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ADAPTATION TO CLIMATE CHANGE THROUGH DISASTER-RESILIENT HOUSING PRACTICE IN THE COASTAL ZONE OF BANGLADESH.

M. R. Rahman[1], A. A. Muhaymin[2] and M. M. Rahman[3]

ABSTRACT

The coastal area of Bangladesh has experienced frequent cyclones associated with storm surges in the last few decades. After the 1990s, activities like construction of cyclone shelter, early warning system, and awareness building program plays a very effective role to reduce the fatalities and damages due to disaster in the coastal area. Though the actions were effective still a large number of houses are damaged due to disaster on a regular basis and cause repetitive economic losses and distresses to the people. From several studies on post-disaster shelter response, has highlighted the need for more contextual approaches such as the construction of the individual housing unit using a participatory approach to make a community more resilient. The aim of the paper is to systematically capture the hazard responses of the individual housing unit, which was developed based on the participatory design process in the coastal zone of Bangladesh. Including absorbing shocks, securing food and water safety, the house can relocate and its materials could be preserved to reduce the repair cost after disaster for ensuring resilience. A schematic prototype house is offered which can adapt to the impact of cyclone-induced storm-surges of the coastal area is under study. Furthermore, upgrading the existing design by addressing the limitations through monitoring and evaluation will enhance the resilience of construction of individual housing unit in the future.

Keywords: Adaptation, hazard response, participatory approach, resilience

Introduction

Bangladesh is one of the most vulnerable countries of the world in the event of climate change (Ali, 1999) and experiences 40% of the total cyclone-induced storm surge events of the world (Murty & El-Sabh, 1992). The coastal zone of Bangladesh is a most vulnerable area for such hazards because of low-lying and relatively flat terrain, geographical setting at the edge of the Bay of Bengal, high tidal range, high density of population and fragile coastal protection system (Dasgupta et al., 2010). In the last decades, the most disastrous events were Sidr in 2007 and Aila in 2009, which mostly affected the housing sector. Because of illiteracy and lacking an idea of a modern house, these coastal people built their non-engineering houses by using locally available woodcraft, artesian using wood, bamboo, tin, and thatches for living somewhat only (Zisan et al., 2013). Henceforth, they have to lose their houses every year even a normal storm condition. Lacking proper knowledge, selection of material and affordability, they will not able to repair their house in a precise way. Aila in 2009, across 11 of the nation's 64 districts, approximately 600,000 thatched homes were damaged or destroyed. Unluckily, Bangladesh National Building Code-93 (BNBC-93) doesn't provide any provision for wind and surge resistant design for above mentioned non-engineering housing (Zisan et al., 2013). To minimize the losses of housing units and for ensuring the safety of basic needs, it's essential to develop new regulation and guidelines for the non-engineering rural house with a minimum construction and repair cost. Considering the above facts, the aim of the paper is to link this knowledge gap through a participatory approached prototype construction in the coastal area.

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Concepts of Disaster Resilient House as an Adaptation

Adaptation includes the adjustments to climatic changes, including moderating potential damage, taking advantage of opportunities, and coping with the consequences (Schipper, 2007). On the other hand, 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). Therefore, resilience perspective on adaptation emphasizes learning, self-organization, and flexibility as crucial ingredients for navigating complex feedbacks, thresholds, and system changes (Berkes et al., 2003). Ultimately, the proper adaptation of a system reduce its vulnerability and enhance the resilience to observed and anticipated impacts of climate change. In disaster-resilient housing concept, it refers to those structures that are expected to not collapse or be destroyed but may still suffer some damage that can be restored. Disaster resilient housing means to build structures and a community considering the disaster resiliency strategies and risk reduction measures so that the houses can withstand the impact of any natural hazard. Besides absorbing shocks of disaster, the house will also ensure the food and water safety during a critical time. After that, it will give enormous support to the restoration of normal time rapidly. 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.

Design Concept and Responses of House

The design has focused on generating resilient home structure for present socio-economic and climatic contexts adopting 'Participatory design' process to define and resolve the present challenges; generating climate, culture, economy, and gender responsive issues in the coastal area. It has involved the community including women and children to exploit local wisdom and technocrats would contribute through incorporating appropriate technology to adapt and mitigate the prevailing challenges. The design has adapted through the consultation with community mason and craftsmen and they are able to implement the design using locally available natural materials such as bamboo, golpata, timber etc. So if necessary they would be able to rectify any flaws generated in any given situation and time.

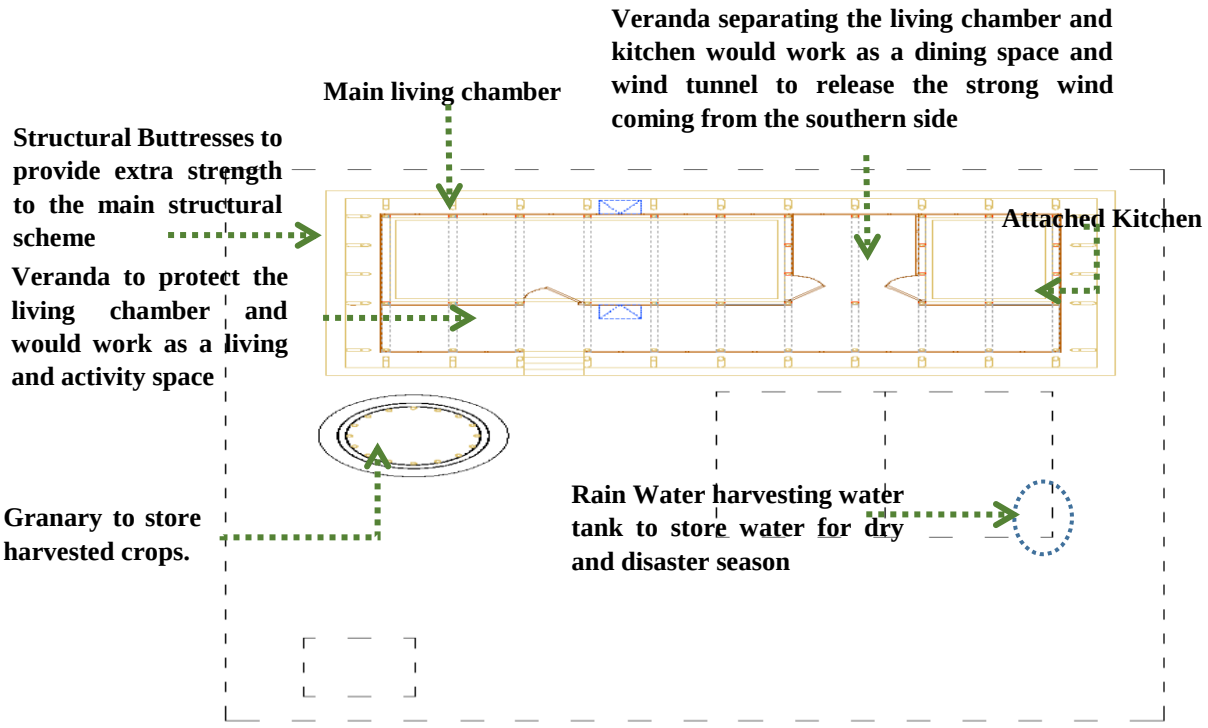

Figure 1. Proposed housing plan.

The proposal of house design made with a bedroom, a kitchen, and space, which can work as a dining space and wind tunnel to release the strong wind coming from the southern side. The house plan is rectangular and symmetrical shape to allow high winds to go around them. The whole design also includes a granary to store crops and a rainwater harvesting system to secure enough water to adapt during dry and disaster times shown in figure 1.

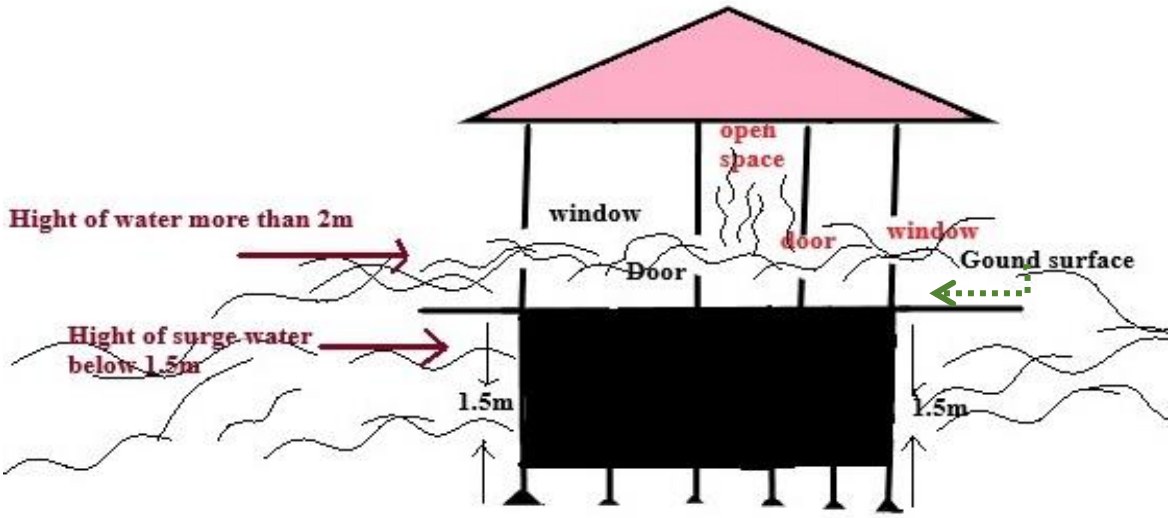

Figure 2. Schematic responses of the house against flood condition.

Figure 2 represents how the house will response during a flood condition. Where plinth height of the house been raised about 1.5 m above the existing ground levels to prevent floodwater entering the house. For storm surges such as Aila, openings have provided near the bottom of walls to allow floodwater to move through the house without causing it to collapse. To prevent the walls from collapsing due to the high pressure caused by the water, doors, and windows were placed in opposite walls to allow water from floods to flow out of the house.

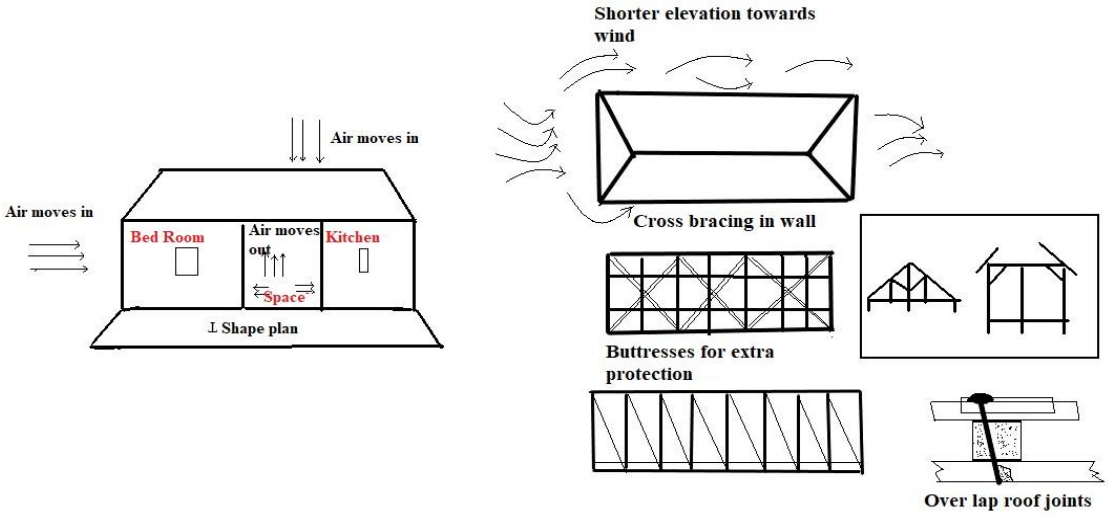

Figure 3. Schematic features of design and responses against wind speed.

The design plan also includes options for sustaining against cyclonic wind speed. Figure 3 gives the idea of house features that used for construction and how it will respond during a cyclonic event. Where it represents

the space between bedroom and kitchen specially designed as a dining space and wind tunnel to release the strong wind coming from the southern side. The shorter elevation of the house has faced towards the dominant direction of strong winds to reduce wind pressure on the construction. During construction, the roof materials have properly tied with the roof structure with extra protection over it to avoid any pressure that could blow away the roof. Bamboos were strongly fixed to each other and the frame includes buttresses that will provide extra protection of the main structural system against strong and lateral forces and avoid the building lifting off the ground shown in figure 4(b). The walls have made strong with vertical and horizontal bamboos and with sufficient cross bracing to reduce the wind load on the structure.

(a) (b) (c)

Figure 4. Implementation of design. (a) Structural frame of the house. (b) Structural buttresses to provide extra protection of the main structural system against strong and lateral forces. (c) Granary for food security.

Monitoring and Evaluation

In December 2017, the design has implemented at Dacope of Khulna district in Bangladesh. Dacope is known for Aila affected area. After implementation, the house is still in routine basis monitoring program. Last one year we tried to keep in touch of users especially in the time of natural calamities such as northwester, heavy rainfall, flooding condition, and natural depression etc. to find out how the house is responding against disaster and design lacking. Through user's feedback, it has been evaluated that they are psychologically satisfied by using it and seems that this housing unit improves their social status in society. Until any extreme event as Aila 2009 didn't hit that area but the house has faced 5 times low to medium types of natural calamities in last one year, which has described in Table 1. Major damage hasn't occurred yet and a very small amount of cost was required for repair and restoration.

Table 1. Systematically capturing information of hazard responses of the house.

Date	Types of Hazard	Magnitude	Impact on house	Types of damage	Repair cost
March, 2018	Northwester	Warning signal 3	No impact	No damage	NA
April, 2018	Northwester	Warning signal 3,4	No impact	No damage	NA
July, 2018	Heavy rainfall	----------	Small impact	Small hole in roof	Significant
September, 2018	Depression in Bay of Bengal	Warning signal 3	No impact	No damage	NA
October, 2018	Cyclone Titli	Warning signal 2,3,4	No impact	No damage	NA

Conclusions and Recommendations

The coastal area of Bangladesh is vulnerable to cyclone-induced surges, which directly affect the housing sector. The proposed design conceived as an action research work, which covers the adaption through housing unit during a hazard that could enhance the resilience of a community. This paper would let us explore in real context and issues which would be very vital to generate the resilient building structure in near future. However, from monitoring and evaluation of the house performance**,** recommendation for further research would be that the design materials are natural, which are susceptible to decay. Its need to take all the possible measures to increase the longevity of the materials. Besides, users of the design should be aware of that fact and need to conduct routine basis monitoring and maintenance of structure for more robustness against disaster.

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