Resilient Housing Design Competition 2013: Discussion of Resilience Innovation

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INTRODUCTION

Gorakhpur is a major cities in eastern India located in the mid- Gangetic Plains between the Rapti and Rohini River basins, and faces recurrent riverine floods and inundation in the urban and peri-urban areas. Over the years, the city has grown rapidly and is now home to more than a million people. A large number of unauthorized developments have also come up in flood prone areas of the city. Recurring floods and inundation not only disrupt city functions, but they also cause major economic losses due to damaged buildings and infrastructure as well as losses to individuals in terms of work-days lost and health impacts. Although inadequate physical infrastructure, limited local capacities, and the city's haphazard built form are largely to blame for the situation, the low lying, saucer shaped terrain of the city adds to the extent of problem. Climate change brings a new dimension to the problem as more intense, unseasonal, and erratic rainfall results in unexpected changes to flooding and inundation patterns. In recent years, floods that occurred earlier than normal caught people off guard and caused more damage than usual. The City Resilience Strategy identified housing and related issues as key areas where vulnerability needs to be addressed (Wajih, Singh, Bartarya, Basu, & ACCCRN ISET Team, 2010).

Shelter is one of the most important factors influencing the exposure of people and assets to disaster risks. Flood- and climate-adapted shelter designs protect livelihoods and assets and reduce the types of climate-disaster-related losses that impoverish families, thus playing a critical role in enabling vulnerable groups to accumulate the resources required for long-term adaptation. However, although there are more modern houses now, many of them have been built without design considerations or regulation, resulting in houses that remain vulnerable to floods.

CITIATION

Singh, B., Singh, D., Sabbag, L. (2014). *Resilient Housing Design Competition: Discussion of Resilience Innovations (The Sheltering Series No. 10)*. Boulder, CO: Institute for Social and Environmental Transition-International.

Only a few decades ago, Gorakhpur was known for its mild and pleasant summers with average mean temperature highs around 30°C. In the past decade, however, the temperatures in the city have shown increasingly varying patterns and in recent years, the average mean temperatures have been around 32–34°C, even during monsoon months. Coupled with humidity levels of over 60%, the local climate creates an environment conducive to heat stress and vector- borne diseases. For people living in slums and low-income colonies, housing conditions exacerbate heat impacts mainly due to the structural design (a roof made of tin or asbestos, thin walls, little or no ventilation), congestion (little space between houses), and lack of air-conditioning (Tran, 2012).

THE PROJECT AND THE DESIGN COMPETITION

The Sheltering from a Gathering Storm project was undertaken with the aim to improve understanding of the costs and benefits of climate resilient housing and contribute to the transformative change necessary to make communities more resilient to future disasters. The goal is also to influence housing practices among local stakeholders such as masons and individual households, so they start to include design features that would improve housing resilience.

To influence local construction practices, a nation-wide design competition was launched wherein key attributes of a resilient structure in the local context could be showcased. These designs would then be used to disseminate the learning to professionals and communities through interactive workshops and media campaigns. Some of the key attributes of a resilient design include raised plinth, two rooms, ventilated kitchen, safe place inside the house in case of unprecedented floods. A reasonable cost range was determined through community consultations and shared learning dialogues (SLDs). The Resilient Housing Design Competition—hosted in 2013 by GEAG, SEEDs, and ISET-International—created an avenue for innovation in traditional shelter systems. The winning design from the housing competition integrated a number of key features for living with increased flooding levels and temperature extremes.

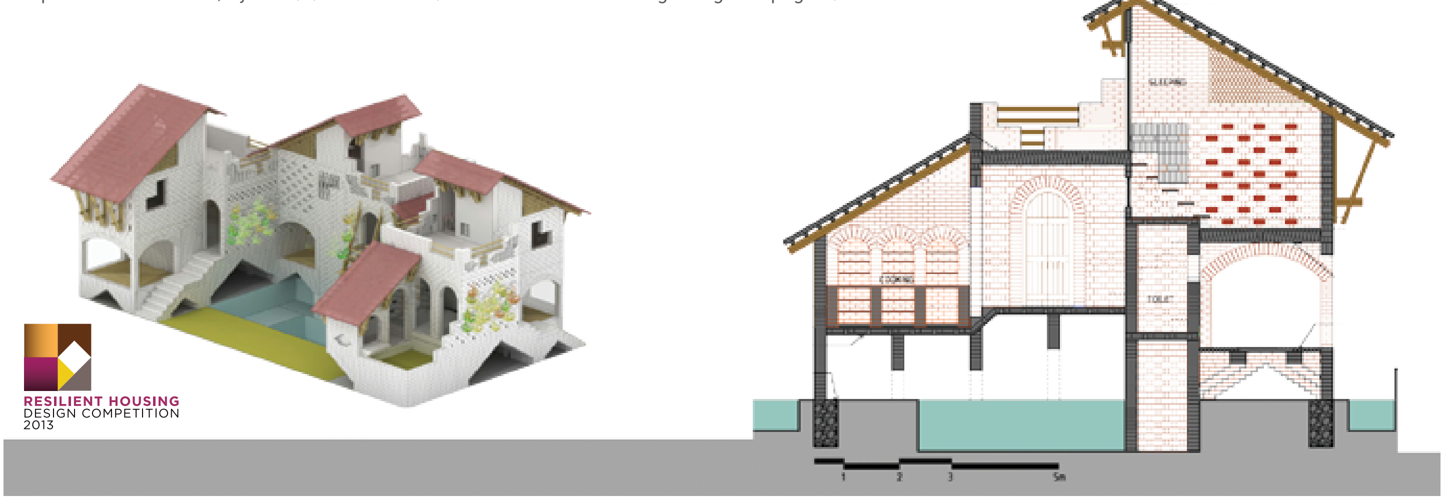
The competition required each design to include the following: one or two rooms, a kitchen, and a toilet; limit the construction costs up to Rs 500,000; consider climate resilience, environmental sustainability, and the sourcing of local materials and labor; integrate innovative construction technology that meets building codes and bylaws; and make all design considerations for low income households as the target population.

The designs were judged by a panel of three eminent architects and based on the ability to achieve the following requirements: how it addressed flood resilience problem, cost effectiveness, appropriateness of materials and technologies, innovation in concept, and detailing of design and presentation. From the many entries received, one winner was selected from two categories—professionals and students. The features of the winning entry from the professional category are discussed below to showcase the resilient aspects.

FIGURE 1

THE HOUSING DESIGN SHOWN HERE IS THE WINNING ENTRY OF THE RESILIENT HOUSING DESIGN COMPETITION 2013

Aqueous Communes, by Mad(e) in Mumbai. (See more of the winning design on page 6)



RESILIENCY ASPECTS IN THE WINNING DESIGN

In the effort to provide low-cost housing that is resilient to climate change, the winning team of architects identified design issues that were socially acceptable, cost-effective for low-income households and utilized low-cost construction techniques. The specific features of the this design that make the shelter resilient to flooding while providing comfortable living conditions include raised houses, thermal insulation techniques, and locally available construction materials. Such building features not only improve living conditions but also produce economic benefits.

<u>Raised Plinth Levels</u>

Because flooding is an inevitable hazard throughout parts of Gorakhpur, an obvious measure when building climate resilient housing includes raising houses to create space for water to flow underneath. Most homeowners raised the plinth levels of their houses after the 1998 flood that devastated a number of houses. However, these traditional plinth designs are usually enclosed brick, mud or concrete structures that provide no avenue for water to flow. While this is currently a widely used method to prevent floodwater from entering the house, the winning design integrated the use of brick corbelled arches, which act as open-plinths and do not obstruct the flow of water, but rather help with natural drainage.

<u>House Leveling</u>

In Gorakhpur, traditionally, the houses for low-income groups are single storey structures and do not have any upper levels. In the wining design, the architect understood the need for platform escapes during events when flood levels rise above anticipated levels. The first level incorporates a traditionally platform raised to 1.8 meters, which is above current projected 100-year flood levels (Singh, Singh, & Hawley, 2014). In the case of unprecedented flood heights above that limit, the occupants can utilize the upstairs bedroom as a safe location.

<u>Safe Storage Locations</u>

Not only does the upstairs bedroom provide locations for safe storage, but the design incorporates low-cost built in shelving that can hold important valuables during flooding periods.

<u>Sloping Roofs</u>

Another feature to the winning design included a sloping roof with terra-cotta tiles. A sloping roof made of bamboo rafters and terra-cotta tiles ensures that even in a heavy rainfall the water will run off the roof quickly, hence reducing the cost of the roofing as compared to reinforced cement concrete (RCC). Also, the use of terra-cotta tiles as a roofing material ensures that the house remains cooler, as the tiles reflect the sun's rays.

Temperature Reduction Strategies

In addition to flooding, high temperatures remain a common health problem. Increased climate variability, coupled with poor construction materials and design, result in high temperatures in the indoor thermal environment. This not only perpetuates health concerns but also increases energy costs. Therefore, the winning design took into account potential building techniques that increase thermal comfort while remaining financially feasible for low-income households. These included the use of rat-trap bonds for walls and jali walls. The use of rat-trap bonds for wall construction (a technique that creates space inside the wall and thus provides thermal insulation) and inclusion of jali walls for ventilation purposes would help in keeping the inside temperature low, especially during the night. In addition, less bricks are needed, therefore, cutting down on costs.

Modular Design

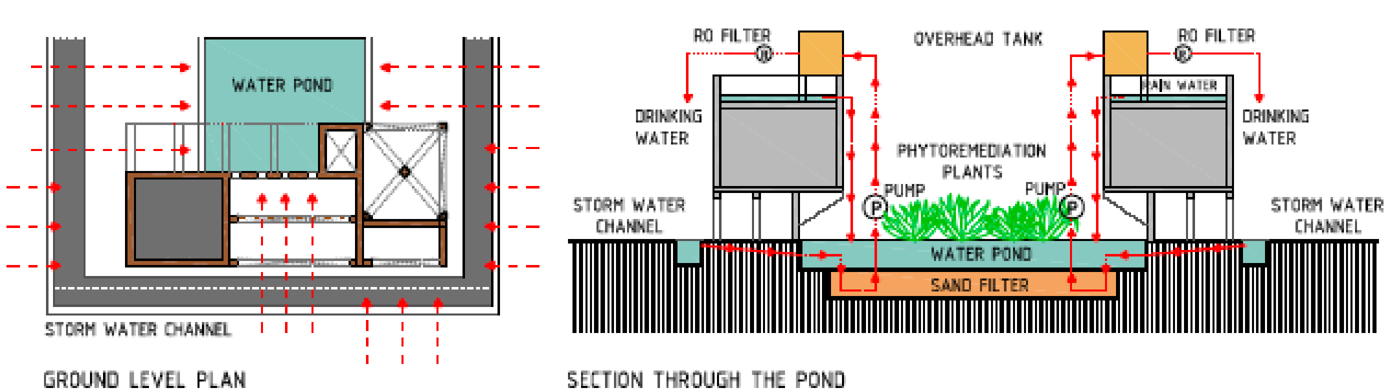
The architects have utilized creative modular designs that can be replicated to develop interconnected neighborhood houses that would also allow mobility from one location to another during flooding. The plot over time could accommodate more houses of similar structure to build a cohesive neighborhood around the ponds system. By sharing wall systems, the cost of building will also be reduced.

Water Network

The house is situated on corbelled arches (plinths) and allows for water to flow towards the pond. A stormwater drainage channel is installed on the outside of the plot, while water collected on terraces and roofs, will also be transferred to the plot. The water in the pond has a biological filtration system in place where sand, gravel and plants purify the runoff water. This runoff water is then pumped to overhead tanks on the house that can be reused for various purposes.

FIGURE 2

WATER FILTRATION SYSTEM



KEY RECOMMENDATIONS

1. **In a community that's prone to flooding, it is necessary to implement techniques that account for safe failures, redundancy and modularity, and flexibility and diversity.** In the event of a flood, having a raised plinth allows for water to flow freely while at the same time keeping occupants safe up above. Even during unprecedented flood levels, the occupants can move up to the second level in the house. This is known as a safe failure. In addition, redundancy and modularity play an important role in the ability to buffer shocks and remaining economically feasible. The raised space underneath the house that allows water to flow through can also be used for parking motorbike/bicycles during the non-flood season. In addition, although the wining design is a single house, it can be integrated with other similar structures allowing for multiple rooms, houses, or neighborhoods. This is necessary, due to the fact that most households build incrementally due to financial restrictions. Flexibility and diversity also play an important role in a number ways. Built-in shelves save costs for households and act as a storage space during flood events. In addition, building techniques such as rat-trap bonds and jali wall systems not only reduce construction costs, but also keep indoor temperatures down and promote ventilation.

2. **Necessary to build the capacity of masons in order to promote resilient housing.** Local masons are one of the key stakeholders in housing construction for low-income households. Most houses for this group are built by local masons, who also determine the designs for the houses based on current practices and their knowledge and skill level. Capacity building for masons at the local level is critical if resilient housing designs are to be promoted. In addition, consultations with local masons and architects are necessary to ascertain the local construction practices and designs used in urban and peri-urban areas and their associated costs.

3. **Awareness amongst low-income households.** While households prefer homes that are resilient to flooding and inundation, the most common option adopted is raising plinth levels. This, in the long run, will have a negative impact on inundation levels as more and more houses are built with block-plinths. There is a need to make households aware of techniques (such as corbelling, which is used by the winning architect) that are both cost effective and allow for the free flow of water during floods.

REFERENCES

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Wajih, S., Singh, B., Bartarya, E., Basu, S., & ACCCRN ISET Team. (2010). *Towards a Resilient Gorakhpur*. Gorakhpur, India: Gorakhpur Environmental Action Group. Retrieved from: http://www.acccrn.org/sites/default/files/documents/GorakhpurCityResilienceStrategy_ACCCRN_Jan2011_small_0.pdf

CHARACTERISTICS OF RESILIENT SYSTEMS

The characteristics of resilience are drawn from the Climate Resilience Framework. A robust collection of materials, including training materials, further elaborate on this conceptual framework and are available at **www.i-s-e-t.org/crf**

1 SAFE FAILURE:

Safe failure refers to the ability of a system to absorb sudden shocks or the cumulative effects of slow-onset stress in a way that avoids catastrophic failure. Safe failure can also be shown through the interdependence of various systems, which support each other—failures in one structure are then unlikely to result in cascading impacts across other systems (Little, 2002).

1a The plinth of the main living room is at a height of 1.8 m. Even if there is a flood that enters the house, the sleeping room on the second level will keep the occupants safe in the event of rising flood levels.

2 REDUNDANCY AND MODULARITY:

Interacting components composed of similar parts that can replace each other if one, or even many, fail. Redundancy is supported by the presence of buffer stocks within systems that can compensate if functions in one area of the system is disrupted.

2a This is a single house design but can be integrated with other similar structures to develop into a neatly stitched design of multiple houses or a neighborhood

2b The raised space underneath the house for water to flow can be used for parking motorbikes/ bicycles during the non-flood season.

3 FLEXIBILITY AND DIVERSITY:

A resilient system has key assets and functions physically distributed so that they are not all affected by a given event at one time (spatial diversity) and has multiple ways of meeting a given need (functional diversity).

3a The house can be expanded to have more rooms if the need arises.

3b Built-in shelves save costs for the household and act as a storage space during flood events.

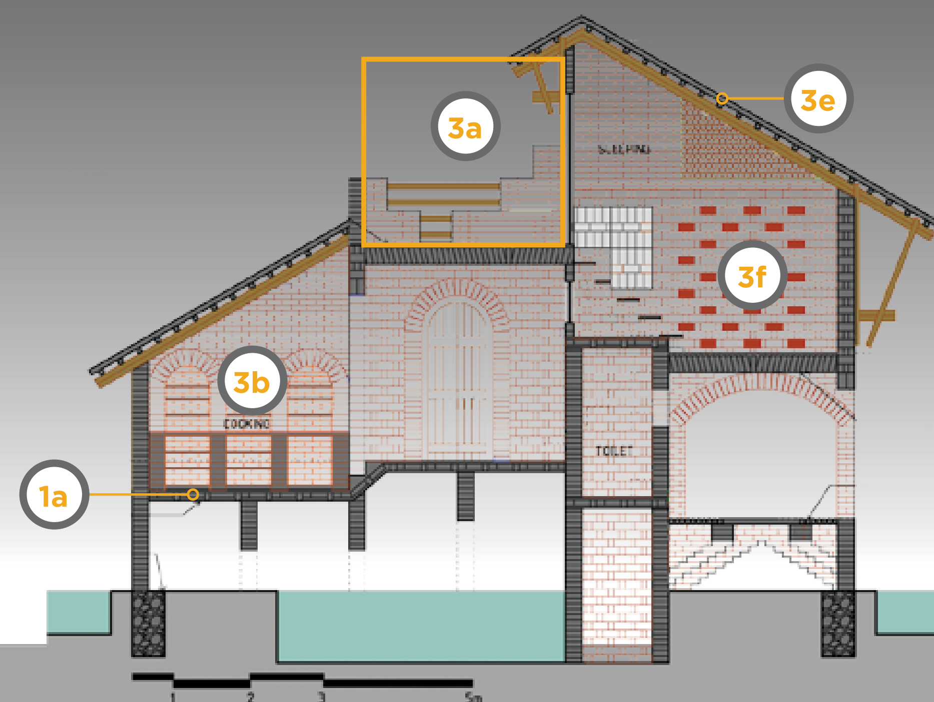
3c The vegetable garden is raised above the flood level.

3d A hanging wall garden has been integrated into the design of the house to act as an additional space for vegetable production.

3e The house has built-in design features like rat-trap bonds and terra-cotta tiles that help keep the temperatures down.

3f For better ventilation and light during the daytime, walls have been designed with slits (jali wall system).

RESILIENT HOUSING DESIGN COMPETITION 2013



The housing design shown here is the winning entry of the Resilient Housing Design Competition 2013—Aqueous Communes, by Mad(e) in Mumbai.