

Chapter 15

Analysing the Household-Level Adaptation to Flood Hazard in Bhagirathi Sub-basin of West Bengal, India: A Concern for Mitigation



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Introduction

Flood is the most disastrous phenomenon that may not only cause socio-economic vulnerabilities but also result in prolonged mental distress. Increasing climate change is making the flooding new normal globally. The global annual temperature anomaly is around 0.98 °C, while the monthly anomaly is about 0.91 °C. These rising temperatures are likely to enhance the evaporation over the surface and increase the retention capacity of air to hold more moisture, which will lead to frequent, intense precipitation even for a period of time (UNEP, 2021). Intergovernmental Panel on Climate Change (IPCC) in AR6 with high confidence highlighted that warmer climate may lead to flooding and drought incidence whose intensity would depend on the regional climatic conditions, i.e. mid-latitude storms and monsoon (IPCC, 2021). Global Climate Risk Index 2020 indicated that Japan, Philippines, Germany, Madagascar, India and Sri Lanka are the most disaster-affected nations, where India ranks 5, incurring a share of 0.36% disaster losses of the GDP. The major fatalities in India were found from landslide-induced flooding (Eckstein et al., 2019). Around 15,082 deaths were reported globally (NDRCC, 2021) where maximum deaths (6171) were reported from floods followed by storms (1742), landslides (514), earthquakes (196) and wildfires (70). Flash floods have also caused severe implications in northern and coastal India (Eckstein et al., 2019).

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Vulnerability analysis is an integral part of flood risk assessment. Vulnerability reflects a situation where a system is exposed and sensitive to climate change-induced implications and tries to cope with them (Rehman et al., 2019). This coping mechanism or ability to resist the changes driven by climate change is called adaptation. Adaptation has now become an essential aspect of climate change analysis. Scientific assessments and policy progress on understanding varied dimensions of adaptation have increased recently (Swart et al., 2014). Adaptation at the local level may help in modulating risk and increasing resilience to prevent the climate change-induced disaster implications. IPCC special report (IPCC, 2012) defines adaptation as *'In human systems, the process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities. In natural systems, the process of adjustment to actual climate and its effects; human intervention may facilitate adjustment to expected climate'*. Substantial attention has been given to the factors that determine the ability of a region or community to adapt to the effects resulting from disaster-induced vulnerability and risk (Smit & Pilifosova, 2003; Crane et al., 2011; Chersich & Wright, 2019). Ullah et al. (2018) examined the climate change-induced vulnerability and varied adaptation strategies by the farming community in Khyber Pakhtunkhwa, Pakistan. De Silva and Kawasaki (2018) investigated the flood- and drought-induced socio-economic vulnerability of rural Sri Lankan community. Their findings indicated that rural households are largely dependent on natural resources for their livelihood, which is largely affected by flood and drought. Singha et al. (2018) analysed the flood erosion-induced livelihood vulnerability along the Ganges riparian corridor of India. They suggested expansion of cultural and urban landscape and unplanned manmade resources combined with physical vulnerability are leading to social and ecological losses.

The coastal areas are largely affected by multi-hazard shocks, which raises the vulnerability of the coastal communities. Inadequate planning, preparedness and management of land also raises the vulnerability of the community to disaster events. In such areas, adaptation and resilience are required for lessening the risk and vulnerability caused by hydrometeorological disasters (Buchori et al., 2018). Resilience reflects the ability of the community to absorb and recover the effects of disasters in an efficient manner (IPCC, 2012). Bhagirathi sub-basin is an important hydrological unit of India, lying over the states of Jharkhand, Bihar and West Bengal. The southern part of the sub-basin is undermined by various disasters including flooding, cyclones, storm surges and coastal erosion (Sahana et al., 2020; Rehman et al., 2021). River flooding is a big concern in West Bengal, Bihar and some adjacent parts of Jharkhand. The riverine topography, changing land use, massive discharge from barrages and dams and extreme rainfall are some of the causes of flooding (Tripathi et al., 2020; Ghosh & Kar, 2018). Owing to these implications, this chapter examined the household-level adaptation to flood in the Bhagirathi sub-basin. The findings of the analysis may aid in formulating effective measures for obtaining sustainable adaptation to floods.

Study Area

Bhagirathi sub-basin is located between $86^{\circ} 7' - 89^{\circ} 28' E$ and $21^{\circ} 39' - 26^{\circ} 56' N$ latitudes (Fig. 15.1) extending over the three states (administrative division of country) of India, namely Jharkhand, Bihar and West Bengal comprising 35 districts (administrative division of state). A total of 75 watersheds are located in the study area (Hasan & Rai, 2020). This hydrological unit is formed by the three important rivers of India, namely *Ganga*, *Meghna* and *Hooghly*. The sub-basin is marked by diversified topography, microclimate and vegetation types. The study area is also rich in water resources including 77,873 surface bodies, 12 reservoirs and 12 dams. Rainfall ranges between 1000 and 1500 mm with maximum showers during the monsoon season (June–September). The study area experiences tropical savanna and hot Mediterranean-type climate. Around 9.3 billion reside in the sub-basin (Census of India, 2011). The population is largely dependent upon natural resources and agriculture for their livelihoods. Moreover, animal rearing, honey collection and fishing are also prominent among the coastal communities. The relief variation, extreme weather events and riverine topography have increased the vulnerability of the communities in the sub-basin (Sahana et al., 2021). Flood has been evident since several decades causing severe devastation to life and property. Thus, a close examination of household-level adaptation to flood hazard is essential for enhancing the resistance of the local communities.

Methods

Sampling Criteria

A household-level survey was conducted to derive the database for analysing the socio-economic vulnerability to floods in the sub-basin during June and August 2019. These 2 months witnessed huge monsoonal rainfall and thus selected as study period to get personal observation on the intensity of rainfall. The sample design adopted for the study consisted of two stages (Fig. 15.2). In the first stage, selection of villages was made from 12 drainage systems. From each drainage basin, 2 villages (one located near the river and one away from the river) were selected randomly, and thus, a total of 24 villages were selected from the sub-basin. The second stage consisted of selection of households. The selected villages were classified into three categories (high, medium and low) based on population. From each category, six households were selected randomly. In this way, a total of 432 households were surveyed in the study area. Perception of the households on various adaptation strategies including effectiveness of early warning system, adaptation by community during and post flood strategies, protection strategies and role of stakeholders in respective villages was observed. During the field visit, a close disclosure of the social and economic conditions of the households was also observed to determine flood-induced implications (Table 15.1).

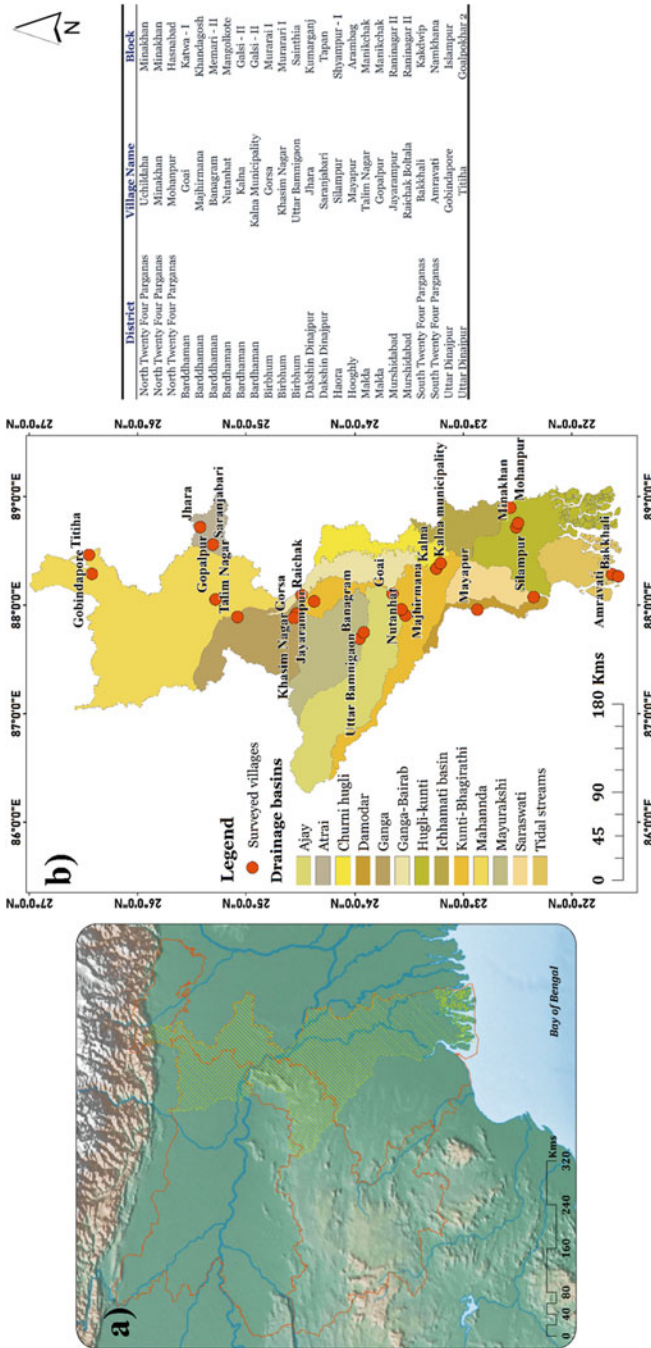


Fig. 15.1 Location of the sub-basin in India and (b) surveyed villages identified among different drainage basins

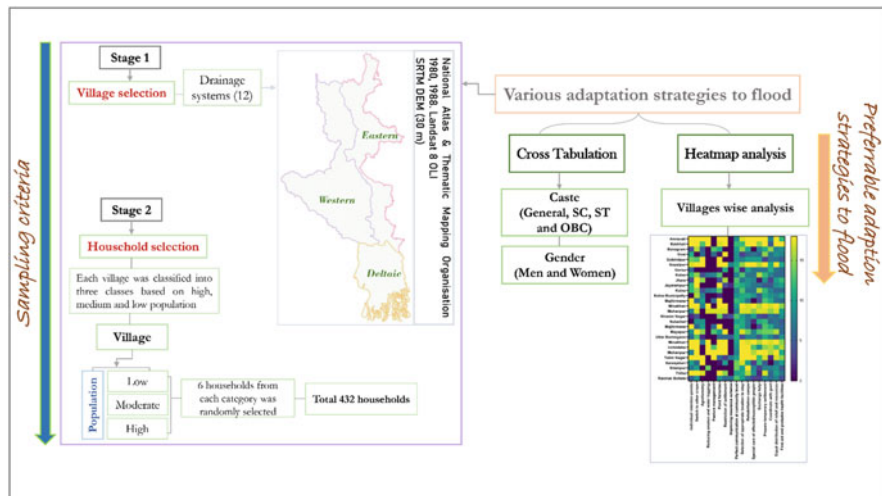


Fig. 15.2 Flowchart of methodology

Table 15.1 Descriptive statistics of housing characteristics in the sampled households

Housing characteristics		Percentage	Mean	First quantile	Third quantile	Std.
Housing type	Muddy house	27.8	25	22.07	31.02	14.31
	Semi-cemented house	28.4				
	Fully cemented house	4.9				
	Grass/bamboo/ others	38.9				
Housing facilities	Electricity	61.6	33.33	19.18	44.52	25.86
	Drinking water	11.0				
	Latrine	27.4				
Combustion materials	Firewood and chips	0.2	20	6.71	40.52	20.21
	Dung cake	43.1				
	Kerosene	9.4				
	LPG	40.5				
	Others	6.7				

Std. standard deviation

Cross Tabulation

After examining the various adaptation strategies, a cross-tabulation analysis was carried out to ascertain the effective adaptation methods by communities in general,

during and post flood strategies particularly preferred by gender and caste groups (Table 15.2). A heatmap was also prepared to ascertain the preferable adaptation methods in the surveyed villages (Fig. 15.2).

Results

Of the total sampled households in the study area, around 85% were males while 15% were females. Average age of the respondents was found 44.7 years. Majority of the sampled households (62%) belonged to Hinduism followed by Islam (35%) and Christianity (3%). Nearly 41% of the sampled households belonged to general category followed by other backward castes (27%), scheduled castes (26%) and scheduled tribes (7%). About 73% of the head of the households have completed the primary education followed by secondary (20%) and graduate (5%), while only 2% were post-graduates. Most of the sampled households around 53% were having nucleated family system followed by joint family (45%) and extended family systems (2%). Only 1% of them were found living single. Most of them were married (91%), while 6% were unmarried and 3% were widows. The descriptive statistical results demonstrated that over 39% of houses were made of grass, bamboos and other locally available resources in the sub-basin. Table 15.1 also displays that more than one-fourth of the houses are still made of mud. Though the houses are not cemented, about two-thirds of houses are having electricity facilities.

The adaptation among the sampled households was analysed as strategies adopted by local communities, effectiveness of early warning system, during and post flood strategies, measures for flood protection and role of stakeholders.

Perception of Adaptation Strategies Adopted by Local Communities

The most preferred strategy adopted by the sampled households was switching over other crops (63%) followed by pond fisheries (47%), crop insurance (43%), agro-forestry (33%) and restricting construction in flood risk areas (32%). Pasture management (40%) and reducing soil erosion and waterlogging (31%) were less adapted strategies by the sampled households (Fig. 15.3). Improving insurance schemes (45%) was the least adapted by the sampled respondents. Plate 15.1 represents the fishing ponds in various villages.

Table 15.2 Gender- and caste-wise preferred adaptation strategies

Adaptation strategies	Gender				Caste							
	Men		Women		GEN		OBC		SC		ST	
	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
Individual retention ponds	57.2	42.8	66.7	33.3	64.4	35.6	53.4	46.6	50.5	49.5	56.7	43.3
Switch to other crops	72.4	27.6	76.4	23.6	84.6	15.4	61.2	38.8	66.7	33.3	73.3	26.7
Agroforestry	48.2	51.8	38.1	61.9	54.9	45.1	36.2	63.8	37.8	62.2	73.3	26.7
Reducing erosion and waterlogging	21.4	78.6	50.8	49.2	29.7	70.3	21.6	78.4	23.4	76.6	26.7	73.3
Pasture management	22.8	77.2	17.5	82.5	8.6	91.4	35.3	64.7	29.7	70.3	20	80
Pond fisheries	59.6	40.4	58.7	41.3	71.4	28.6	51.7	48.3	50.5	49.5	53.3	46.7
Restriction of settlement	48.2	51.8	63.5	36.5	58.3	41.7	39.7	60.3	45	55	66.7	33.3
Improving crop insurance scheme	7	93	9.5	90.5	10.9	89.1	6	94	4.5	95.5	3.3	96.7
Perfect communication at community level	58.3	41.7	69.8	30.2	58.9	41.1	53.4	46.6	66.7	33.3	66.7	33.3
Selection of appropriate location to stay	65	35	74.6	25.4	65.1	34.9	55.2	44.8	73	27	93.3	6.7
Rehabilitation camps	65.6	34.4	76.2	23.8	70.9	29.1	62.9	37.1	68.5	31.5	56.7	43.3
Special care of affected/susceptible people	50.4	49.6	61.9	38.1	56.6	43.4	52.6	47.4	44.1	55.9	53.3	46.7
Exchange help	50.4	49.6	55.6	44.4	47.4	52.6	43.1	56.9	62.2	37.8	63.3	36.7
Prepare temporary settlement	65.9	34.1	68.3	31.7	61.7	38.3	66.4	33.6	75.7	24.3	56.7	43.3
Coordinate with govt	46.6	53.4	54	46	38.9	61.1	53.4	46.6	56.8	43.2	43.3	56.7
Equal distribution of relief and resources	58.8	41.2	66.7	33.3	63.4	36.6	56.9	43.1	56.8	43.2	63.3	36.7
First aid and probable health facilities	51.2	48.8	57.1	42.9	55.4	44.6	53.4	46.6	41.4	58.6	66.7	33.3

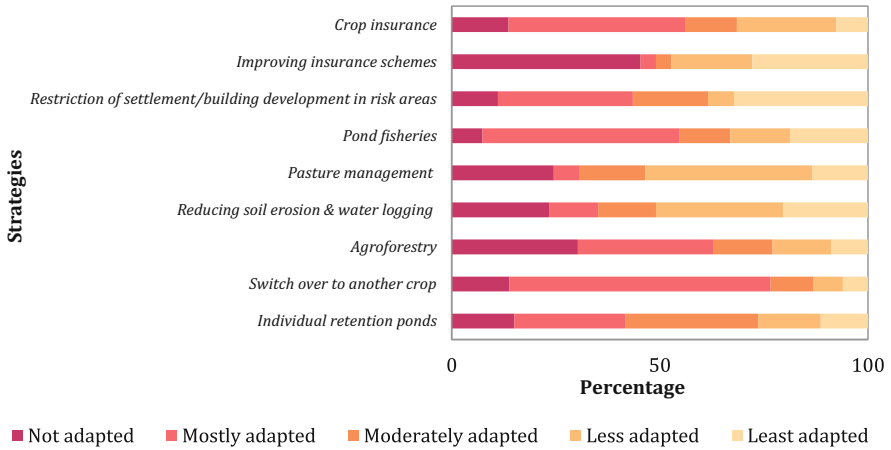


Fig. 15.3 Adaptation strategies adopted by local communities



Plate 15.1 Snaps captured during field survey (2019): (a) a big pond at Titha village, (b) fish pond in Jhara village, (c) a bird-protected fish pond in Gopalpur village and (d) remote location of village

Effectiveness of Early Warning Systems

Effectiveness of early warning systems was examined among the sampled households (Fig. 15.4). Among the early warning systems, own observation (74%) was

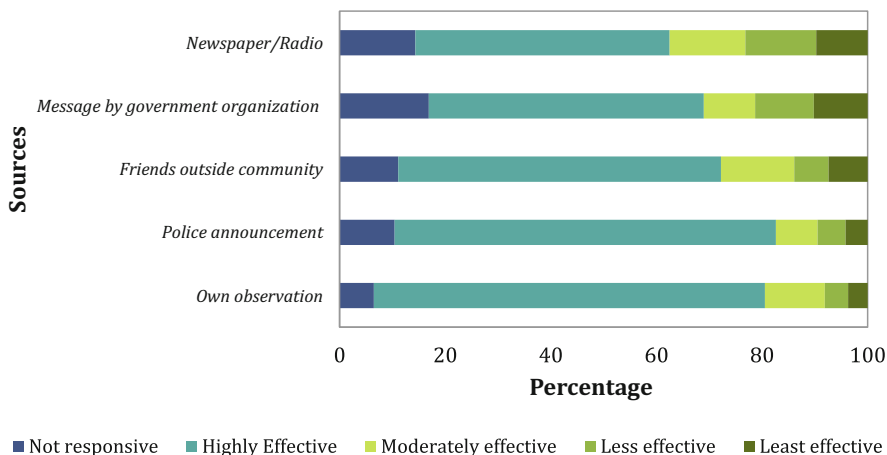


Fig. 15.4 Effectiveness of early warning system among the sampled households

found highly effective by the sampled households followed by police announcement (72%), friends outside the community (61%), information by government organization (52%) and newspaper and radio (48%). Own observation was considered highly effective by more than half (74%) of the sampled respondents followed by moderately effective (11%), not responsive (7%), less effective (4%) and least effective (4%). Announcements by the local policy were also identified as highly effective according to 72% of sampled respondents while nearly 10% stated that police were not responsive during floods followed by moderately effective (8%), less effective (5%) and least effective (4%). Most of the households (61%) also received disaster information from their friends living outside their communities. Nearly 52% of the sampled households disclosed that message from government was highly effective during flood events, while 17% stated that these were not so responsive followed by less effective (11%), least effective (10%) and moderately effective (10%). The main reason for this lack of information is remote locations of the houses and lack of communication. In case of hazard information from newspaper and radio, nearly 48% of sampled respondents identified it as highly effective followed by moderately effective (14%), not responsive (14%), less effective (13%) and least effective (10%).

Adaptation Strategies During Flood Hazard

Adaptation strategies during flood hazard involved perfect communication at community level, selection of appropriate location to stay, rehabilitation camps and

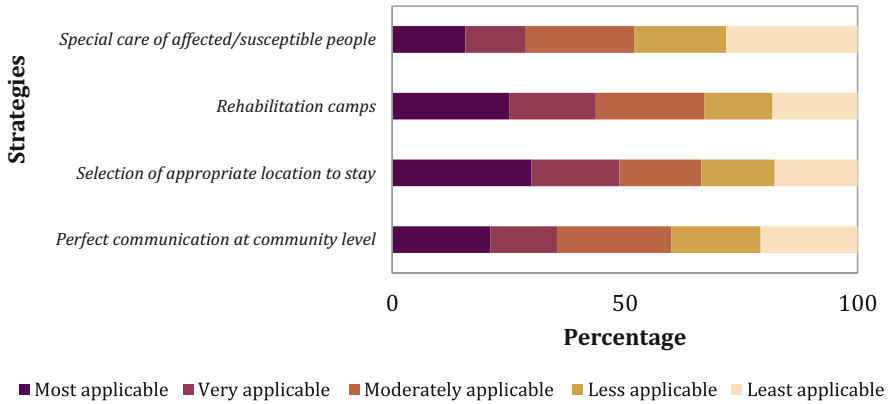


Fig. 15.5 Strategies adopted by sampled households during flood

special care of susceptible people. Selecting appropriate location to stay (30%) and staying in rehabilitation camps (25%) were mostly adapted by the respondents. Perfect communication at community level (24%) and special care of susceptible people (23%) were observed to be moderately adapted among the sampled households (Fig. 15.5).

Post Flood Adaptation Strategies

Post flood strategies consisted of exchanging help, preparing temporary settlement, coordinating with government and NGO, equal distribution of relief and first aid and probable health facilities. Post flood adaptation strategies were found moderate to less applicable among the sampled households (Fig. 15.6). Moderately adapted strategies among the sampled households were first aid and probable health facilities (30%) followed by equal distribution of relief and resources (30%) and preparing temporary settlement (23%). Coordinating with government and NGO (36%) and exchange help (31%) were found least adapted by the sampled households.

Flood Protection Strategies

Flood protection strategies involved technical flood protection (e.g. raise dykes, enlarge reservoirs, upgrade drainage systems), natural retention of flood water (e.g. floodplain restoration, change of land use), upgrading drainage systems, heightening existing infrastructure, diversion of excess water to irrigation fields, disaster response enhancement and improving insurance schemes against flood damage (Fig. 15.7). Improving insurance schemes against flood damage (45%),

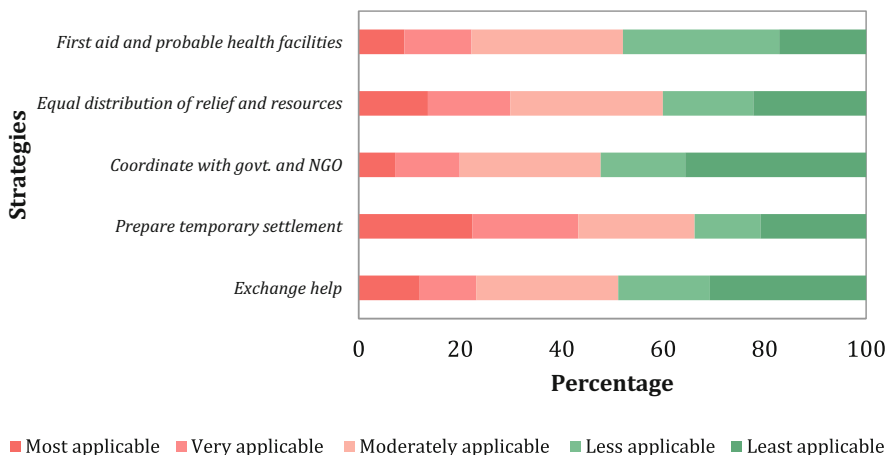


Fig. 15.6 Perception of sampled households on post flood strategies

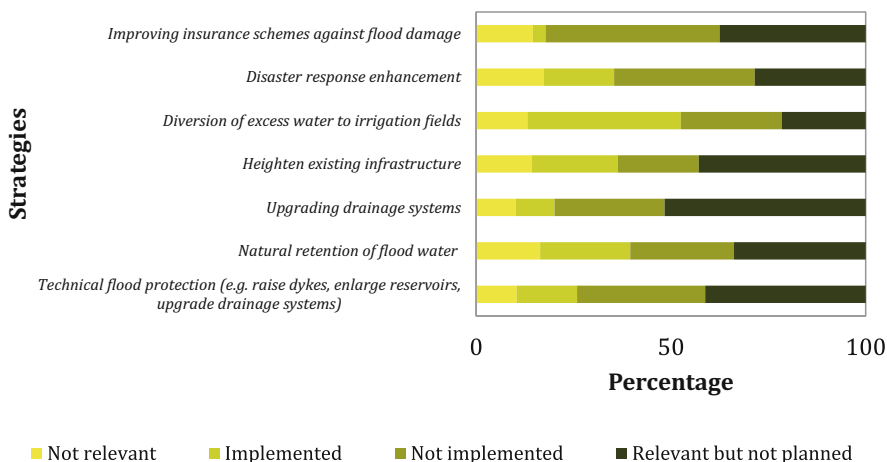


Fig. 15.7 Perception of sampled households on measures of flood protection

disaster response enhancement (36%) and diversion of excess water to irrigation fields (39%) were not implemented as disclosed by the sampled households. Heightening existing infrastructure (43%) was observed relevant but not planned followed by upgradation of drainage system (52%), technical flood protection (41%) and natural retention of flood water (34%).

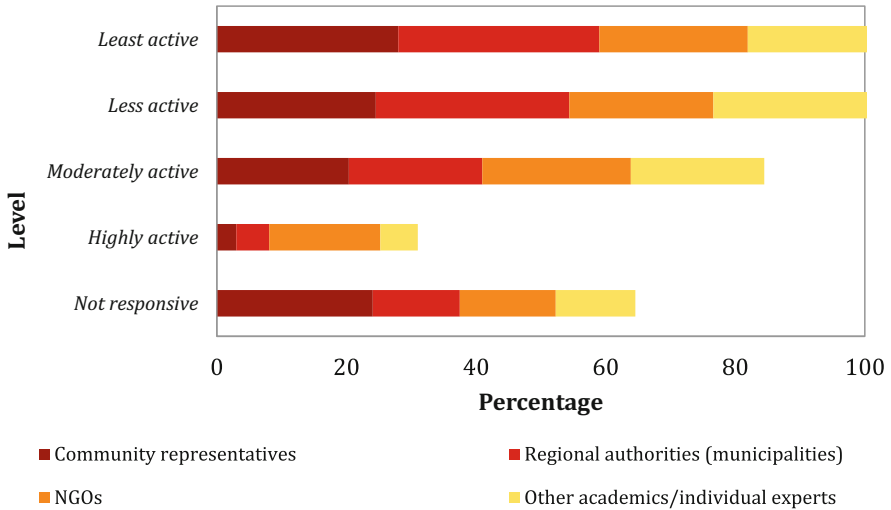


Fig. 15.8 Perception of sampled households on role of stakeholders

Role of Stakeholders

The role of community representatives, NGOs, regional authorities, academicians and researchers in lessening the flood risk was analysed among the sampled households (Fig. 15.8). The role of stakeholder analysis revealed that regional authorities (31%) followed by academicians and individual experts (31%) and community representatives (28%) were least involved in mitigating the flood hazard. Nearly 24% of the sampled households disclosed that local NGOs were moderately active (24%). Household characteristics revealed significant insights about the people living in the sub-basin. Most of the households were found having low socio-economic status. However, some villages were found connected by roads and found to be less impacted by flood.

Preferred Adaptation Strategies

Individual retention ponds, switch to other crops, pond fisheries, perfect communication at community level, selection of appropriate location to stay, rehabilitation camps, prepare temporary settlement, equal distribution of relief and resources, first aid and probable health facilities were preferred by all caste and gender groups (Table 15.2). The least preferred strategies among respondents identified were pasture management and improving crop insurance schemes. In case of village-wise analysis, Mohanpur, Minakhan, Uchildaha, Gopalpur, Amravati and Bakkhali villages performed well in all adaptation strategies except improving crop insurance

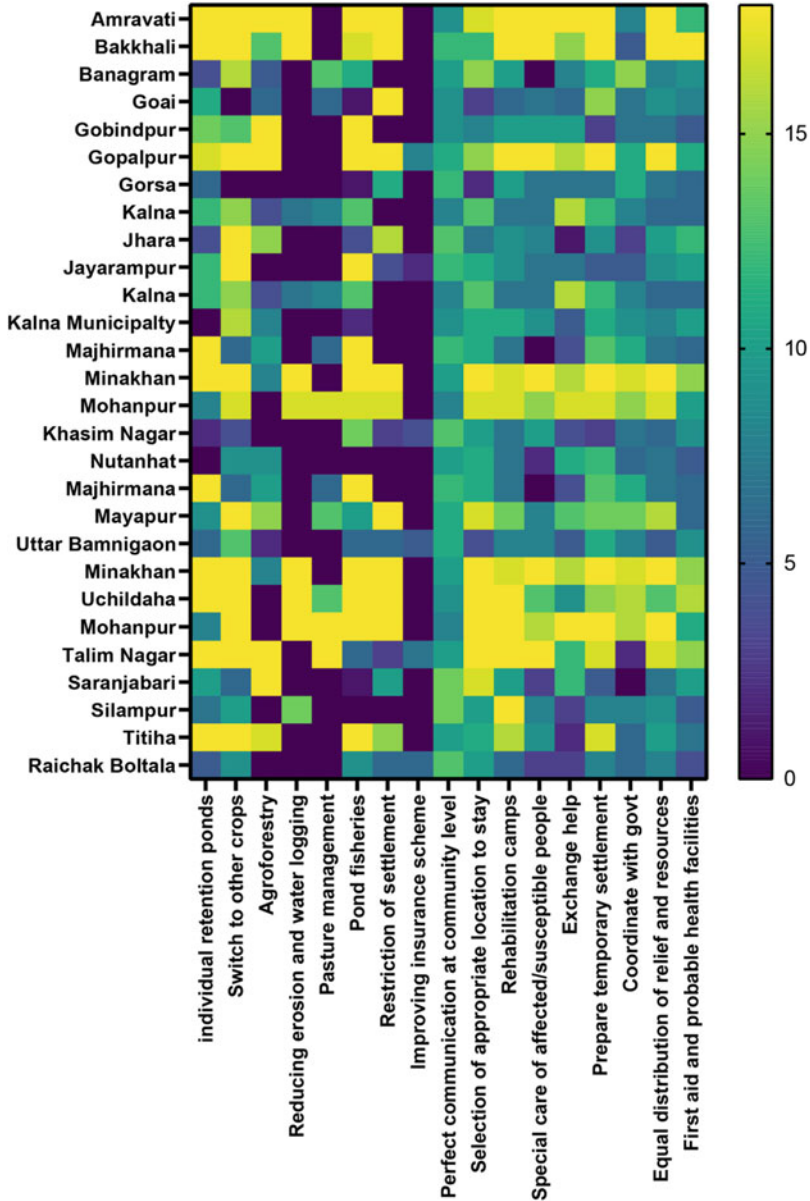


Fig. 15.9 Preferred adaptation strategies in the surveyed villages

scheme. The reason behind the highest preferability is the frequent flood events during the monsoon season (Fig. 15.9). Moreover, Amravati and Bakkhali villages are located in the southern coastal stretch where a series of multi-hazard events are prevalent and people tend to adapt more to the environmental casualties.

Discussion

The adaptation strategies discussed in this study are entirely based on the casualties induced by flood, traditional and natural methods. Earlier adaptation studies were mainly concerned with increasing understanding over the climate change implications. However, the local communities are more aware about the changes driven by climate and response accordingly. Recent climate change studies are providing better knowledge about the response of the communities in changing climatic conditions. The fifth assessment report of IPCC provided a detailed discussion on economics of adaptation citing various studies (Fankhauser, 2016). In the present analysis, most of the villages were found experiencing severe implications induced by floods, and sometimes their frequency is unpredictable due to changing climatic conditions. Studies have also indicated towards the increasing magnitude and frequency of the extreme weather events induced by climate change. Geographical locations, population growth, limited natural resources and assets and maladaptation increase the severity of these events (Ullah et al., 2018). The expensive implications of flood attracted the stakeholders and scholars to identify the suitable measures at global, regional and local levels for lessening implications. The flood adaptation includes various actions that strengthen the socio-economic and ecological systems against the adverse effects (Pathak, 2021).

In case of West Bengal, Bhattacharjee and Behera (2018) identified that shifting towards non-agricultural activities, elevating the houses and using flood-resistant crops are the prominent flood adaptation measures by farmers. Execution of good agronomic activities and climate information services may be effective adaptation strategies for the flood-affected rural communities (Koppa & Amarnath, 2021). On the other hand, in case of the northern mountainous region, Ghosh and Ghosal (2021) suggested that migration for better income opportunities, education, better transport connectivity, flood-resilient infrastructure and women self-help groups may be ideal adaptation measures for reducing flood vulnerability. The northeast parts of Bihar and Jharkhand, which lie in the *Ganga* Plain, have experienced severe incidents of flood where appropriate adaptation design is essential at village and household level (Jha & Gundimeda, 2019; Raghu et al., 2021). In the Bhagirathi sub-basin, most of the respondents engaged in agriculture have less land holdings, and they only grow crops for their sustenance. Flood-induced asset losses, health impacts, damages to agricultural land and changing climate conditions are the major complications of flood occurrences. Households with low income were found indebted at high-interest rates to support their needs. All these implications may only be reduced through effective adaptation strategies.

Climate change has also widened the flood implications that demand sustainable adaptation strategies (NITI Aayog, 2021). For strengthening this vision, the Government of India has initiated the estimation of sustainable development goals (SDGs) by NITI Aayog at state and union territory levels to reinforce the sustainable development of the states. NITI Aayog has classified SDG index score into aspirant (0–49), performer (50–64), front runner (65–99) and achiever (100). If we analyse



Fig. 15.10 Level of SDG goals in case of Jharkhand, Bihar and West bengal. (Source: NITI Aayog, 2021)

the level of overall SDG attainment of states lying in the sub-basin, all the states were found performer. All these states were found the aspirants of SDG2 (zero hunger) and SDG13 (climate action), while they found performer in SDG8 (decent work and economic growth). They were also identified as the front runner in case of SDG3 (good health and well-being), SDG6 (clean water and sanitation), SDG7 (affordable and clean energy) and SDG16 (peace and justice strong institutions). However, none of these states were recognized as achiever of any SDGs (Fig. 15.10). During fieldwork, it was observed that people have started constructing toilets in their houses with the help of government's welfare schemes such as *Swachh Bharat Mission* and WaSH (Water, Sanitation and Hygiene) programmes. However, the majority of the houses are still using dung cake as the main source of cooking fuel (43.1%). Here it is worth mentioning that recently, the households are increasingly using liquified petroleum gas (LPG), which accounts for 40% of the total cooking fuel. This increasing use of clean cooking fuel (LPG) may be attributed to welfare schemes such as *Pradhan Mantri Ujjwala Yojana* aiming to achieve energy-related SDGs (6 and 7), i.e. clean water and sanitation for all and affordable and clean energy in India (Plate 15.2).

In case of composite score, Jharkhand and Bihar were identified the performer while West Bengal is found the front runner. Moreover, there is a need for improvement especially in case of climate action (SDG13) goal of SDG

The present analysis has revealed that the adaptation strategies preferred by the households were largely pointing towards alternative liveihood, community participation during flood and provision of better healthcare systems. The low

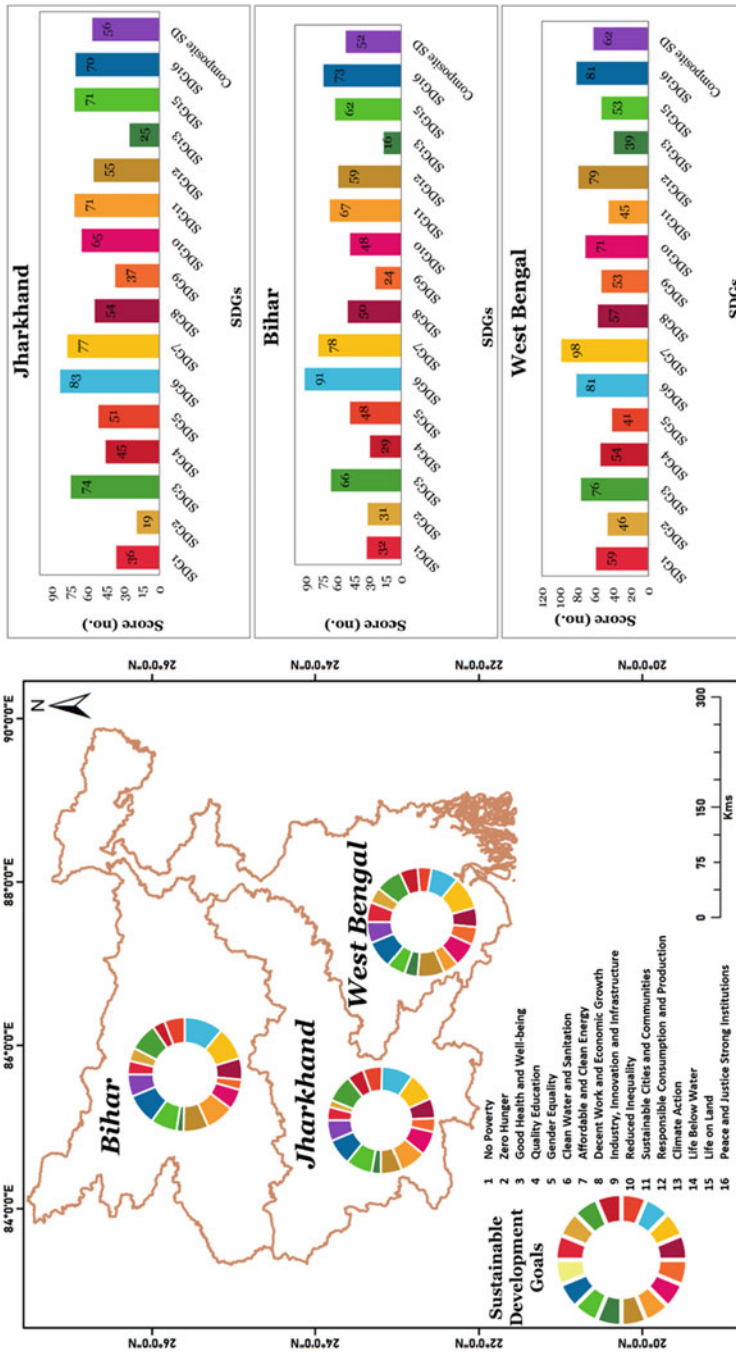


Plate 15.2 Typical view of kitchen in the surveyed households

performance of Raichak Boltala, Silampur, Khasim Nagar, Nutanhat and Kalna villages also indicates the high degree of flood implications and less adaptive capacity. The image of implications is much complicated at district or state level, which requires a unifying adaptation measure to enhance the adaptive capacity of the communities. However, this analysis is limited in terms of inclusion of only household-level adaptation but provides a concise interpretation of adaptation in surveyed villages. Furthermore, such an assessment may not only be helpful in identifying the adaptation strategies but to discriminate the level of adaptation in different social groups.

Conclusion

The present study has explored the adaptation strategies in one of the important hydrological units of India, i.e. Bhagirathi sub-basin. The analysis of household-level adaptation assessment is based on 432 households, and their perception of the effect of early warning system, adaptation by community, during and post flood strategies, protection strategies and role of stakeholder in selected villages was examined. Findings revealed that individual retention ponds, switch to other crops, pond fisheries, perfect communication at community level, selection of appropriate location to stay, rehabilitation camps, preparing temporary settlement, equal distribution of relief and resources, first aid and probable health facilities were preferred by all caste and gender groups. Pasture management and improving crop insurance schemes were found the least preferable. Village-wise analysis indicated towards the low performance of Raichak Boltala, Silampur, Khasim Nagar, Nutanhat and Kalna villages, whereas Mohanpur, Minakhan, Uchildaha, Gopalpur, Amravati and Bakkhali villages performed well in all adaptation strategies due to their better connectivity to urban areas.

SDG analysis has also raised the need for improvement in SDG1 (no poverty), SDG2 (zero hunger) and SDG13 (climate action) for achieving sustainable adaptation among communities while uplifting their socio-economic status. The study suggests that the policymakers should provide better economic opportunities, education levels and healthcare facilities, and encourage community-based adaptation strategies to mitigate the flood implications. Unbiased gender and community involvement, adequate support from government, crop insurance for individual support, strengthening the role of community-based organizations and modernizing indigenous flood control methods may effectively further enhance the response and adaptive capacity of the local communities.

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