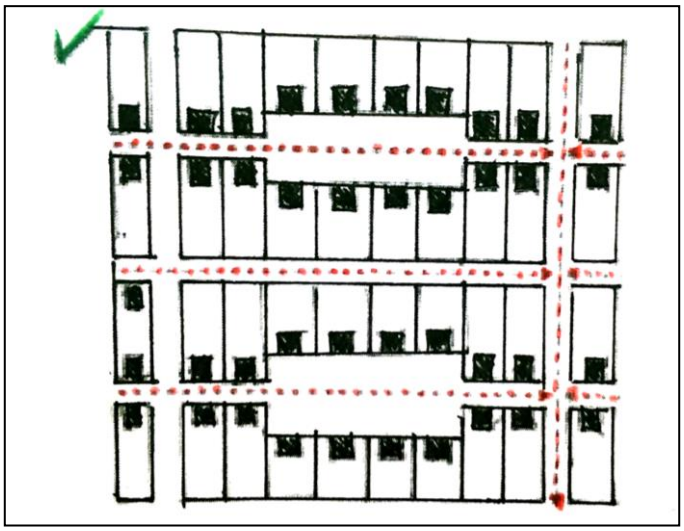

Fig 4. 34 : Drainage System
Source: Prepared by author from IFRC (2011)

4.7.2.3 Construction

Building a strong house is the next most important point that can withstand the forces created by the moving water, and which will not collapse when wet. Below are some measures to reduce the vulnerability of shelter to floods.

Foundations: Build the shelter on foundations or piling that rest on stable ground.

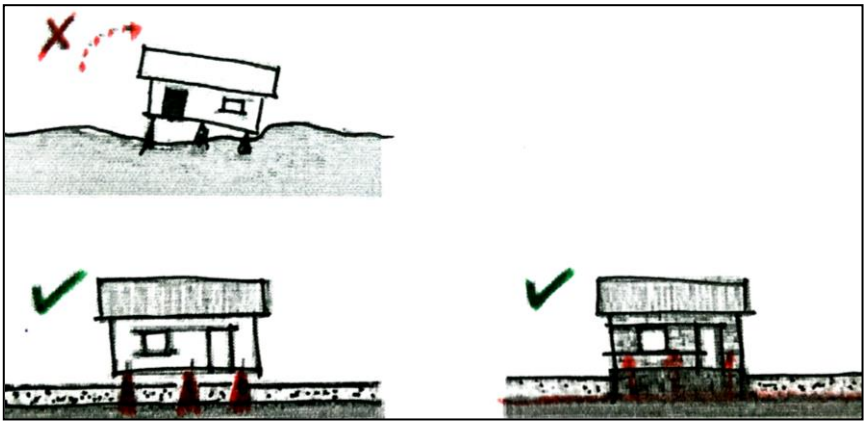

Fig 4. 35: Building foundation
Source: Prepared by author from IFRC (2011)

Good drainage system should be provided to the house and settlement to minimize erosion of foundations. Badly maintained drainage systems cause saturation of the ground leading to instability. The base of the walls should be protected from erosion by rainwater by using gutters, downpipes and drainage.

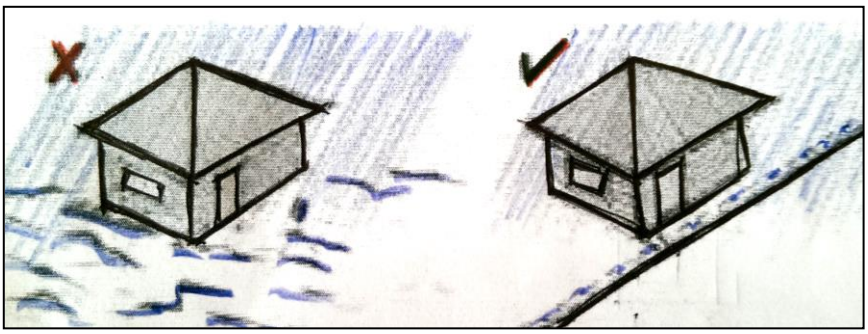

Fig 4. 36: Drainage system
Source: Prepared by author from IFRC (2011)

Houses should be built on water-resistant foundations and footings or piling to resist water pressure and remain resistant when wet. Plastic sheeting can be put between the ground and the foundations to further protect the structure. Drainage should be provided close to the foundations, to reduce water pressure on the foundations and to the floor of the house. Build sufficiently deep foundations to avoid undercutting by moving water.

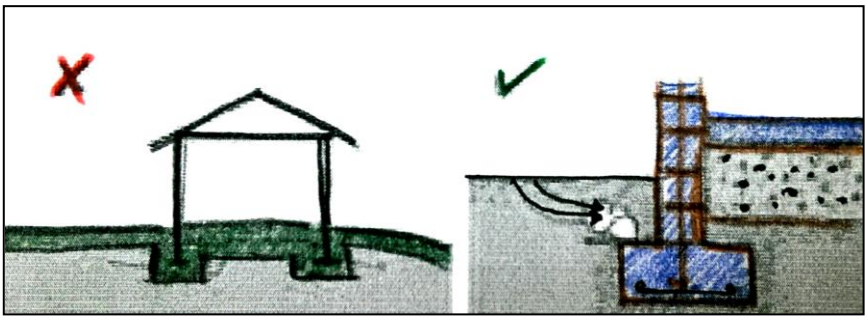

Fig 4. 37:Water resistant foundation
Source: Prepared by author from IFRC (2011)

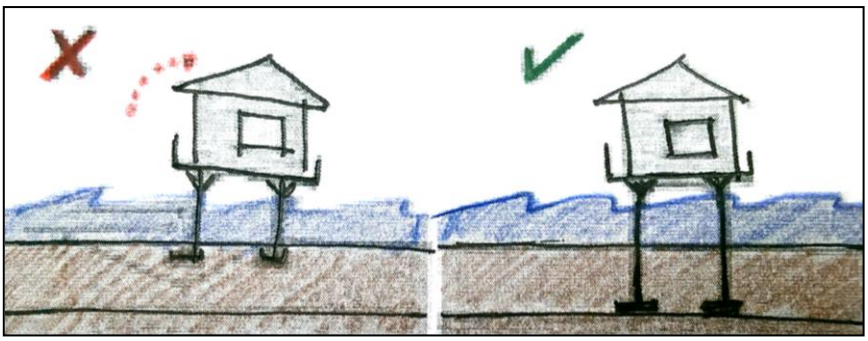

Fig 4. 38: Deep foundation
Source: Prepared by author from IFRC (2011)

4.7.2.5 Walls and Openings

Houses should be built with heavy walls, or wherever there are light walls, they should be well anchored to foundations or piling, to be able to resist pressure from water.

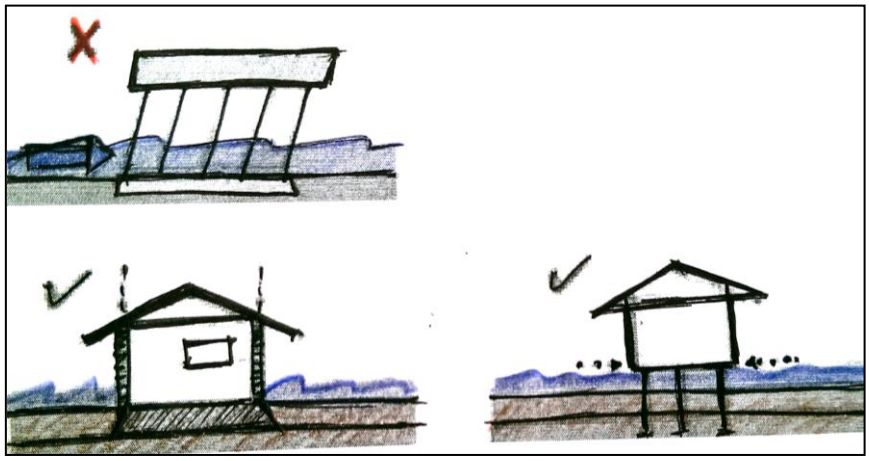

Fig 4. 39: Building walls
Source: Prepared by author from IFRC (2011)

Wall materials should be water-resistant and protective coating added to resist waterlogging and retain strength during heavy rain and flooding. To create a waterproof barrier, a mortar mixed with sharp or coarse sand should be applied to the wall.

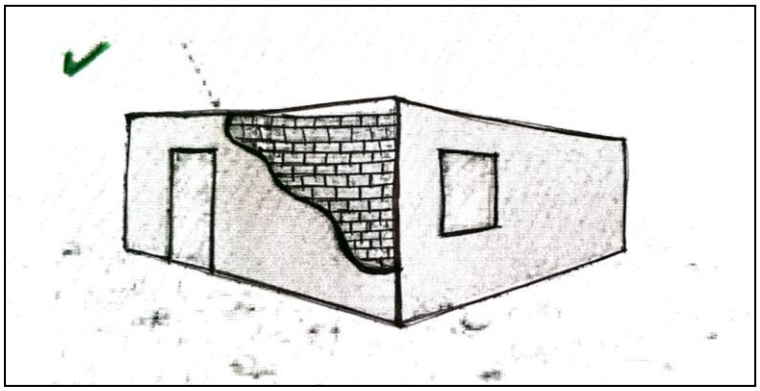

Fig 4. 40: Water resistant wall materials
Source: Prepared by author from IFRC (2011)

To increase stability and wind resistance of the structural frame of bamboo-framed houses, cross bracing with split bamboo sections that is treated with chemical preservatives, should be done. If a house becomes weakened at its base due to flood, cross-bracing helps to keep the structure stable. Good quality galvanized wire should be used for tying the elements of the structural frame.

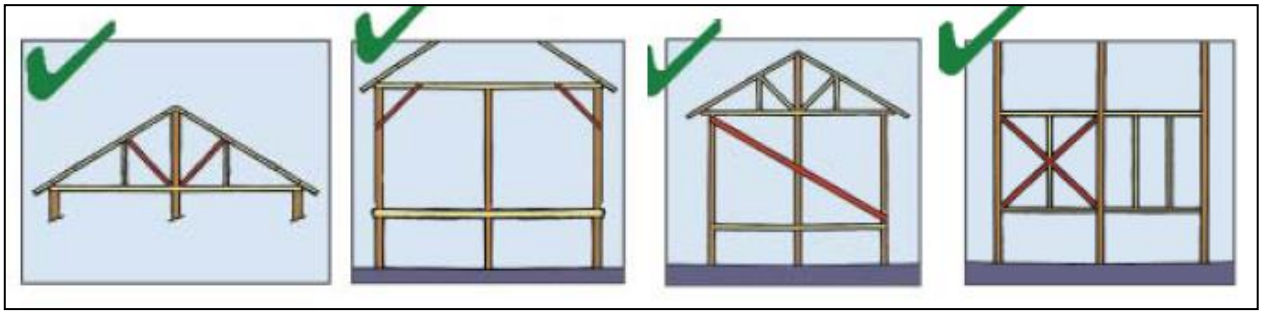

Fig 4. 41: Cross-bracing of bamboo structural frame
Source: Agarwal, 2007

In some cases, openings should be provided near the bottom of walls to allow flood water to move through the house without causing it to collapse. To prevent the walls from collapsing due to high pressure caused by the water, doors and windows should be placed in opposite walls to allow water from flash floods to flow out of the house.

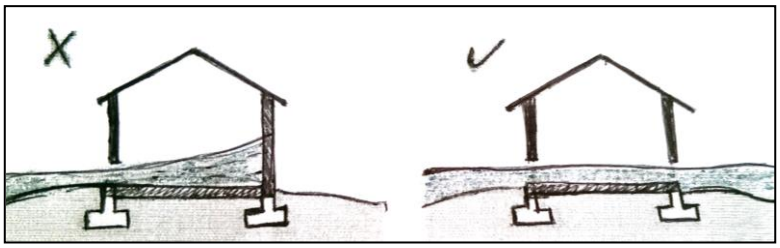

Fig 4. 42: Wall opening
Source: Prepared by author from IFRC (2011)

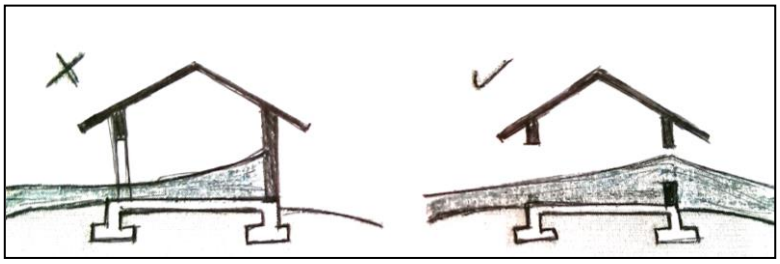

Fig 4. 43: Doors and windows
Source: Prepared by author from IFRC (2011)

4.7.2.6 Floors

To prevent flood water from entering the house, ground floors should be raised above known flood levels. In some cases, a raised platform should be provided inside or beside the house to allow people and possessions to be above the flood level. Houses should be constructed on silts wherever possible.

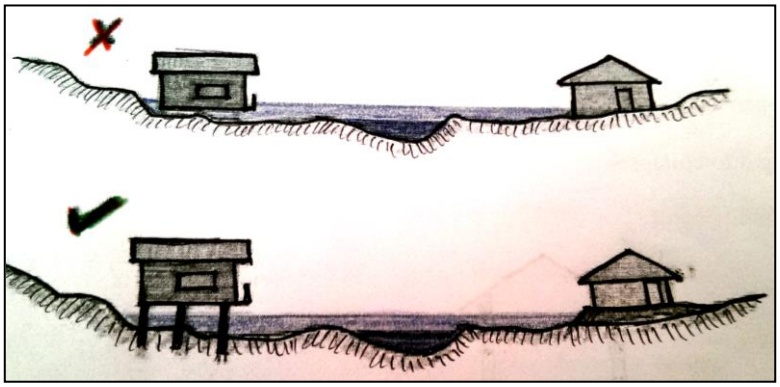

Fig 4. 44: Raised floor
Source: Prepared by author from IFRC (2011)

4.7.2.7 Roof

Rainwater gutters should be provided to protect the base of walls from heavy rain, and to ensure that the water runs away from the walls. Drains should be provided to take away rainwater falling from the roof if no gutters are provided.

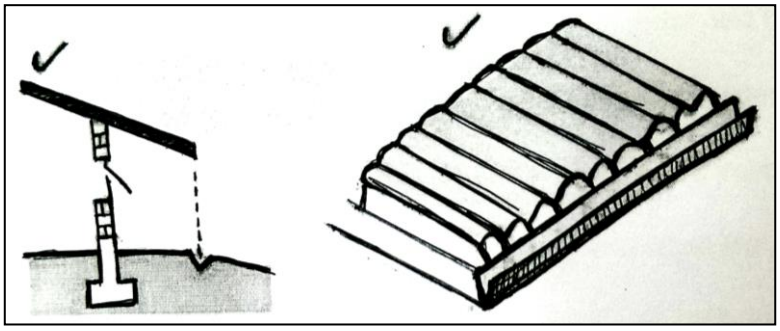

Fig 4. 45: PVC pipe rainwater gutter
Source: Safety Shelter Handbook

4.7.3 Landslide

The landslide mitigation works are broadly classified into two categories:

• Control works

• Restraint works

The control works involve modifications of the natural conditions of landslides such as topography, geology, ground water, and other conditions that indirectly control portions of the entire landslide movement. The restraint works rely directly on the construction of structural elements.

4.7.3.1 Location and Siting

The houses in the hilly regions of Bangladesh are vulnerable mainly because of their location and siting. Generally, settlements are formed right at the foot of the hill which is the risk zone. Therefore housing needs to be sited at a distance from the foothill so that the debris during a landslide doesn't bury the houses. A drain trench to be constructed at the foothill which will elongate hill slope downward and hold landslide debris during disaster, an elevated green belt will serve as a buffer for the informal settlement, and the road beside the green will give an easy access to the settlement during post disaster rescue work.

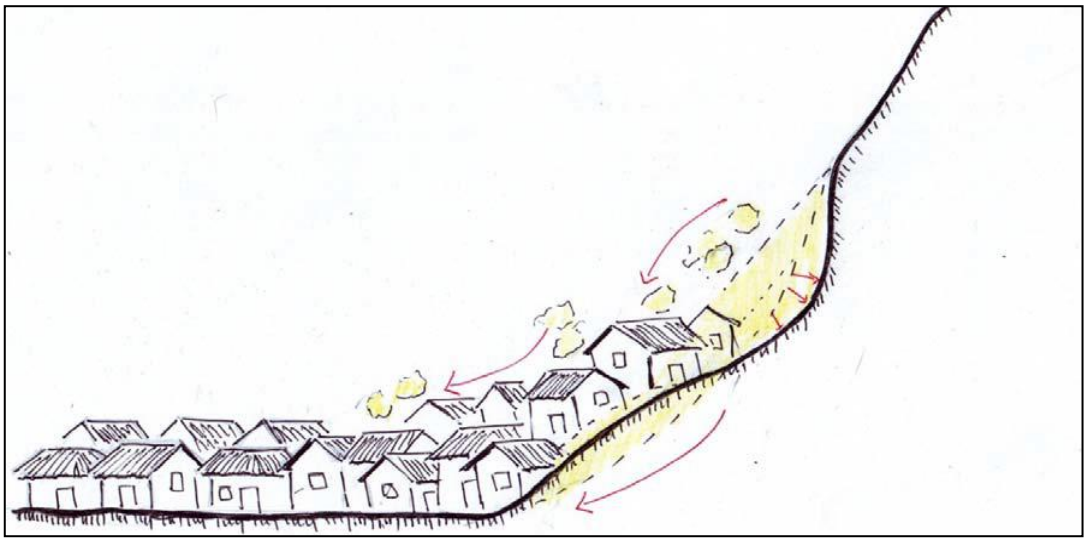

Fig 4. 46: Landslide risk at the foothill
Source: Rahman, 2012

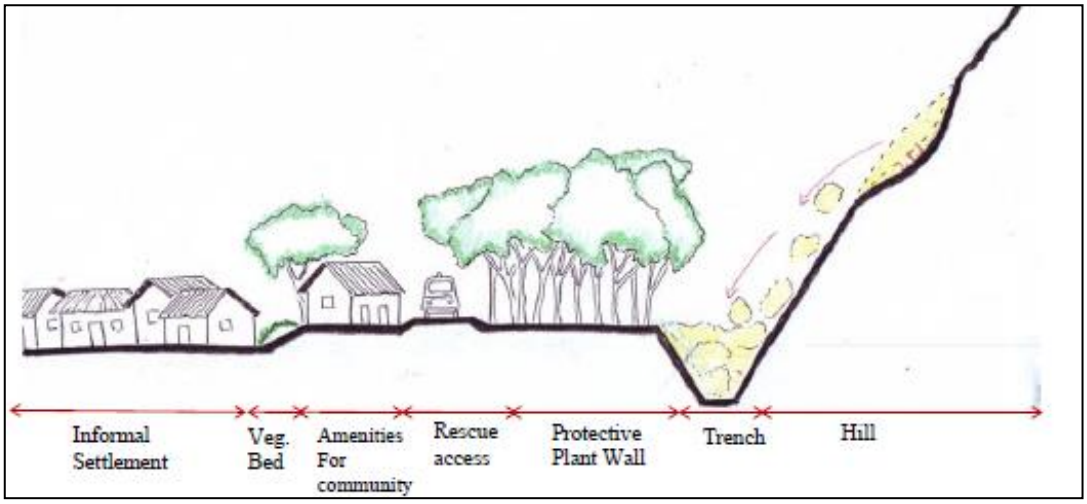

Fig 4. 47: Proposed design reducing landslide risk
Source: Rahman, 2012

During landslide, the trench works as the first layer of protection. It holds most of the landslide debris. If a massive landslide takes place and the drain trench over flows, the thick layer of trees will work as a wall. It will reduce the speed and most of the debris will get trapped within the green belt. Layers of the connecting road and amenities will provide extra protection (Rahman, 2012).

4.7.3.2 Construction of houses

When selecting a specific mitigation and stabilization method, it is best to keep it simple to match the capabilities of contractors and availability of materials. Constructability and construction requirements should be evaluated, including sequencing, temporary support and protection of nearby property, facilities, utilities, traffic and the public.

One of the best ways to avoid immediate damage is to build houses on silts (also known as Machan House) wherever it is possible. In the case of Machan House it has been found that lesser number of bottom posts is adequate to support the house. Corner bracings make the house resistant to the heavy flow of debris from the landslide. This makes the house strong enough to withstand the force and lessen the damage caused.

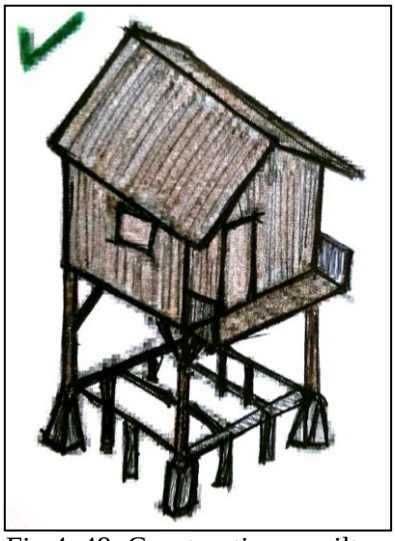

Fig 4. 48: Construction on silts
Source: Prepared by author from IFRC (2011)

CHAPTER 05: CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary of Major Findings

- **Local housing practice to be considered as foundation for disaster resilient housing:** It is important to use locally available materials and technology and show respect for local culture and practice. The natural resources are different from one site to another; therefore the coping strategies for shelter also differ. There is a lot to learn from the existing vernacular houses even they lack technical adequacy. Maximising the use of local knowledge, local resources, particularly locally available materials and construction techniques, and effectively translating them into locally responsive and adaptive housing options can be substantial and valuable to the future development of disaster resilient housing.
- **Develop methodological approach in order to minimize the impact of recurrent disasters:** In designing houses, the level of hazard needs to be estimated. Community people's opinion should be taken into consideration for design of houses. Housing should be designed to develop contextual solution that fit better to people needs and that have better impact, both in the local economy and the local building practices. In places where different organizations are intervening to build housing for the community, they should consult with the local allies and artisans/masons and validate the design by the community.
- **Awareness of the at-risk communities to be improved to build disaster resilient housing:** Although many awareness raising activities are in place already, but these activities focus on the preparedness of any upcoming disaster event. However, more emphasis should be put into raising awareness regarding climate risks and the need for risk reduction. Rural people still underestimate the threats of climate risks and its increasing severity in the future. Due to the lack of awareness, disaster preparedness is not as important as basic needs of living to the low income people and for the medium and high income people, fashionable construction that focuses on decoration and details are preferred over safe construction practice. Therefore, the government, non-government and international organizations should design for awareness programs that focus only on climate risks and disaster risk reduction measures.
- **Provide permanent housing solution for a resilient community:** Aftermath of any disaster event many organizations implement post disaster programs to provide shelter to the affected

people. Most of the time these programs focus in providing approaches of giving back roof to the people than in enabling strategies to help people to access to a roof and a knowledge that will help them to build more resilient houses on their own. These organizations, however, while working on the post disaster program could also train the local people about the tools and techniques they can apply along with their local knowledge in building houses that can withstand natural disasters. In this way the community people don't have to be dependent on external aid, rather can build back better by themselves.

- **Bridge the gaps between the local masons and the in-field professionals (architects/engineers):** The vulnerable communities due to their financial difficulties cannot afford to access the professional services for better housing design and construction. Generally they design their houses by themselves based on need or hire the local masons to build for them. However, these local masons also lack proper skills and techniques of construction methods. They have least knowledge on the appropriate use of materials and the climate risk and disaster risk reduction factors to be incorporated during construction. In recent times, the role of built-environment professionals in disaster risk reduction is of increasing concern. To effectively assist the at-risk communities, professional expertise and skills are crucial to better cope with future disasters. Therefore, it is important to have mutual and interactive learning and sharing processes among at-risk people, masons and the in-field professionals through communication and consultation activities indoor and outdoor. Government and non-government organizations that work with housing and post disaster reconstruction programs should arrange for disaster resilience workshops for these local people and masons where leaders from engineering and architecture practices and research communities shall interact with them to identify the gaps in their current practice. They should be trained for the assessment and design of resilient housing and infrastructure. These workshops should focus on the need for resilience in housing, community planning for resilience, insurance perspective on housing, tools and techniques for better construction, material knowledge etc. Even the in-field professional communities on their own initiative can campaign for safe construction in the disaster prone areas.
- **Application of safety related codes and criteria for a disaster resilient housing:** The current codes do not have provisions for disaster resistant rural house design and so, there is no policy related to rural housing improvement that may end to risk reduction and disaster preparedness strategy in this particular sector. This makes housing more vulnerable to

disasters. Therefore, the government along with the concerned authorities should enforce the incorporation of clear codes, zoning, and planning criteria for climate and disaster risk reduction in hazard prone areas, in the building standards. Not only should elements of design be enforced to incorporate, but also, the application of these safety related codes and criteria for disaster resilient housing should be properly inspected. The standards Governance mechanisms for civil construction should focus more on peri-urban and rural areas that are, in fact, more vulnerable to climate risks. Improving local construction practices through the application of safety-related regulations in form of building permits help to create an enabling environment for resilience performances and enforces a future resilient housing system.

- **Proper maintenance of houses and buildings:** Economic difficulty of rural people leads to the lack of proper maintenance of houses. Generally, after the houses are constructed, they are not followed up by proper maintenance, modifications or improvements catering to the needs of disaster resilience. The building materials used to construct these houses are generally temporary and not durable, therefore, needs replacement immediately after they wear out. However, the people overlook the need to do so. This makes the structures weak and exposed to damage during a natural disaster. The local authority of the disaster prone areas should be responsible for ensuring regular maintenance of the houses. There should be housing insurance policy in place for the rural poor for maintenance and improvement of their houses for better preparedness. Government and non-government organizations can design maintenance programs and conduct workshops to educate people on the importance of this maintenance.

5.2 Conclusions

Majority of the families in Bangladesh, that are poor and marginalized locate themselves in the rural areas that are prone to disasters. They live in vulnerable housing that is easily damaged by natural disasters such as cyclone, flood and landslide. Hazards in nature do not constitute disaster risk, however, the underlying vulnerabilities to hazards and external drivers construct disaster risk and resulting losses. The variety of factors, which contributes to the vulnerability of the housing stock ranges from having systems in place for proper settlement planning, appropriate technical guidance in forms of building codes, suitable enforcement mechanisms, capacity for implementation, and skilled labor as well as enabling factors such as good governance. The preparation for appropriate design and structure of these rural houses is a crying need of the day.

It is a social responsibility of architects, engineers, educational institutions, civil society, government and non-government organizations to take positive initiatives for this issue.

This paper has highlighted some of the important approaches where disaster risk reduction can be mainstreamed to achieve resilience through housing practices in Bangladesh. In a nutshell, the value of local construction practices, expertise in disaster risk reduction and management, measures for economic development, improved public awareness, planning codes and regulations, and effective governance are crucial for disaster resilient housing. These findings can be valuable lessons that potentially inform further research and practices in terms of building resilient housing in extremely disaster risk exposed areas of Bangladesh and may also generate some policy implications for local authority to issue appropriate legal frameworks and supportive programs to improve local construction and to build safer and more resilient communities. This paper may be a good initiative to raise awareness of stakeholders including administrative officers, scholars, practitioners and professionals working in architecture and the construction sector.

5.3 Recommendations

- The government and international organizations should set up institutions that will specifically work on two important issues; raising awareness and educating the local people about climate risks and DRR in all parts of the country that is prone to disasters.
- The shelter based organizations should introduce training sessions and activities for local builders, masons and labors to build their skills and knowledge on housing design, building materials and construction methods, especially focusing on the integration of DRR in the entire process of housing.
- Institute of Architects Bangladesh (IAB) and the Institute of Engineers Bangladesh (IEB) should work in collaboration with the shelter based organizations to design housing models for the disaster prone areas. The architects and engineers have to communicate and interact with the local builders and masons more often to learn about their local practices and provide them with housing solutions considering the local practices to be strong foundation for disaster resilience.
- The Government of Bangladesh should set up more financial institutions that will cover the most remote areas to provide funding to the rural poor in order to improve their existing

houses, to replace temporary building materials with permanent ones and to make their houses more resilient to disasters.

- Every community should have a governing body that will approve building permits for construction. They will inspect the application of safety related codes and criteria for disaster resilience. Once the approval of the design, building materials and building permit is made, the houses can go for construction. This will enforce a resilient housing system in the community.
- The settlement of the rural poor on the most vulnerable lands that is exposed to recurring hazards should be controlled by the land use authorities. They should not be allowed to move to lands that are marked hazardous in the land use map. Lands that are disaster prone should not by any means be of use for settlement purpose.
- The government should invest more in providing disaster resilient housing as a means of pre-disaster mitigation measure. This will not only save more lives, but also reduce the costs of disaster recovery.
- The state and local government and related entities should have access to sufficient financial resources in order to incorporate safer housing and renovation methods, develop and enforce new housing and zoning codes, implement enhanced land use planning strategies and develop more cost-effective support programs.

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