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# A Multi-Domain Assessment of Flood Adaptive Capacity: A Case Study

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**ABSTRACT** Enhancing flood-affected people's adaptive capacity is necessary as structural measures fail to mitigate its impacts. This research investigates the flood-coping ability of the selected population of Barak Valley, Assam, utilising ten indicators distributed across six adaptive capacity domains. The data obtained from household surveys indicates limited access to credit (46%) and remittances (34%), and moderate saving rate (52%) in the asset domain. Very few respondents (12.4%) experienced occupational changes in the livelihood flexibility domain, but 55.6 percent engaged in multiple economic sectors. Social organisation is robust, with a significant portion of respondents (60.2%) affiliated with local institutions and trusting government organisations. In the agency domain, many believed participating in local decision-making was relevant (57%). Regarding flood risks, the majority (76.7%) believed they were worsening. Adaptive capacities exhibited variations across domains, with their distribution notably influenced by the income levels of households.

## INTRODUCTION

Flood causes the most damage to infrastructure, homes, and livelihoods of all the hazards. The degree of impact of flood results from the interaction between the nature of the hazard and the socio-economic system of the affected population, both of which are dynamic (Duzi et al. 2017). The Intergovernmental Panel on Climate Change (IPCC) reports that climate change will exacerbate the frequency and intensity of floods in the future, disproportionately affecting the vulnerable population of Asia (IPCC 2022). India, with 12 percent of its geographical area classified as flood-prone, is one of the most flood-affected countries in the world. It bears the burden of one-fifth of global flood deaths (NRSC 2023). According to an estimate, the country suffered an economic loss of over three billion dollars due to flooding in 2021 alone (ESCAP 2021). These losses, human lives and finances, occur unevenly across seasons and regions of the country, with floods of severe magnitude primarily prevalent during the monsoon season in river plains.

India has been implementing flood management policies since independence, but the country still faces a high flood impact due to a variety of reasons. Many argue that obsession with structural measures has led to the failure of the flood risk management system in India to adapt to rapidly evolving flood risk scenarios in the country (Mohanty et al. 2020). As a result, the implementation of soft measures to enhance the resilience of people and communities in flood-prone regions, such as Assam in northeast India is almost absent (Wasson et al. 2020). However, there is a continued occurrence of flood-related damages in these areas. In the frequently inundated Brahmaputra and Barak Valleys, the primary flood management strategy is to construct embankments along the banks of the rivers with little incentive to adopt more flexible and adaptive measures of flood impact management (Pal and Singh 2017).

Nevertheless, communities living in flood-prone regions take steps to adapt to flood hazards, and it is crucial to bolster their adaptive capacities. Enhancing people's adaptive capacity is vital for reducing vulnerability and achieving resilience against the impacts of flooding. In this context, this paper aims to assess the current status of flood adaptive capacity and understand what factors influence it among the residents of two villages in Barak Valley, Assam. The following section provides a detailed explanation of the concept of adaptive capacity and explores its relationship with effective flood risk management. Following a discussion on the concept of adaptive capacity, the paper is organ-

ised into sections that describe objectives, the methodology, the results, the discussion, the conclusion drawn from the study, and finally, the recommendations proposed.

### Concept of Adaptive Capacity and Its Application in Flood Risk Management

Adaptive capacity is a critical concept in the study of the ability of individuals, communities, and systems to cope with and adapt to changes in environmental and social conditions (Engle 2011). Its evolution can be traced back to the early 20th century when it was first introduced in ecology to explain how ecosystems respond to environmental changes (Holling 1973). Since then, it has been adopted in social science to investigate the resilience of human communities and their capacity to manage environmental and social stressors (Folke et al. 2002). It is now recognised as an essential area of research in disaster risk management, particularly in flood risk management (Birkmann et al. 2013), and various factors cause flooding, significantly damaging homes, infrastructure, and livelihoods. Adaptive capacity can reduce the risk of flood impacts by allowing communities to take preventive measures, such as building flood-resistant homes, establishing emergency response plans, and developing early warning systems.

Determining adaptive capacity is complex and multifaceted, involving social, economic, institutional, and environmental factors (Schipper and Pelling 2006). Social factors such as education, health, and social networks can enhance adaptive capacity by providing individuals and communities with the knowledge and resources necessary to cope with hazards (Adger 2006). Economic factors, including income, employment, and access to credit, are also crucial in building adaptive capacity by enabling individuals and communities to invest in protective measures, such as insurance and infrastructure (Gupta et al. 2010). Institutional factors, such as governance and policy frameworks, are critical in enhancing adaptive capacity by providing legal and institutional frameworks for disaster risk management (Birkmann et al. 2013). Environmental factors, such as climate change, land use change, and ecosystem services, also influence adaptive capacity by affecting the availability of natural resources and ecosystem services essential for adaptation (Adger et al. 2005).

Cinner et al. (2018) synthesised previous literature to propose a comprehensive framework for determining adaptive capacity across five domains, that is, assets, flexibility, social organisation, learning, and agency. The assets domain refers to the material and non-material resources that individuals and communities can draw upon during times of need, such as financial capital, social networks, and education. Flexibility relates to the ability to change strategies and adapt to new circumstances. Social organisation refers to the capacity of individuals and communities to organise and collaborate, such as through community-based organisations or disaster response teams. Learning involves recognising and responding to changes through monitoring and evaluation systems, for example. Finally, agency relates to the ability of individuals and communities to determine whether to change or maintain existing practices. Subsequent research has also identified the importance of socio-cognitive constructs in shaping adaptive capacity (Barnes et al. 2020).

### Objectives

This research assesses the adaptive capacity of people inhabiting flood-prone areas of Assam to understand the drivers of flood vulnerability using the conceptual framework presented by Cinner et al. (2018). The research will address the following objectives:

i. To examine the variation in adaptive capacity across its six domains among the flood-affected vulnerable population of Barak Valley, Assam.
ii. To evaluate adaptive capacity among households with different income levels and those with differing levels of engagement in local decision-making processes.

## METHODOLOGY

### Study Area

The case study sites for this research are the villages of Mongolpur and Borbil located in Barak Valley, Assamin India. Administratively, the

villages come under the Cachar district of the state (Fig.1). Meitei, a minority ethnic group in Assam hailing originally from Manipur, inhabit these villages. Physiographic character of the area is a combination of hills and plains, with flat terrains and low-lying areas drained by meandering Barak River and its tributaries. Because of this and the heavy rainfall the area receives during monsoon months has made the inhabitants of the region highly vulnerable to flood induced damages on a regular basis (Sahoo et al. 2021). The two study sites are located in the immediate vicinity of the Gor Gori River (Mongolpur) and the Chiri River (Borbil), both tributaries of Barak. The Barak River's tributaries are equally notorious for producing frequent floods. Gor Gori and Chiri rivers have caused widespread flood damage, including displacement of communities in the past. Agriculture is the primary livelihood of the population, mainly consisting of small or marginal farmers. The community members lack flood impact coping ability and are rendered more vulnerable by their socio-economic status. The combination of these factors makes the sites an ideal setting to study the adaptive capacity of people to flood hazards and to understand the role of socio-economic factors in shaping their resilience to aid in future policy interventions.

**Data Collection and Analysis**

The study employed primary data collected at the household level to understand the adaptive capacity of the people to flood. An extensive literature review identified six flood vulnerability reducing attributes of adaptive capacity (Cinner et al. 2018). The field survey questionnaire consisted of ten indicators organised across these six domains of adaptive capacity. The questions were framed to allow participants to answer on a Likert scale (1 to 5) or respond with binary choices (Yes or No) and nominal responses (Hernandez Cruz and Davila 2020). Table 1 provides information on the indicators, their measurement scales and the domains of adaptive capacity used in this study. The data was collected in the month of June 2022 purposively, as monsoon rains during this period have led to floods in the past. Asking questions about floods during this time of the year may make the

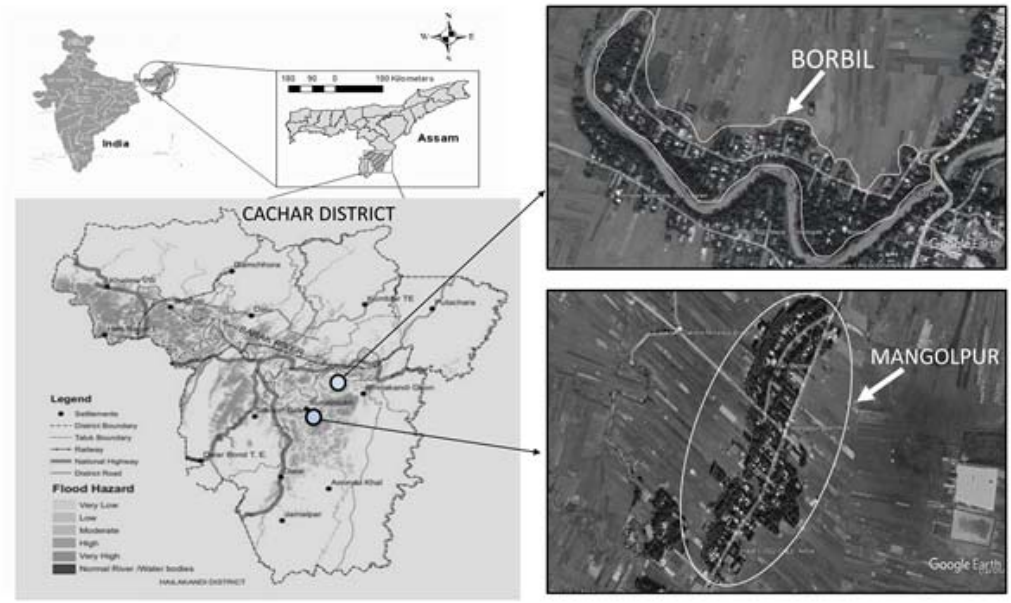


**Fig. 1. Location map of the study sites**

respondents more relatable to the study, and increase the chance of eliciting accurate responses. A total of 259 households were administered the survey questionnaire, accounting for more than eighty percent of the total households in the two study sites. In all cases, heads of households responded as representatives of their families. In addition to the survey, at least two key informant interviews were conducted with community leaders, one in each village.

The primary data were cleaned to ensure consistency before subsequent processing. This study performed two sets of analyses. First, to understand the variations in adaptive capacity indicators and relationships among them, the whole dataset was used. Descriptive statistics were obtained from this dataset. Secondly, to understand how the indicators varied, the dataset was disaggregated according to the income levels of the households and their engagement in the local decision-making process (Cinner et al. 2018). Statistical differences in adaptive capacity indicators between the two data groups were checked for the two covariates (Hernandez Cruz and Davila 2020).

## RESULTS

### Household Characteristics

Male-headed households comprised the majority of heads of the surveyed households. The average age of the respondents was 45 years (Table 1), and the typical family size of the surveyed population was five members. Most respondents derived their livelihood from agriculture, while others were engaged in daily wage labour, government jobs, or small businesses. About 52 percent of the population comprised dependents, including teenagers, infants, and

**Table 1: Indicators of adaptive capacity**

| *Indicator* | *Description* | *Data type* | *Domains of adaptive capacity* |
|---|---|---|---|
| Access to credit | Measurement is made by considering the individual's historical usage of credit and their perceived potential to obtain credit in the future, whether through formal establishments or informal sources (friends and family) | Binary | Asset |
| Saving | Does any member of your house save money? (yes/no) | Binary | |
| Remittance | Does any member of the family work outside the community? | Binary | |
| Occupation mobility | Occupation change in the last five years (to a better job) | Binary | Flexibility |
| Occupation multiplicity in terms of sector | Economic sector in which one or more family member/s work for livelihood; primary (0) and non-primary (1) | Binary | |
| Membership of organisations | Total number of local organisations/ groups the respondent belonged to | Continuous | Social organisation |
| Community trust | Average of five- point Likert scale response to questions about the trust the respondent reposed on: community leaders, local government and first responders | Continuous | |
| Education of family head | Measured as illiterate (0) and attended school (1) | Binary | Learning |
| Human agency | Assessed by determining if the respondent believes that their involvement in the local decision-making process would be advantageous for the community. | Binary | Agency |
| Perceived risk of flood getting worst | Evaluated based on whether the respondent perceives that floods have become more severe in comparison to previous occurrences. | Binary construct | Socio-cognitive |

older adults. The average monthly income of all surveyed households was aboutINR 26,000. Male-headed households had a slightly higher monthly income than the average. In comparison, the monthly income of female-headed households was 12 percent lower than the average income of the surveyed population. The literacy rate of the respondents was found to be 73 percent, which is slightly lower than the national figure (74%) as per Census 2011.

## Hazard Profile of the Study Area

Respondents reported experiencing floods on average one and a half times in the past five years (Table 2). Notably, 64 percent of households suffered losses to valuable assets during the last experienced flood. This study found a statistically significant ($p = 0.022$) relationship between households that suffered flood-induced damage and their willingness to adopt adaptive measures to avert flood loss. However, research has shown that intentions to undertake behavioural adjustments do not always translate into actual adaptation. The survey showed that only 47 percentof the households had taken measures to adapt to flood hazards, such as raising the foundations of their homes. Although this figure is low, the relationship between households that incurred losses and their adoption of adaptive measures was also statistically significant ($p = 0.028$). The frequency of floods experienced by households does not appear to have a positive correlation with adopting adaptive strategies.

Furthermore, the survey revealed that respondents had diverse opinions about flood risk adaptation measures. Respondents recommended both structural and non-structural measures for flood risk adaptation. The structural measures suggested include the construction of dams and embankments, as well as raising the height of roads, which were to be carried out by the government. Non-structural measures, such as dredging riverbeds, planting trees, and reducing deforestation, were also suggested. Many also believed that providing financial aid to flood-affected families during disasters would be an effective means of reducing the effects of floods.

## Overall Adaptive Capacity

A description of the results obtained from the study's data on the indicators of different domains of adaptive capacity of surveyed households is presented in Table 2. It reveals suboptimal financial preparedness, indicating reduced coping capacity of people. Less than half (46%) of the surveyed households had access to credit, while the figure for households saving money was marginally higher (52%). These two indicators with remittance, which only 34 percent of the surveyed households received, constitute crucial components of the asset domain

**Table 2: Key factors influencing flood adaptive capacity in the study population**

| *Indicator* | *Unit/s* | *Value* | *Domains of adaptive capacity* |
|---|---|---|---|
| HH* having access to credit | % | 46.3 | Asset |
| HH saving money | % | 51 | |
| HH receiving remittance | % | 34 | |
| HH with member who changed occupation | % | 12.4 | Flexibility |
| HH with members employed in more than one sector of economy | % | 55.6 | |
| HH with member/s having membership to at least one organisation | % | 60.2 | Social organisation |
| Trust score in government institutions | mean | 3.16 | |
| | maximum | 5 | |
| | SD | 50.83 | |
| HH with family head having formal education | % | 73 | Learning |
| Respondents perceiving their participation in local decision making is useful (human agency) | % | 57.1 | Agency |
| Respondents that perceived risk of flood getting worst | % | 76.7 | Socio-cognitive construct |

*HH- Households *Source:* Field Survey

of adaptive capacity. The data showed that very few households (12.4%) have had members change their occupations during the last five years, suggesting low flexibility in occupation changes. However, the survey also found many households (55.6%) with members engaged in livelihood activities in more than one sector of the economy.

The study population had a close-knit social system, as evidenced by the high proportion of respondents (60.2%) being members of at least one local community organisation. Thus, community engagement and the potential for collective action among the population is robust, reinforced by the high level of trust people reposed in government institutions and first responders. The observed data revealed values of 5 and 3.16 respectively, on a five-point Likert scale. However, capturing people's opinions on government institutions is more nuanced than that is revealed through a single measure.

In the agency domain, the data shows that 57 percentof respondents perceived their participation in local decision-making as relevant. Lastly, the perception of risk reflects the socio-cognitive construct domain, and a large section of respondents (76.7%) believed that the risk of floods is worsening. Overall, these results indicate that the surveyed households possess varying levels of adaptive capacity across different domains.

### Disaggregated by Income and Local Decision Participation

This study analysed data from low, medium, and high-income households to compare various indicators. As shown inTable 3, across all income groups, the education of the head of the family was relatively high, with higher literacy rates for medium and high-income households compared to low-income households. High and medium-income households also had a higher proportion of households with occupations in multiple sectors. Financial capacity is positively associated with income levels, as households with more significant income had a higher proportion of access to savings, credit, and remittances. Medium-income households also had a higher percentage of occupational changes. The sense of agency was relatively high across all income groups, with the highest percentage among high-income households. However, high-income households had a higher perceived risk than low and medium-income households. The mean value of trust in community leaders, local government, and first responders was relatively similar across all income groups. Overall, these results show a mixed pattern where some indicators are positively associated with higher income while others are not.

Analysis of the indicators thus demonstrates a positive relationship between literacy rates, occupation diversity, financial capacity, and trust in community leaders, local government, and first responders with income, as medium and high-income households had higher levels of these indicators compared to low-income households. On the other hand, access to credit, remittances, occupational changes, and perceived risk were not positively related to higher income, as low and medium-income households showed higher levels of access to credit and remittances, and medium-income households had a higher percentage of occupational changes. In contrast, high-income households had a higher perceived risk.

## DISCUSSION

This study examined factors driving flood resilience in two villages of Assam by assessing the adaptive capacity of households through a

**Table 3: Indicators of adaptive capacity disaggregated by household income (in %)**

| *Group* | *Education* | *Occupation in 2+Sectors* | *Saving* | *Credit access* | *Remittance* | *Occupation changed* | *Agency* | *Perceived risk* | *No. of org. membership* | *Trust* |
|---|---|---|---|---|---|---|---|---|---|---|
| *Low Income* | 69.80 | 21.10 | 29.10 | 37.20 | 15.10 | 12.80 | 40.70 | 74.10 | 0.67 | 3.17 |
| *Medium Income* | 72.00 | 66.30 | 50.00 | 47.70 | 36.00 | 11.60 | 67.40 | 73.30 | 0.94 | 3.06 |
| *High Income* | 77.00 | 71.30 | 73.60 | 54.00 | 50.60 | 12.60 | 12.60 | 82.80 | 1.1 | 3.26 |

*Source:* Field Survey

cross-sectional survey. The household data was disaggregated on income and agency basis to understand the underlying factors across different groups. The results indicate that households fared better in indicators representing learning, agency, and social organisation aspects of adaptive capacity. At the same time, weaker performances were observed in other domains, such as assets and flexibility. Furthermore, the study revealed a strong influence of household wealth on adaptive capacity, with families having higher incomes performing better in other areas.

An impoverished household's ability to adapt is limited due to economic constraints. This study discovered a strong connection between income levels and a household's ability to adapt to heightened level of flood vulnerability, which is consistent with findings by Diana and Atikah (2023). They explained that economic limitations diminish the capacity of impoverished households to withstand and rebound from flooding, thereby exacerbating their vulnerability.Mahanta and Das (2017) reported that communities are similarly susceptible to the adverse impacts of floods in Assam.

In addition to absolute access to economic wealth, Bavel et al. (2018) reported that adaptations occur primarily when affluent individuals are directly affected by floods, underscoring the importance of income distribution patterns within a society. The high disparity in income among the village households, with most belonging to the low-income group, could lead to delayed activation of institutional responses to flooding in the study area. Rigid livelihood options can render the population more vulnerable to flood impacts (Liu et al. 2022).

The prevalent rigid livelihood flexibility stemming from low-income source diversification could hamper individual resilience to flood hazards by impacting access to the financial safety net for recovery and adaptation efforts. Datta and Roy (2022) agree with this observation, emphasizing the significance of income and livelihood diversification and the utilization of savings instruments in the financial market to bolster an individual's adaptive capacity. Income diversification for enhancing adaptive capacity has its downside for farming communities. According to findings from flood-vulnerable communities in Pakistan (Aqib et al. 2024), an unintended consequence of alternative income sources is that farmers may reduce their dedication and investment in agricultural activities or require additional motivation to improve their farming practices. Therefore, it is crucial to consider the low livelihood flexibility issue within the broader context of other indicators of adaptive capacity and the socio-economic factors that influence them.

A robust social organisation within the study population is a prerequisite because flood-induced disasters are a social phenomenon. Das (2020) argued that a well-connected social system is necessary for framing effective flood policies, particularly in regions like Assam. The finding about solid social bonding and trust among populations agrees with the study of Behera (2023) on the prevalence of robust social connections in India's rural populace, particularly during disaster events.Similar findings on the role of social networking and self-help groups in enhancing community resilience were seen in flood-prone areas of Bihar (Yadav and Ibrar 2023).

The majority of participants experiencing more severe floods when compared to their past experiences supports Pal and Singh's (2017)observations of the inadequacies of current flood control structures, which are old and outdated. In this connection, EPW Engage (2021) found growing empirical evidence indicating that embankments have worsened the severity of floods in India. On the other hand, Bania's study (2022) identified the situation as particularly more precarious in regions like Assam. The preceding discussion echoes the call for a change in how flood managers view and handle floods, towards adopting what Kundzewicz et al. (2018) term as adopting a portfolio of strategies to manage flood impacts. This change, as Wang et al. (2022) suggest, may involve moving away from depending only on rigid structural measures and including softer intervention strategies. According to Kim et al. (2021), these strategies should focus on improving the ability of people affected by floods to adapt.

## CONCLUSION

Despite implementing flood management strategies over a long period, floods remain humanity's costliest hazard. Across its six domains, this study assessed the determinants of adap-

tive capacity in a flood-vulnerable community in Barak Valley, Assam. The results found significant variations across as many as ten indicators of the different domains of adaptive capacity. While indicators of social organisation, agency, and risk perception domains were strong, the values of other indicators suggest households lacked financial assets and showed weak flexibility and learning domains. Furthermore, the study highlighted vulnerability's social and economic differentiation within seemingly homogenous groups, emphasising the need for targeted community-level interventions based on income and relevant criteria to improve adaptive capacity.

## RECOMMENDATIONS

Based on the abovementioned issues, this study recommends emphasising the importance of building adaptive capacity in flood-prone communities. Achieving this must include strengthening domains of adaptive capacity, such as social, economic, and institutional capacities, and utilising existing government interventions for community development, with initiatives like introducing new income-enhancing measures and provisions of equitable access to additional financial resources for every household. A multi-faceted strategy that combines strengthening the capacities of both community and government should be adopted toeffectively bolster the resilience of vulnerable communities and reduce the adverse effects of flood hazards and climate change impacts.

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