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Utilizing indigenous knowledge for flood prediction and mitigation in Assam: a framework for sustainable disaster management

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Abstract

Assam, located in northeastern part of India, is faced with annual cycles of flooding create havoc upon many millions of lives each year. This paper examines the potential of infusing indigenous systems of knowledge with contemporary disaster management strategies to create a sustainable framework for managing and predicting of floods in Assam. It argues that through the study of indigenous systems of knowledge, community-based practices and local forecasting systems, indigenous knowledge systems can contribute significantly to traditional 'Scientific' methods of "Flood Disaster Management". This paper suggests a composite framework combining indigenous knowledge systems with modern technology for the purpose of creating a framework with significant focus on participatory processes, building community resilience and ensuring subsequent ecological sustainability. The result of this paper indicate that the inclusion and organization of indigenous knowledge systems will considerably improve Flood Disaster Management strategies while enhancing social equity and protecting the environmental resources in Assam.

Keywords: Indigenous knowledge, flood management, disaster mitigation, traditional ecological knowledge, community resilience, sustainable development

1. Introduction

Assam is home land of numerous tributaries. The river Brahmaputra and Barak with their tributaries the state suffers from worst and most frequent flood. Every year, the Brahmaputra River system floods about 3.2 million hectares of land and impacts more than 4 million people resulting in a loss of economic resources (Goswami, 2020). The geographical setting's, high rainfall amounts, seismic activity and diverse river systems greatly contribute to Assam's susceptibility to flood disaster. Climate change has increased the frequency and severity of flood throughout the world which increase the difficulties faced by disaster management agencies (Mishra et al., 2021).

Although major advances in contemporary period many advanced flood management infrastructures have been made many areas in Assam still subject to recurrent flood damages. The growing recognition of the shortcomings of flooding control measures based solely on technological advancements has prompted

researchers and government officials to explore additional solutions and sustainable methods of managing flood in order to better meet the ecological environment, local communities' requirements and traditional flood coping strategies (Dutta & Borah, 2019).

Generation after generation, Indigenous communities have gained knowledge through their interactions with their environment. Rather than looking at just the scientific methodology of predicting, preparing and properly managing floods, the indigenous communities used a systematic way to gather and evaluate this information through their community's cultural practices and traditions. For example, the people of Assam have a good historical perspective of how to read their rivers. They also have knowledge how the weather will be changed through various different seasons and how various natural indicators help them to know when the floods are coming. This information has been passed down through oral tradition and is integrated in the culture and practices of the Assamese.

By implementing the integrating Indigenous knowledge into flood management systems, management practices in Assam will enhance the level of sustainability, efficiency and equity in the region. This paper includes three primary components: to document, evaluate and analyze the flood prediction and flood management practices that exist in Assam. It will identify the opportunities and barriers that subsist with the integration of Indigenous knowledge and practices into contemporary disaster management systems. It also develops a comprehensive holistic framework for the sustainable management of floods that includes the use of Indigenous wisdom and modern-day technologies.

2. Theoretical Framework: Indigenous Knowledge and Disaster Management

Indigenous or Traditional Ecological Knowledge (TEK) is how people in a given area adapt to their environment and learn from each generation what would be good for them as compared to the past. Indigenous people have over thousands of years interact and utilize their natural resources. The way TEK is used and learned which is not through any written text. It is learned and passed down orally and through the practice of one's culture. TEK continue to change and adapt based on observation, experimentation and interaction with the environment.

In the context of disaster management, TEK can aid in many ways. TEK can alert people close to disaster, often by using the way the animals interact with their environment prior to an event. Animals often behave differently before natural disasters (severe storms or earthquakes). Both plants and animals rarely bloom or flower differently at different times based on environmental conditions and climatic events. TEK provides an example of local strategies for mitigating disaster, using the resources available in their local ecology. For example, TEK can help Indigenous communities develop their own strategies and plans for disaster recovery using natural methods rather than engineered solutions. TEK aids in building stronger communities through preserving and utilising social networks and collective memory and retaining cultural identity and history, which in turn strengthens communities’ ability to recover from disasters.

International Policy Frameworks have recognized the significance of traditional (indigenous) knowledge & Scientific Methods related to Disaster Management (like The Sendai Framework for Disaster Risk Reduction 2015-2030- UNDRR, 2015) state that traditional knowledge needs to be used for reduce disaster risk. Yet many practical barriers exist that make it difficult to apply this concept of integrating indigenous & scientific knowledge. The differences in the way IKS disseminate 'Knowledge' imbalances between

indigenous people and those who research it and institutional barriers to integrate traditional knowledge within disaster management institutions (Gaillard & Mercer, 2013).

This research's theory framework is based on the co-production of knowledge. Knowledge can be co-produced by engaging both scientific methods and traditional Indigenous Knowledge Systems. It is equally valid sources of information through collaborative efforts and respecting the unique ways of knowing of each Source (Armitage et al., 2011). This collaborative approach allows for the valuation of both indigenous & scientific knowledge systems without limiting their influence on the process of creating appropriate environmental solutions.

3. Floods in Assam: Context and Challenges

Assam's flood situation is complicated, serious and recurring. Rainfall in the state averages 2,818 mm annually with 80% occurring during the monsoon (June-September) Indian Meteorological Department (IMD) (2019); the Brahmaputra River runs approximately 720 km through Assam (one of the largest rivers in the world) and as a result creates a very vulnerable floodplain.

The severity of flood in Assam is determined by a combine of factors. The Brahmaputra River carries a large sediment load from the Himalayas which causes the riverbed to continually aggradations (Sarma, 2005) and also continues to change the morphology of both the channel and banks. This results in frequent channel shifts, erosion of the banks and reduced capacity of the river. Secondly earthquakes cause subsidence of the land and therefore change the drainage pattern of the area (Goswami, 2020). Thirdly deforestation in the upstream catchment has caused increased surface runoff and peak flood flow (Das et al., 2018). Lastly the variability and extreme precipitation events associated with climate change have rendered flood patterns even more unpredictable (Mishra et al., 2021).

The current flood management strategies used in Assam have mainly relied on structural solutions like the construction of embankments on large rivers to mitigate flood. However, this strategy has had limited success and has created additional problems in some areas. In addition to preventive the natural flow of floodwaters the presence of embankments increases the rate at which sediment is deposited within the river and increases the risk that the embankments will fail (Goswami & Das, 2020). The majority of flood management projects are planned in a "top-down" manner, often disregarding the needs and challenges faced by local communities and ignore to include local communities' input. Ultimately the flood management systems cannot meet the unique needs of the communities for which they were designed and ultimately become unsustainable (Hazarika, 2019).

4. Indigenous Knowledge Systems for Flood Management in Assam

Over the centuries various communities of the state has constant interaction with the Brahmaputra River and its tributaries. They are well acquainted with the complex systems and therefore they can predict the arrival of floods and prepare for them and mitigate the impact. These knowledge systems are comprised of numerous components that include environmental indicators, traditional forecasting methods, architectural adaptations, livelihood diversification, organisation of the community etc.

4.1. Traditional Flood Forecasting Methods

Traditional flood forecasting methods in Assam monitor environmental index to predict the arrival of floods their severity and how long they will last. Examples of these environmental indicators include animal behaviour e.g., ants moving to higher ground, birds showing strange behaviour e.g., fish swimming erratically or an increase in snake and frog activity (Sarma, 2018). In addition, certain plant species are also important indicators of the arrival of floods. An early flowering of certain tree species for example, indicates the imminent arrival of floods (Deka & Nath, 2021) .

Elders living on riverbanks observe atmospheric indicators and hydrological indicators to forecast the predictions of the floods. As such they observe atmospheric indicators (cloud formations, wind patterns, colour and smell of the water) and Hydrological Indicators allows the elders to anticipate a flood events (Bhuyan et al., 2017)

The way in which agrarian societies time their agricultural activities using the traditional calendar, based on lunar cycles, allows them to prepare for the flood season. Traditional flood forecasting methods are highly tuned to local conditions and can often provide a warning time that is greater than would be provided by formal forecasting methods (Hazarika, 2019).

4.2 Traditional Architectural and Settlement Patterns

Assam's Indigenous Architecture demonstrates of flood and flood dynamics. The indigenous people of Assam *built Chang Ghar* made from Bamboo and other materials easily found in their natural environment. The *Chang Ghar* allowing floodwaters to pass below while keeping the inside dry. The use of lightweight, adaptable materials provides flood mitigation and reconstruction following floods (Borthakur, 2020).

The plan of the Indigenous communities reveals their knowledge of assessing flood risks. They used high ground (i.e., Natural Levees) where possible to build their villages while irrigation fields are located in the low-lying flood-prone areas (Sarma, 2018). The way in which these areas are zoned indicates the communities view floods as both a hazard and a potential resource. The communities capitalize the nutrient-rich floodwaters and minimizing risk to human settlement.

4.3 Livelihood Diversification and Agricultural Practices

The adaptive livelihood strategies of the indigenous people are different. It provides the local people ability to adjust and respond to the flood. By growing mixed crops of vegetables and pulses along with flood-resistant rice types they are able to minimize the risk of losing all of their crops due to flooding (Deka & Nath, 2021). Traditional rice types like Bao or Boro are called deep-water varieties that can bear prolonged periods under water. People in the communities also practice several different types of economic activities like fishing, raising animals, making crafts and gathering non-timber forest products that provide other sources of income during periods of lost crops from flooding (Das et al., 2018).

Flood-based agricultural practices are a new method for the people of these communities to use temporary flooding and sediment from floods to create fertile land for growing crops. An exceptional way of growing vegetables on floating beds made from aquatic plants and water hyacinth (known as dhap cultivation), allows these communities to cleverly utilize flood conditions for their economic needs and the environment (Bhuyan et al., 2017).

4.4 Community Organization and Social Capital

Flood management in the state of Assam is rooted in the social institutions and community organisations of the indigenous people. These include village councils that operate as traditional governance structures which provide for the preparation, rescue operations and recovery from flood (Hazarika, 2019). These structures maintain a corporate memory of past flooding events, transmit traditional knowledge to future generations.

Social networks and reciprocity systems provide the basis for community adaptation to the impact of flood. Households sharing resources during flooding, providing shelter to displaced families and working together on rescue and relief efforts are examples of these informal support structures (Borthakur, 2020). While these informal support systems assist with immediate flood impacts, they are also used in conjunction with and often prior to formal disaster response systems.

5. Integration Challenges and Opportunities

Indigenous Knowledge can be extremely beneficial for flood management. However integrating indigenous and modern scientific knowledge systems has shown to have numerous challenges. Often there are significant epistemological differences between these two types of knowledge which may negatively impact communication and collaboration (Gaillard & Mercer, 2013). While Indigenous Knowledge relies on a holistic approach with qualitative data and cultural context. Scientific knowledge is based on a theory using measurable quantities and providing universal principles. Misunderstandings of Indigenous Knowledge by technical specialists and policymakers may arise due to these significant differences.

The power imbalances are significant challenge as scientific and bureaucratic authority dominates disaster management institutions and provides limited participation for indigenous communities in the decision-making process (Dutta & Borah, 2019). The social process of indigenous communities can result in indigenous knowledge being labeled as "unscientific" or "outdated," even though such knowledge has effectively been demonstrated in the local context. The limitations of language, documentation of Indigenous Knowledge, and the oral transmission of Indigenous Knowledge further hinder attempts at integrating with the modern scientific approach.

Existing indigenous forecasting techniques can increase formalized early warning systems by delivering more relevant information specific to each individual community (Mercer et al., 2010). There are many traditional indigenous architectural designs and settlement planning principles that can assist in culturally acceptable and ecologically sustainable land use regulations, building codes and land-use planning principles. Furthermore, traditional indigenous methods of creating livelihoods could provide a valuable guide for the development of climate change resilient agriculture models and diversified livelihoods (Sarma, 2018).

The ongoing shift towards using ecosystem-based disaster risk reduction approaches correlates very well with the focus of indigenous knowledge systems on working with nature instead of against it (Renaud et al., 2013). For example, an ecosystem-based disaster risk reduction approach would not only use the traditional knowledge to develop disaster risk reduction measures based on wetlands, riparian forests or sustainable land usage. They also coincide with many of the principles of working alongside the environment to develop better sustainable disaster risk reduction measures. Additionally, the participatory nature of indigenous knowledge systems provides opportunities for the empowerment and inclusion of local communities in disaster management.

6. **A Framework for Integrating Indigenous Knowledge in Flood Management**

The analysis of the integration and local knowledge systems in Indigenous Communities leads to this comprehensive framework of sustainable flood management in Assam. The framework incorporates indigenous wisdom along with modern scientific approaches based on five pillars i.e. participatory knowledge co-production, hybrid electronic warfare systems, ecosystem-based mitigation, community-based preparedness and institutional reform.

6.1 Participatory Co-production of Knowledge

In order to create a framework for sustainable flood management, a collaborative approach must take place. The framework should serve as a means of bringing together indigenous knowledge holders and scientific researchers on disaster management practitioners. The policymakers to create an equal partnership in the development of the framework through the creation of opportunities for these groups to engage in regular constructive conversations learning from each other solving problems collectively (Armitage et al., 2011).

Community-based Participatory Research (CBPR) will be critical for creating a platform for communities to collect and document Indigenous Knowledge. This manner the culturally appropriate and respects local cultural protocols, intellectual property rights and cultural ways of knowing (e.g., "traditional" ways of knowing).

Joint field observations are an example of knowledge co-production because it allows both scientists and the community to collaborate with each other to monitor environmental indicators (e.g. indicators linked to climate change), validate "traditional" forecasting methods, document flooding patterns from indigenous communities and identify the processes through which flood occurs. It allows scientists to improve their scientific literacy regarding local flood dynamics, while building community confidence in and validating indigenous knowledge systems (Berkes, 2018).

6.2 Hybrid Early Warning Systems

This model discusses how to improve the timeliness of warning capacities by combining modern weather forecasts with Traditional Environmental understanding (TEK) or indigenous peoples' understanding in a hybrid system. For instance, Indigenous forecasts are electronically gathered by trained locals and routinely shared with the disaster response agency or agencies (Dekens, 2007). Additionally, early warning information must be disseminated to communities by disaster management organizations in customary ways including in the local language.

Communication between the community and disaster management agencies may take place through the use of mobile technology and community radio stations. In order to produce locally relevant warnings using indigenous symbols and modern forecasts a community-based early warning system should have a committee of traditional knowledge keepers along with trained individuals (Shaw et al., 2009).

6.3 Ecosystem-Based Mitigation

Instead of depending solely on structural solutions this framework promotes the use of ecosystem-based methods to support natural flood processes by restoring wetlands & floodplain forests, implementing sustainable land-management techniques in upstream catchments and establishing ecological "corridors"

that permit natural river processes (Renaud et al 2013). The more traditional methods for managing floods e.g. bamboo plantings on riverbanks to prevent soil erosion, beel (oxbow-lake) flood/stage water retention & chapori (island associated with a river) vegetation protection should also be used as an integral part of local flood management plans. Local traditional ecological knowledge e.g., local plant species' suitability and their planting, maintenance techniques can help promote ecosystem restoration efforts (Deka & Nath, 2021).

6.4 Community-Centered Preparedness

The community-based framework approved by the Government of Canada on utilize a community-based approach to develop disaster preparedness strategies. This involves building on traditional indigenous practices and providing greater access to contemporary methods and technology. This change livelihood diversification based on local knowledge and market opportunities. It promotes traditional housing designs with better materials and construction techniques and setting up community-managed resource banks that contain equipment, emergency supplies and seeds of flood-resistant crop varieties (Borthakur, 2020).

Disaster preparedness through education will also involve integrating traditional Indigenous knowledge into school curricula and community-based training programs. To facilitate the transfer of traditional indigenous knowledge to younger generations, projects that document this information, cultural festivals that celebrate traditional ways of life and the relationship between elders and youth through mentorship programs can be created (Hazarika, 2019).

6.5 Institutional Reform

Significant changes must be made to both the systems used to regulate disasters and the management in order to successfully integrate Indigenous Knowledge into Disaster Management Governance. Institutions in charge of disaster management governance should grant legal recognition to Indigenous peoples' rights to Indigenous Knowledge, allow indigenous communities to participate in local, regional and national disaster management committees and grant local institutions the power to make disaster management decisions (Gaillard & Mercer, 2013).

It is essential that all Policy Frameworks require consideration of Indigenous Knowledge as a component of EIA´s [Environmental Impact Assessments] Flood Management Planning and Disaster Response Protocols. Capacity building for Government Officials and Technical Experts on indigenous knowledge systems must include training on: Indigenous Knowledge Systems, participatory approaches and cultural competency (Dutta & Borah, 2019).

7. Implementation Strategies and Recommendations

In different levels, actions must be taken to achieve the proposed framework for Indigenous Knowledge Integration. The Assamese Government should develop a comprehensive Indigenous Knowledge Integration Policy at the policy level that establishes legal and institutional structures for recognizing and using traditional knowledge in disaster management. As part of this policy, benefit sharing, protection of intellectual property and protocols for community consent should be included.

Pilot projects should be done for the information of flood-prone areas to demonstrate the effective of integrated approaches. These projects should operate as learning laboratories that allow testing, evaluating

and refining different models of integration based on feedback from communities and performance outcomes (Mercer et al., 2010). Once proven successful these models can then be replicated in other areas.

Both communities and government institutions need to build up their capacity for success in this regard. Community-level training programmes should be designed to strengthen documentation of Indigenous Knowledge, improve communication of early warning systems and teach leadership skills for disaster management. Government should encourage capacity building in participatory methodologies, intercultural communication and an adaptive management approach (Shaw et al., 2009).

Indigenous Weather Forecasting Methods to be backed with research-based evidence through the R&D process. Conducting research on the effectiveness of ecosystem-based mitigation approaches. Evaluating the different integrated approaches, the universities and research organizations located in Assam will need to create programs to study Indigenous Knowledge and how it can assist with disaster management and create partnerships between the academic and community sectors (Sarma 2018).

To support the integration of Indigenous Knowledge into Disaster Management, Financial Mechanisms must be put in place. Financial Mechanisms include creating budgets that allow for the allocation of financial contributions for disaster preparedness activities, establishing community-managed finance accounts for disaster preparedness. Mobilizing resources through climate adaptation & biodiversity conservation programs that recognize the co-benefits of integrating Indigenous Knowledge into disaster management (Renaud et al., 2013).

8. Conclusion

The recurring floods in Assam highlight the need for innovative and sustainable approaches that go beyond technological solutions. Indigenous Knowledge systems have a lot to offer in regard to flood prediction, mitigation and adaptation knowledge that has sustained communities living with floods for centuries. The depth of sorting out environmental indicators, developing traditional forecasting methods, modifying buildings, adapting livelihoods and connecting communities through Indigenous Knowledge are of great benefit to communities managing disasters.

Challenges and opportunities exist in using Indigenous Knowledge as the basis for modern scientific knowledge. There are issues due to an inability to integrate them because of differences in how Knowledge is unequal power and institutional barriers. The increasing recognition of Ecosystem-Based Approach (EBA), Participatory Governance (PG) and Building Community Resilience (BCR) offers viable conditions for synthesizing the two knowledge systems into one. The framework for sustainable management of floods in Assam includes participatory knowledge co-production, a hybrid Early Warning System (EWS), Ecosystem-Based Mitigation (EBM), Community-Centered Preparedness (CCP) and Institutional Reform (IR). These areas provide an opportunity to build on the inverse strengths of Indigenous Knowledge Systems (IKS) and Scientific Knowledge Systems (SKS).

For the successful establishment of this framework, there must be support from the governments, researchers, NGOs and most notably the Indigenous communities themselves. There will also be an overall shift from the traditional disaster management style of a top-down, technological and governmental approach to a participatory, multi-vocal form of disaster management, where Indigenous communities are viewed as active participants in the disaster process not as a passive audience.

The inclusion of Indigenous Knowledge will result in not only improved flood management, but also an unequal distribution of social equity, as Indigenous communities will receive recognition for their knowledge and contributions. The integration of Indigenous Knowledge into disaster management will ultimately enhance environmental sustainability through ecosystem-based approaches to flood management (working with nature). In addition, the preservation and transmission of Indigenous Knowledge to subsequent generations will reinforce the importance of Indigenous culture and maintain cohesion within Indigenous communities. By integrating Indigenous Knowledge into disaster management, Assam will have a direct path toward achieving social justice, sustainable development and increased resilience to flood.

Climate change has made flooding management increasingly difficult and increased the importance of Indigenous Knowledge systems that have developed over generations as a result of management practices for maintaining a relationship between individuals and the environment. The Indigenous Knowledge systems of Assam have developed over centuries methods for coping with floods based on the region's ecosystem and community. The inclusion of these knowledge systems into contemporary disaster management methodologies will serve as both an ethical duty and an effective means of developing flood resilient Assam.

Conflict of Interest: *The author declares no conflict of interest.*

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