International Journal of Technology Engineering Arts Mathematics Science
Special Issue 1, August 2023, pp. 223-228
ISSN: 2583-1224,

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Strategies for Disaster Resilient Vernacular Architecture in the Flood-Prone Areas of Kosi Region, Bihar

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Article Information

Article history:

Received Jun 10, 2023
Accepted Dec 10, 2023

ABSTRACT

This research paper focuses on the strategies for disaster-resilient vernacular architecture in the flood-prone areas of Kosi region in Bihar. With 76 percent of the population in Bihar's northern region constantly at risk of flooding destruction, Bihar is India's most flood-prone and so frequently referred to as "Sorrow of Bihar. Vernacular architecture, which refers to the traditional buildings constructed using local materials and techniques, has proven to be resilient in such situations. This study aims to identify the characteristics of vernacular construction that make it resilient to floods, as well as to examine the challenges faced in preserving and promoting vernacular architecture in the region. The research methodology includes literature review, site visits, and interviews with architects, engineers, and local residents. The findings suggest that the ability of vernacular construction to withstand floods is due to several factors, such as the use of local materials, incorporation of flood-resistant design features, and the community's knowledge and skills in construction. However, the challenges to promoting and preserving vernacular architecture includes the lack of government support, the dominance of modern construction practices, and the changing lifestyles and preferences of the younger generation. This paper concludes that a holistic approach is required to promote and preserve vernacular architecture. This approach should include strengthening community participation, providing incentives for traditional construction practices, and incorporating vernacular architecture principles into modern construction practices. The study's recommendations can guide policymakers, architects, and engineers in developing disaster-resilient infrastructure in flood-prone areas, thereby reducing the impact of floods on communities.

Keywords: Disaster resilient, kosi river flood, vernacular architecture, housing reconstruction.

1. INTRODUCTION

The study examines the unsafe circumstances associated with conventional residences in a local community situated in the Kosi region that are vulnerable to natural disasters. Additionally, it identifies several traditional characteristics of such homes that must be maintained in future construction.

The study highlights critical deficiencies in traditional housing in terms of disaster risk reduction, revealing opportunities for new construction techniques to withstand extreme climate events.

Gujarat in India experienced an earthquake, and Bihar in India experienced flooding seven years later. putting in place housing rehabilitation schemes after a disaster.

The second-most important concern in case of climate change is an increase in riverine and inland floods, notably in parts of northern and eastern India

and neighboring countries Nepal and Bangladesh. [1] In eastern India, floods currently afflict tens of millions of people for three to six months out of the year. The scenario could become worse for extra tens of millions of people due to more precipitation and higher peak monsoon river flows. This is mostly because of the extremely high population densities in this region and the extreme vulnerability caused by a confluence of poorly designed and implemented management systems for flood prone areas, complicated land and water tenure regimes, and high poverty levels, All of which have significantly lowered the ability of millions of citizens of eastern India to cope with this during the past few decades.

1.1. ABOUT KOSI FLOOD

One-fifth of all global deaths from floods are attributable to India, one of the nations with the worst flood damage. With 76 percent of the population in Bihar's northern region continuously at risk of flooding destruction, the state of Bihar is India's most flood-prone. When it comes to long-lasting and recurrent flood hazards, the Kosi River in the northern part of Bihar plains serves as a problem. Even though for more than five decades there has been substantial flood control management in the basin, the river nevertheless causes a lot of pain through frequent floods. It is frequently referred to as "Sorrow of Bihar" because of this. One of India's most flood-prone districts is Saharsa, Supaul, Madhepura, Darbhanga however there are insufficient facilities and plans for disaster management there. Majority of the blocks are impacted by this. The kosi area has seen the most flood occurrence during the past 30 years. In the previous two centuries, the channel of the Kosi River has changed by 150km.

The Kosi River is known as the "Sorrow of Bihar" as it frequently alters its path as it flows from Nepal to Bihar, resulting in flooding and extensive human suffering in the past. The flood in 2008 affected 26 lakh people and 700 hectare fertile land in India and Nepal. Almost three million people, dispersed among 995 villages in the seven districts of the Kosi region—Supaul, Araria, Madhepura, Saharsa, Purnia, Khagaria, and Katihar—were victims of an unprecedented tragedy. The flood damages infrastructural facilities and hundreds of villages were submerged. Based on information from GOB, a total of 236,632 houses were completely or partially ruined in Supaul, Madhepura, Saharsa, Araria, and Purnea districts, with an estimated cost of damage of INR 5,93.5 crore. The highest level of destruction was found in the first three districts, which accounted for more than 95 percent of the reported damage. [2]

2. FLOOD RESILIENT CONSTRUCTION

Making room for water and dealing with floods are two concepts that are explored and through these ideas, the integrated approach to flood risk management has grown to be generally accepted, and flood resilient construction has become a crucial part of it. Although resilient building has been used for millennia, it has only recently been recognized as a part of a more comprehensive flood risk management strategy. Since buildings and the greater built environment are known to be essential in the management of flood risk, it is clear that protecting these is required when buildings are situated on or near flood plains.

The flood risk mitigation techniques can be developed using five major characteristics which are as follows: [3]

1. Location and Orientation
2. Plan arrangement
3. Superstructure
4. Substructure
5. Services

Raising the plinth above the flooding surface is the best way to safeguard a building in a flood-prone area. One of two methods—elevating the entire building on a high plinth, earth mound, or sturdy stilts with apertures that would allow floodwaters to pass underneath—can be used to do this.The plinth component of the foundation needs to be sufficiently elevated to prevent flood water from entering the buildings. Long-wall structures are more brittle, more prone to flooding, and more likely to accumulate debris. [4].

There are three primary approaches to tackle flood: [5]

1. avoidance
2. water exclusion
3. water acceptance

2.1. AVOIDANCE

Avoidance is most preferred which can be achieved by elevation, landscaping, drainage, retention features, barriers, etc. Buildings can be elevated by raising on pillars, or earth structures. For wooden construction raising on pillars is a good option.

2.1.1. AVOIDANCE STRATEGY

Using earthworks, floating homes, and raised buildings are a few examples of avoidance tactics.

Property level flood resilience" is a growing concept in the UK, which admits that in some situations a hybrid strategy would be preferable in which the amount of water entering a residence is reduced along with the expected damage that is produced.Advances in technology and understanding are being driven by a deeper understanding of the benefits of integrating approaches and property-level measures that incorporate water-resistant and robust materials. The process of resilient repair and mindful reinstatement, which recognises the need to dry, clean, and repair flood-damaged buildings, is another element that is starting to take shape.The requirement of using materials that dry quickly and are simple to disinfect, as

well as the importance of efficient and appropriate and on time drying of characteristics, has increased.
Future advances are anticipated to focus on encouraging the adoption of flood-resilient technologies and materials for both new construction and for retrofitting and adapting existing structures. The adoption of measures would be supported by further advancements in flood resistance technology that improve the aesthetic appeal of modified property.

Floating Houses - Houseboats in Kashmir are great examples of floating houses which are free to move both in horizontal as well as vertical directions. [6]

Lift House - A housing option for communities at risk of flooding is the Lift House. Innovatively designed home floats with floodwater as it rises and sinks back to the earth as it recedes.
The building adjusts to floods rather than obstructing water flow. The concept of flood mitigation is applied to small-scale residential modifications. By creating buoyant foundations, amphibious architecture provides a safe, affordable alternative to permanently elevated structures.
The static Service Spine and the Amphibious Units make up the two components of the Lift Home. The service spine, a static building made of brick and concrete that offers the two homes vertical guidance and stability while the houses float on water, is connected to the two amphibious bamboo units on buoyant foundations.

Dwelling Mounds - Early homes were constructed on terps, or dwelling mounds, in the low-lying areas of the Netherlands [7]. Individual clay mounds were also used in the United Kingdom (e.g., Glastonbury) [8], as well as crannogs made of stone, earth, and wood in Ireland (9).

Raising on Stilts - Raising on Stilts - The United States is pushing the flood mitigation strategy of permanently elevating homes in South Louisiana.
In hot, muggy circumstances, raising on braces advances unhindered air flow and forestalls flooding. Raising on masonry or concrete produces avoidance and is frequently more stable in high-velocity flooding. In later developments, individual homes were raised without the use of earthworks, such as in Thailand's traditional stilt house and Queenslander-style homes in Australia.

Amphibious Housing – A tried-and-true, low-cost, low-impact flood protection approach is amphibious foundations. (E, 2009) A look at floating docks and houseboats suggests an alternative strategy that would allow a house to remain close to the ground in normal conditions while rising as much as necessary when flooding occurs, even if far above the BFE (base flood elevation).
Clusters of amphibious housing have been operating dependably for over thirty years in rural parts of south Louisiana. One such place is Pointe Coupee Parish's Raccourci Old River. The water level of Old River Lake fluctuates in response to the Mississippi River's spring floods because it was once a branch of the Mississippi and is still joined to it at one end.
Locals and vacationing fishermen devised an amphibious foundation system that has kept their homes and fishing camps dry for more than three decades Under the home, which has been raised to an elevation of three to four feet above the ground, large blocks of EPS—also known as styrofoam or expanded polystyrene—are secured. Near the house's corners, long poles or pipes are buried in the ground. When flooding happens, the EPS blocks raise the house. The home can rise and fall with the level of flooding thanks to sleeves that have been attached to the structural frame of the building around the poles.

2.2. WATER EXCLUSION

Strategies for excluding water from a structure are often referred to as resistance and dry flood proofing. Sandbags and improvised flood boards are regularly utilised by the indigenous population to stop the water from entering during emergency situation. These are temporary methods that are frequently used. It is designed in such a way that it prevents flood water from entering the structure and minimize the impact. It also gives occupants more time for relocation. While sandbags and other temporary solutions may slow infiltration and damage, they are neither sufficient nor long-lasting.

Figure 1 Lift House (Prosun Architects)

Figure 2 Amphibious Housing in Louisiana

2.3. WATER ACCEPTANCE

The last option for limiting damage after water has entered the building is the water acceptance approach. This is diversely referred to as water acceptance wet proofing, flood resilience, or wet proofing and entails using techniques to reduce damage when water has entered an occupied space through a structure's exterior and bypassed the building envelope. In the past, water was just welcomed and washed out of structures. The "traditional" ways, however, are no longer adequate due to the increased technology contained in buildings and building services. The techniques to enter water can be categorised into four categories: avoidance, resistance, resilience, and speed of reoccupation.

Water acceptance technology is also known as water entry, flood resilience, wet proofing, etc. This technology is useful when there is ingress of water in the building premise. The idea here is to minimize the damage to the built structure. This technology has various approaches like resilient, resistance, avoidance, speed of reoccupation, etc. (Lamond et al., 2016). Another practice commonly used is flood resilient floors. Channels are placed in the floor and as water enters the building, it is flushed out from these channels thus saving the structure from excess flooding. Flood-resistant floors come in three basic varieties: suspended timber floors, solid concrete floors, and suspended concrete floors. [10]

3. METHODOLOGY

The purpose of the research is to investigate the construction technology and disaster-resistant performance of vernacular homes and propose strategies or guidelines to be followed in kosi flood region of Bihar. Literature review of existing disaster-resilient settlements or housing in different parts of the world to understand the various techniques of disaster-resilient construction.

A thorough examination of literature regarding rebuilding homes after disasters in developing nations revealed the profound effects of such calamities on housing, as well as the difficulties involved in the reconstruction process.

This paper presents strategies for disaster resilient housing in flood-prone areas of kosi region. Flood-resilient technologies will be identified in the dwellings around the world.

4. FLOOD-RESILIENT CONSTRUCTION MATERIAL

The homes in Nepal's western mid-hill region have been found to use earthquake-resistant technologies. The traditional homes in this area are constructed utilizing stone masonry, which offers considerable earthquake resistance. In order to distribute the pressures of an earthquake and prevent collapse, the dwellings are also built low to the ground, with few windows, and sturdy walls. These homes are frequently constructed out of thatch, mud, and bamboo on elevated plinths.

5. VERNACULAR ARCHITECTURE OF KOSI REGION

Vernacular architecture of the kosi region comes mainly from locally sourced natural materials which are mud, khar or phoos (straw and reed), wood, bamboo, taad (asian palmyra palm), shisham (Dalbergia Sisoo), cow dung, etc. (Alam, 2021) Other construction materials include khapda (pot tiles), sun-dried bricks as well as fired clay bricks, lime, etc. In recent times due to modern construction technology and maintenance issues, there is a huge loss of vernacular architecture. Most of the houses are made of mud, bamboo, straw and reed, which gets flooded easily.

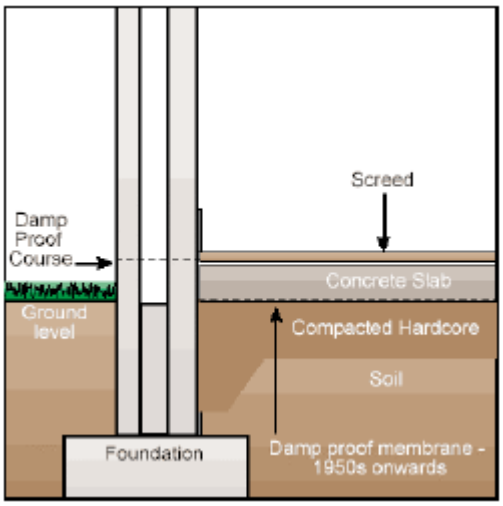

Figure 3 Example of Flood Resilient Floor - Solid Concrete Floor (CIRIA, 2003)

Figure 4 Vernacular Architecture in Kosi region (Alam, 2021)

Figure -5 Houses inundated in flood water

6. RESULTS AND DISCUSSION

The kosi region which is being flooded annually needs slightly different approach as the kosi river keeps changing its course. Flood resilient construction techniques used in various parts of the world as seen in the literature review can be of little use due to financial challenges.

Communities traditionally and naturally house themselves through vernacular buildings. As a reaction to social and environmental restrictions, it is a continual process that includes essential modifications and constant adaptation.

Based on the concept of the vernacular given above, buildings show a response to environmental limitations. In the case of the Kosi region, the reactive actions to the flood danger would be changes to the conventional methods of designing and building homes. This study intends to propose flood risk reduction measures in the design of vernacular dwellings and their building systems.

7. CONCLUSION

Adaptive strategies include stilt houses, floating construction, masonry walls of different materials and thickness, floodable ground floor, perimeter walls, orientation in mainstream direction.

Construction should be avoided on the floodplain (Proverbs & Lamond, 2017).

The vital information and qualities ingrained in vernacular architecture should not be disregarded or overlooked. The goal should be to find and develop new interpretations that can be implemented into contemporary design approaches. Similar to local customs, this kind of information is unique to a certain area.

Strategies for building flood resilient structures:

1. Choosing the highest location for construction of houses.
2. If the whole structure cannot be raised at least one room should be raised above the flood water.
3. Plinth should be raised above the flood water level
4. Construction on stilts will allow flood water to pass below the main structure.
5. Foundation should be deep to prevent undermining.
6. Long walls should be avoided and if constructed should run parallel to the flow of water.
7. Opening should such that it should allow flood water to flow through the structure,
8. The roof ought to be sturdy enough to withstand the weight of the structure.
9. Conducting risk assessment to improve decision making process and action planning.
2. Communities and local governments need to work together on vernacular solutions

Reconstruction Strategies

Following the Kosi River floods of 2008, the state of Bihar launched an Owner-Driven Reconstruction (ODR) strategy. The goal was to pinpoint "key processes" or the efficiency of ODR strategies that improve the long-term resilience of lodging to disasters and community sovereignty. [1]

8. REFERENCES

[1] Revi, Aromar. "Climate change risk: an adaptation and mitigation agenda for Indian cities." Environment and urbanization 20.1 (2008): 207-229.

[2] Singh, Manoj, Not Everyone Is Happy With New Embankments On The Kosi In Bihar, https://thewire.in/politics/kosi-river-embankments-bihar. [Accessed Apr. 5, 2023]

[3] Dilhani, K. A. C., and N. Jayaweera. "A study of flood risk mitigation strategies in vernacular dwellings of Rathnapura, Sri Lanka." Built-Environment Sri Lanka 12.1 (2016).

[4] Haekesbury - nepean floodplain management steering committee (2006). Reducing vulnerability of buildings to flood damage guidance on building in flood prone areas, http://www.ses.nsw.gov. au/contents/documents

[5] Lamond, J., Rose, C. & Proverbs, D. (2016b). Supporting the uptake of low-cost resilience: Rapid evidence assessment final report (FD2682). London: Defra.

[6] Mustaqeem et al, “Flood Resilient Houses-For Flood Prone Kashmir,” in Journal of Architecture and Civil Engineering, Volume 6 ~ Issue 4 (2021) pp: 34-38.

[7] Beeftink, Willem Gerrit. "The ecological significance of embankment and drainage with respect to the vegetation of the south-west Netherlands." The Journal of Ecology (1975): 423-458.

[8] Barrett, C. F. "Acid deposition in the United Kingdom 1981-85: a second report of the United Kingdom review group on acid rain." (1987).

[9] O'Sullivan, Aidan. "Exploring past people's interactions with wetland environments in Ireland." Proceedings of the Royal Irish Academy. Section C: Archaeology, Celtic Studies, History, Linguistics, Literature (2007): 147-203.

[10] Improving the flood resistance of your home , CIRIA 2003
[11] Vahanvati, Mittul & Beza, Beau. (2017). An Owner-driven Reconstruction in Bihar. International Journal of Disaster Resilience in the Built Environment. 8. 10.1108/IJDRBE-10-2015-0051.
[12] Alam, Md Shahroz. “Loss of Vernacular Architecture in Kusmhi Village” (2022)
[13] Prosun Architects. https://www.prosunarchitects.com/lifthouse/reo9440ejnb98zovll2lr40vbu5tug