Livelihood Resilience in Gandak- Kosi Floodplain Wetlands

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Abstract

Floods are an annual phenomenon in Gandak-Kosi floodplains of North Bihar. According to historical data, 16.5% of the total flood affected area in India is located in Bihar while 22.1% of the flood affected population in India lives in Bihar. Kosi River also referred to as the 'sorrow of Bihar' is one of the main reasons for flood in Bihar. Degraded ecosystem, climate variability and contested social structure have made communities inhabiting the Gandak- Kosi floodplains even more vulnerable to the vagaries of nature. To understand the geophysical, ecological and social context of risk in Gandak- kosi floodplains an integrated vulnerability capacity assessment was conducted in 85 villages within 6 districts under the Partners of Resilience project by Wetlands International- South Asia.

Review of secondary information and analysis of the survey data of a total of 2,578 households of Gandak- Kosi floodplains indicates developmental activities skewed towards structural engineering have led to fragmentation of the floodplain wetland system resulting in high sediment load within river channels which causes overbank flooding in the plains and loss to life and livelihood. Community perception of key elements at risk due to floods were natural infrastructure (70%) followed by shelter (> 60%), human life and asset (60%), drinking water source and sanitation structure (> 55%), source of food (50 %) and institutions (30%) respectively. Natural resources like ponds and grazing land experienced higher level of vulnerability in floods due to siltation. Since, majority of the community depend on wage labour, migration has been adopted as a response strategy for livelihood as well as for coping disaster in periods of stress. More that 60% of the households undertake migration during post-monsoon. Limited availability of early warning systems and lack of capacity to translate sophisticated weather information restricts early action and response during hazard. Measures to improve livelihood resilience in Gandak- Kosi floodplains should take into consideration improving hydrological connectivity, providing alternate livelihood options and increasing disaster preparedness at both individual and community level.

Key words: Gandak- Kosi floodplains, Floods, Disaster risk reduction

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1. Introduction

During the past three decades over 2.2 million people have lost their lives globally in natural hazard-induced disasters, with associated economic losses amounting to USD 1,527.6 billion (ISDR, 2009). Climate variability coupled with widespread ecosystem degradation and hydrological fragmentation is expected to intensity extreme weather events which will further magnify disaster risk associated with storms, floods, landslides and droughts (IPCC, 2007). From 1988-2007, 76 percent of all disaster events were hydrological, meteorological or climatological in nature, accounting for 45 percent of the total deaths and 79 percent of total economic losses caused by natural hazards (UNISDR, 2008).

Vulnerability is a combination of characteristics of a person or group, expressed in relation to hazard exposure which derives from the social and economic condition of the individual, family, or community concerned. It is a relative as well as specific term, always implying a vulnerability to a particular hazard (Blaikie et al., 1994). In addition to the economic dimension, there are also other aspects of social positioning such as class, ethnicity, community structure, community decision making processes and political issues that determine vulnerability of community. Hence, risk reduction requires a multi-dimensional approach with innovative institutional arrangements. The concept lies in reducing disaster risk through systematic efforts of analyzing and reducing the causal factors of disasters. In 2005, the Hyogo Framework for Action, the first global agreement on disaster reduction, recognized the importance of sustainable ecosystems and environmental management in reducing disaster risk.The disaster management practices have witnessed a paradigm shift and have evolved from a relief and response approach to a more inter-sectoral risk management approach. It is now recognized that unmanaged/mismanaged risks (physical, social and economic) for a long time lead to occurrence of disasters. This evolution of approaches from relief and response to risk management has begun to influence the way disaster management programs are now being planned and financed.

2. Ecosystems and Disaster Risk Reduction

Environmental conditions can be one of the major drivers of disaster risk. Degraded ecosystems can aggravate the impact of natural hazards, by altering physical processes that affect the magnitude, frequency and timing of these hazards. This has been evidenced in the US during the devastation caused by Hurricane Katrina in 2005 exacerbated due to canalization and drainage of the Mississippi floodplains, decrease in delta sedimentation due to dams and levees, and degradation of barrier islands (DANIDA, 2007). Environmental degradation also contributes to risk by increasing socio-economic vulnerability to hazard impacts, as the capacity of damaged ecosystems to meet people's needs for food and other products is reduced (ISDR, 2009). This was the case in Myanmar where pre-existing degradation of coastal vegetation limited livelihood recovery efforts following the devastating impacts of cyclone Nargis in 2005 (Day et al, 2007). Proper management of ecosystems can therefore play a critical role in reducing vulnerability and enhancing resilience of local communities, as healthy socio-ecological systems are better able to prevent, absorb and recover from disasters (UNEP, 2008). The degradation of ecosystems such as wetlands is now considered as one of the main drivers for increasing disaster risk. The need to integrate ecosystem management solutions in disaster risk reduction and climate change adaptation are the key strategies to reduce disaster risk, increase local resilience and adapt to a changing climate. The 2004 Indian Ocean Tsunami triggered global interest in promoting ecosystem management approaches for reducing disaster risk, placing increased international attention on the role of coastal ecosystems as natural shields against coastal hazards and resulting in major initiatives such as the Mangroves for the Future (MFF) Programme.

3. Vulnerability Capacity Assessment for risk assessment

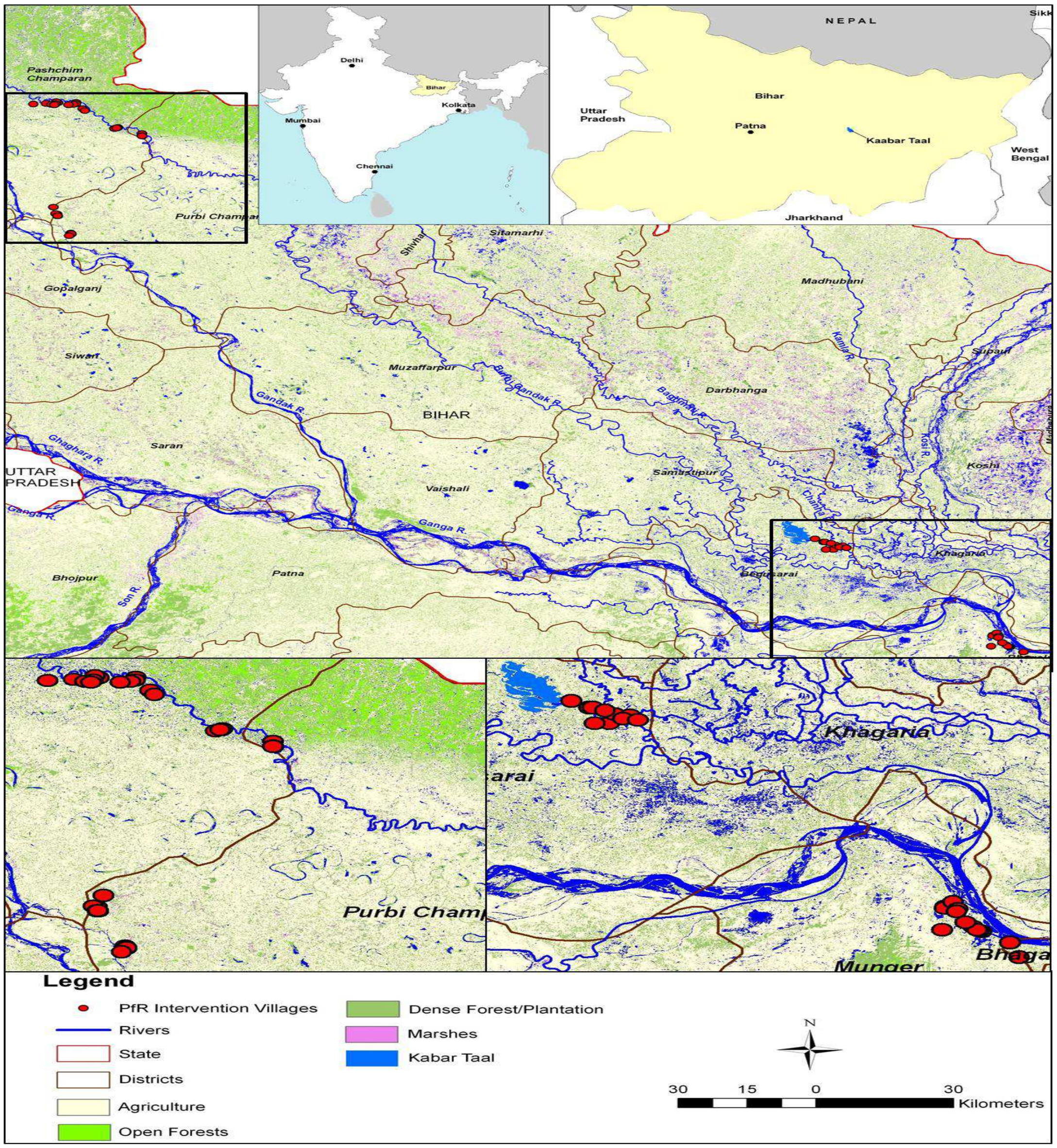
Vulnerability is "The degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity" (IPCC, 2001). Vulnerability is a function of hazard, exposure and sensitivity. It can be broadly classified into biophysical and social vulnerability. Biophysical vulnerability is associated with the nature of hazard and its first order physical impact. Social vulnerability is inherent to a system and relates to community structure, decision making systems, representation in institutions and political issues. Vulnerability Capacity Assessment (VCA) investigates the level of people's exposure to and capacity to resist natural hazards at the grass-roots level. It is a part of disaster preparedness that contributes to the creation of community based disaster preparedness programmes at the rural and urban grass-roots level. As part of the process, it allows people to identify and understand the risk they consider should have priority, even if these are not the natural hazards. It enables local priorities to be identified and leads to the design of actions that help reduce exposure and enhance capacity to reduce disaster risk. Community inhabiting similar geographical location, exposed to common hazard collectively manages and systematically undertakes measures towards becoming a safer and resilient community.

4. Applying an integrated VCA in Gandak- Kosi floodplains

Floods in Bihar are a recurring phenomenon which on an annual basis destroys thousands of human lives apart from livestock and assets worth millions. Bihar is India's most flood-prone State, with 76% of the population in the north Bihar living under the recurring threat of flood devastation (CMDRR IN Bihar strengthening Lives, July 2010, www.caritasindia.org). According to historical data, 16.5% of the total flood affected area in India is located in Bihar while 22.1% of the flood affected population in India lives in Bihar. The plains of north Bihar are drained by five major rivers Gandak, Budhi Gandak, Bagmati, Kamla-Balan and Kosi. Kosi River also referred to as the 'sorrow of Bihar' is one of the main reasons for flood in Bihar. High dependency on local natural resource, frequency of hazard, weak assets base and limited access to basic amenities render the communities vulnerable to the vagaries of nature.

The integrated vulnerability capacity assessment or participatory risk assessment tool developed under the 'Partners of Resilience' project by Wetlands International-South Asia (WISA), Cordaid and ASK was applied to understand the geophysical, ecological and social context of risk in Gandak- Kosi floodplains. Baseline information on demography, social capital; natural capital, financial capital and information on technical knowledge were collected in 85 villages within 6 districts of Gandak- Kosi floodplains under the Partners of Resilience project of WISA. Geo-morphological set up, increased incidence of hazard and ecosystem degradation was the key criteria for selecting villages for household and panchayat level surveys. A total of 2,589 households were surveyed with 10% of the households selected for interview in each village, identified based on occupation and income (high, moderate and low income) Map 1. Based on the geo-morphological set up, two clusters were identified in the Gandak-Kosi floodplains i.e. the Gandak cluster (58 villages within four districts of Begusarai, Sitamari, East Champaran and West Champaran) and the Ganga- Kosi cluster (27 villages in two districts Bhagalpur and Munger).

Map 1: Location of sample villages in Gandak- Kosi floodplains



Source@ Wetlands International- South Asia

5. Geology and Geography of Gandak- Kosi floodplains

Eight major tributaries of River Ganga, namely Gandak, Burhi Gandak, Baghmati, Adhwara, Kamla- Balan, Kosi and Mahananda drained out in North Bihar plains from west to east. On the basis of source area the rivers can be classified in to four main river systems i.e. mountain-fed (including Gandak and Kosi originating in high mountains of Himalayas, foothills fed (including Baghmati system originating in the lower foothills bordering the alluvial plains), plains fed (including Burhi Gandak), mixed fed rivers(including Kamla-Balan system).The mountain fed river system shows the fluctuation of discharge and sediment load and hence are characteristically braided whereas the foothills river fed system are only braided proximally due to meandering morphology and plain fed systems have similar drainage pattern to foothills-fed system. River system, sediment flux and tectonism in the North Bihar, has led to formation two megafans Kosi and Gandak.

Gandak-Kosi floodplians are distinguished by their divergent channel patterns and the subtle topography. Inbetween the megafans an interfan area is present which divides into an 'upstream interfan area' consisting of convergent rivers, flows on average, perpendicular to the mountain front and a 'downstream interfan area' consists of sinuous channels of the Burhi Gandak, Bagmathi, Kamla and Balan systems (Sinha and Friend, 1994). The floodplains of Gandak and Kosi are subjected to channel avulsions, flooding and sedimentation. It is believed that the Burhi Gandak (old Gandak) has developed on the paleocourse of braided Gandak river and the braided Gandak River migrated westward from the position of the present day Burhi Gandak (Old Gandak) river about 100 years ago apparently in discrete steps by avulsion (Sinha, 1996). Similarly, Kosi has avulsed systematically over the whole 120km width of the megafan in about 220 years (Gole & Chitale, 1966; Wells and Dorr, 1987a, b). Channel avulsion of these rivers in the past has left many natural depressions and cut-off meanders, later fed by rainwater and overbank flows to form *Mauns, Chaurs* and *Tals*. The Gandak-Kosi mega fans are sites of high rate of deposition and, as a result, have a steeper gradient with a dicotomic slope pattern (Mohindra and Parkash, 1994). The length and steepness of slope affect the infiltration of water in the soil which in turn governs the amount of runoff and causes quicker depletion of storage which results in larger peak discharge in downstream side.

6. Hydrological Regimes

Hydrology of the Kosi is determined mainly by glaciers and rainfall contributing about 15% and 85% respectively of the total water discharge. Kosi, inspite of being river of the Himalayas, exhibits the distinctive features of a flashy hilly torrent. Sediment load has a significant contribution towards the variation in discharge behavior of river Kosi. The Kosi River carries down about 0.1 million acres feet of sediment every year out of which about 16% is course sediment, 28% medium sediment and 56% is the fine sediment. Maximum amount of sediment load comes down during the monsoon season. This is due to soft sandy alluvium Khadar soil under the foot of Himalayas in the entire region of Nepal and India (North Bihar), there is no rocky base and hence the huge sediment load. The average discharge in normal years for the Kosi is estimated to be 175,000 cusec of water (Shrestha 1993). The devastating flood water quantities of silt and sand as load, which is rendering the vast areas of the fertile land submerged with water and silt bed. This area is about 520,000 to 800,000 ha in Bihar and 80,000 to 120,000 ha in Nepal (UNO 1951). Gandak is a multi- channel river, having low sinuosities and high braid channel ratio. The River also shows frequent lateral migration and has shifted about 105km in over 80 years (Mohindra et al. 1992). Channel avulsion and sediment dynamics play a critical role in shaping the Gandak- Kosi floodplains. Hydrological fragmentation by construction of embankments restricts much of the sediment within river channels making them shallower. Studies indicate Kosi River displays very high discharge variability with difference between monsoonal and non-monsoonal discharges being as high as 5 times. During monsoon months excess discharge cannot be accommodated within the shallow alluvial channels and results in overbank flooding.

7. Ecological significance

Gandak- Kosi floodplains are central to water and food security for the agrarian economy of the region. Traditionally, the exchange of water, sediment and species with the flood pulses has helped to support highly productive fisheries and agriculture, sustaining livelihoods. Communities depended on the floodplain area for their food, fodder and fuel wood needs. Capture fisheries, cultivation of wetland paddy and harvest of aquatic vegetation such as Makhana (*Euryale ferox*), Singhada (*Trapa natans*), Narkat (*Phragmites karka*) have been important subsistence activities. The associated wetland area serve as buffers for accommodating flood water during monsoon and also as recharge of ground water and making it available during lean season.

8. Community Profile

The economy of Bihar mainly depends on three main occupational system i.e. agriculture, fishery and animal husbandry. Agriculture is the key to the overall development of the State economy with 81% of workforce and generating nearly 1/5th of GDP of the state (Bihar's Agriculture Development: Opportunities and Challenges Government of India, New Delhi, April, 2008). Besides agriculture, livestock and dairy also play a significant role in rural livelihood contributing one third of total rural income hence it holds an important position in the state's economy. The landless farmers or wage laborers take up goatery and poultry as their income generation activities.

8.1. Occupation Profile

Within Gandak- Kosi floodplains agriculture is the main occupation of majority of households (50%) followed by wage labours (45%). Fishery, shrimp farming, petty business and government service are amongst other occupations practiced by household members in Gandak- Kosi floodplains (Fig.1). The average household income in Gandak- Kosi floodplains is Rs 32,133 per annum. Such a low income structure is due to maximum dependence on local resource and migration during period of stress by communities living in Ganga- Kosi cluster.

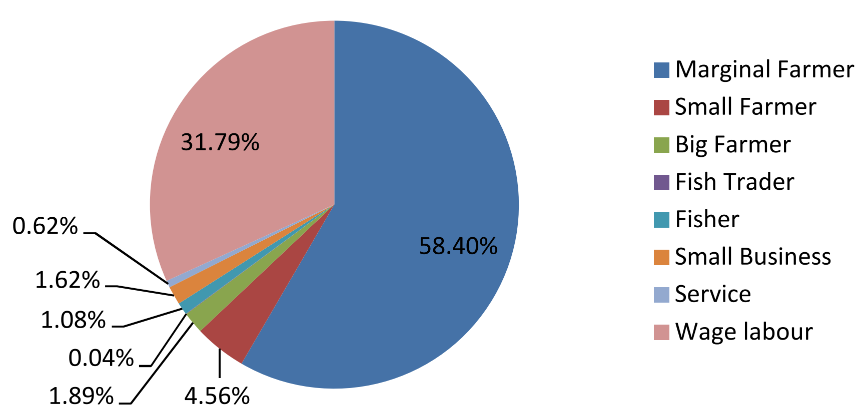


Fig. 1: Occupational profile within sample villages of Gandak- Kosi floodplains
Source: Author's own calculation

8.2. Asset Profile

In terms of asset ownership, 100% of the household record to have a shelter, however, the type of housing differs, with more than 70% of the households reporting kutcha houses vulnerable to flooding. A total of 53.7 % have agricultural land holding of which majority of the households (47%) are marginal farmers with an average of land holding of 1.4 acre. Occupational asset is present in 37 % of the households, wherein the diversity and ownership of occupational asset is higher in Ganga- Kosi cluster (42% of the households). Communities have marginal access to basic amenities (electricity, sanitation, source of energy for domestic use Fig.2).

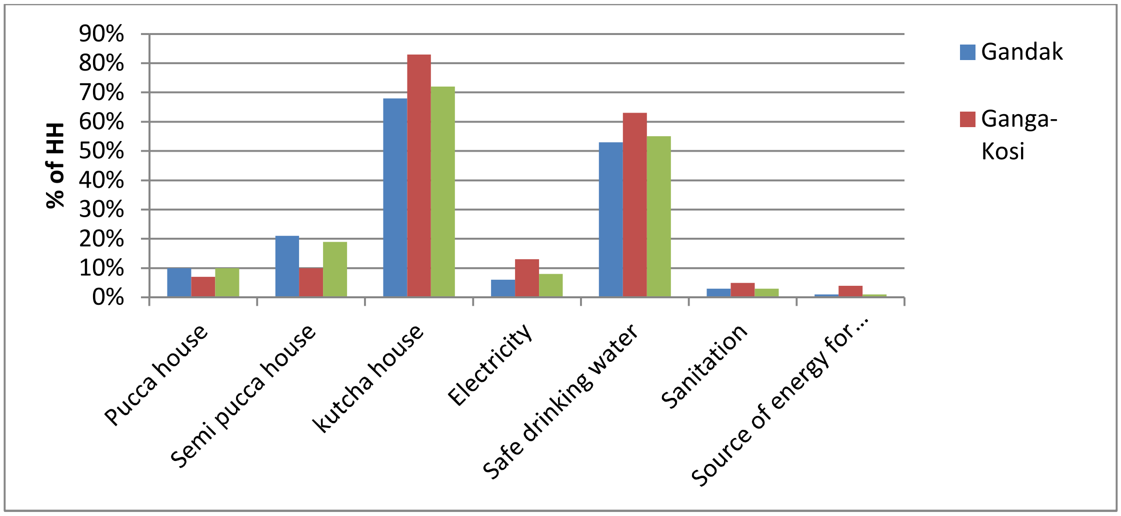


Fig. 2: Access to basic amenities by respondent households in Gandak- Kosi floodplains
Source: Author's own survey

8.3. Membership to Institutions

Membership to community institutions plays a critical role to overcome the impact of hazard. The community institutions present in Gandak- Kosi floodplains include farmers club, primary fishermen cooperative societies, panchayats, nature club, youth club and self help groups. Membership to community institutions is marginal in sample communities with not more than 15% representation in Panchayats and 10% in SHGs (Fig.3).

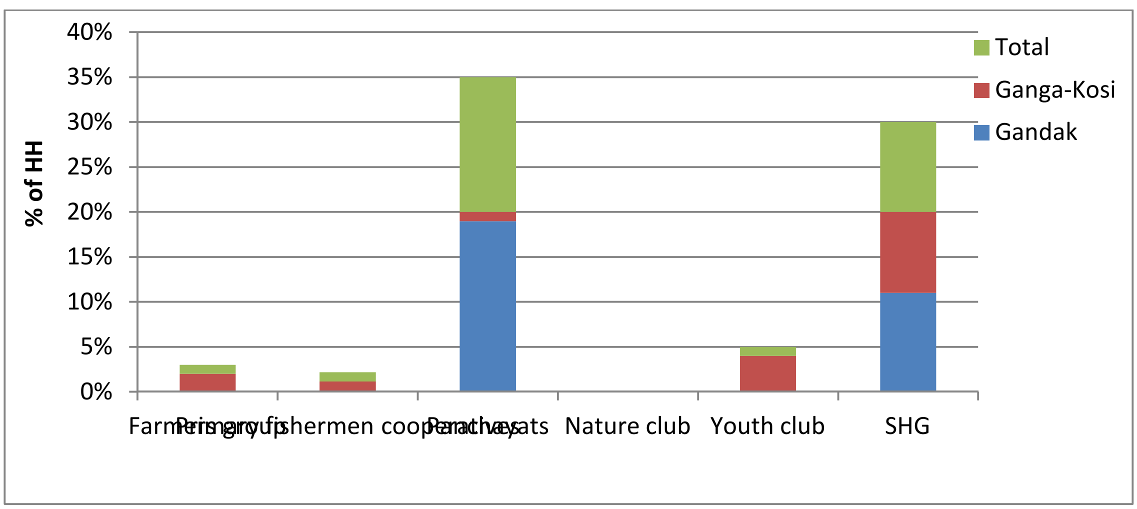


Fig. 3: Access to community institutions
Source: Author's own calculation

8.4. Dependence on natural resource

Communities living in Gandak- Kosi floodplains largely depend on natural resources both for livelihood and household needs. Overall, river (44%), pond (29%), grazing land (100%) and forest (100%) are for household purposes whereas lakes (33%) supports livelihood needs followed by ponds (12%) and river (6%). In Ganga-Kosi cluster ~100% of households depend on grazing land and forest for fulfilling their household needs followed by river (46%) and ponds (8%). For their livelihood purposes maximum dependency is on ponds (92%) followed by river (8%) and lake (3%). Similar dependence is also exhibited in Gandak cluster, with ~100% household dependency on grazing land and forest followed by river (43%) and pond (31%). For livelihood purposes maximum dependency is on lakes (34%) followed by river (7%) and ponds (5%) (Fig.4).

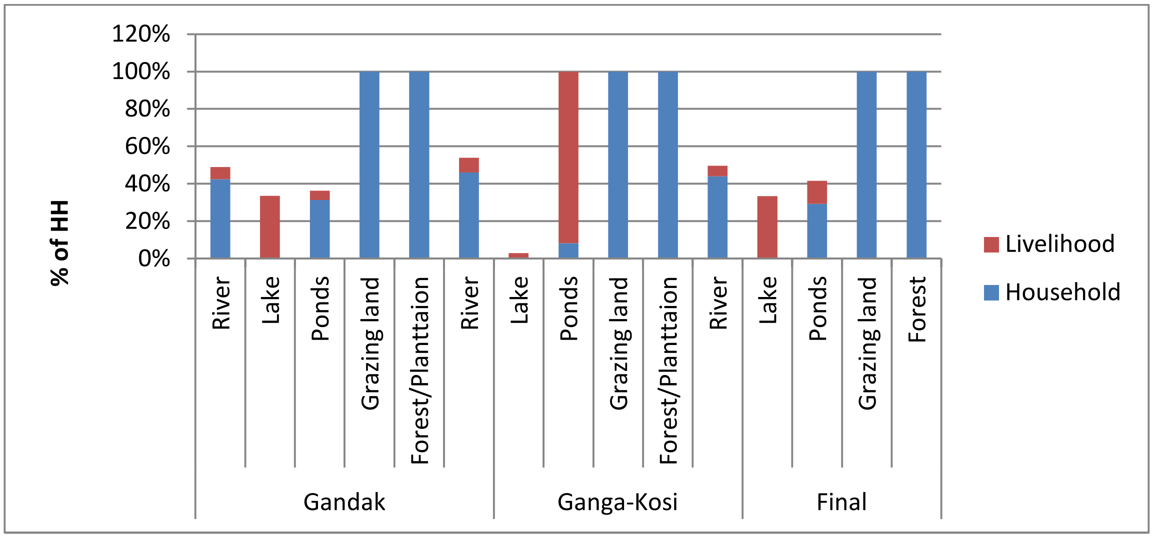


Fig. 4: Dependence on natural Resource for household and livelihood needs
Source: Author's own survey

8.5. Hazard Profile

Floods and droughts are the major hazards in North- Bihar, with 76% of the population under recurring threat of flood devastation. During the last decade (2000- 2011), floods are an annual phenomenon in Bihar affecting over a 100 million people with a death toll of 4099 human deaths and an asset loss of Rs 4,26,845 lakhs (Water Resource Department Bihar, 2011) Table 3. Analysis of data on type and frequency of hazard revealed flood and drought as the major hazards in Gandak- Kosi floodplains with 74% of the villages affected by flood, 13% by epidemic post- flood and 4% by drought. Incidence of flood and epidemic was maximum in Ganga- Kosi cluster affecting nearly 100% and 50% of the villages respectively. Flood was the major hazard in Gandak cluster affecting 65% of the villages (Fig.5).

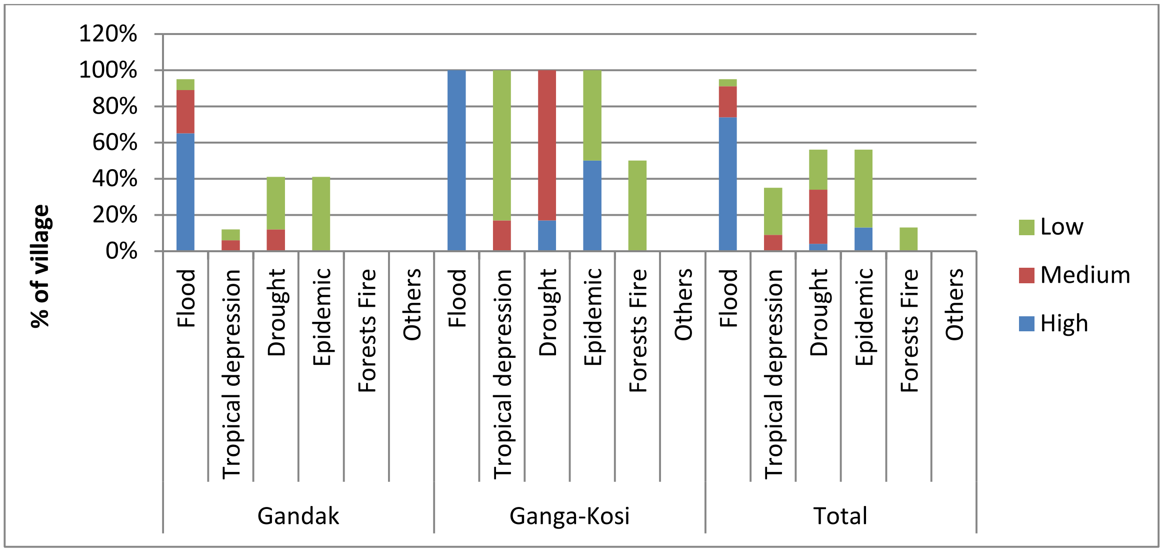


Figure 5: Profile of hazards

Source:Author's own survey

8.6. Elements at risk due to hazard

Community perception of key elements at risk due to floods were natural infrastructure (70%) followed by shelter (> 60%), human life and asset (60%), drinking water source and sanitationstructure (> 55%), source of food (50 %) and institutions (30%) respectively. Natural resources like ponds and grazing land experienced higher level of vulnerability in floods due to siltation. More than 65% households experience high risk on their primary income source (Fig.6).

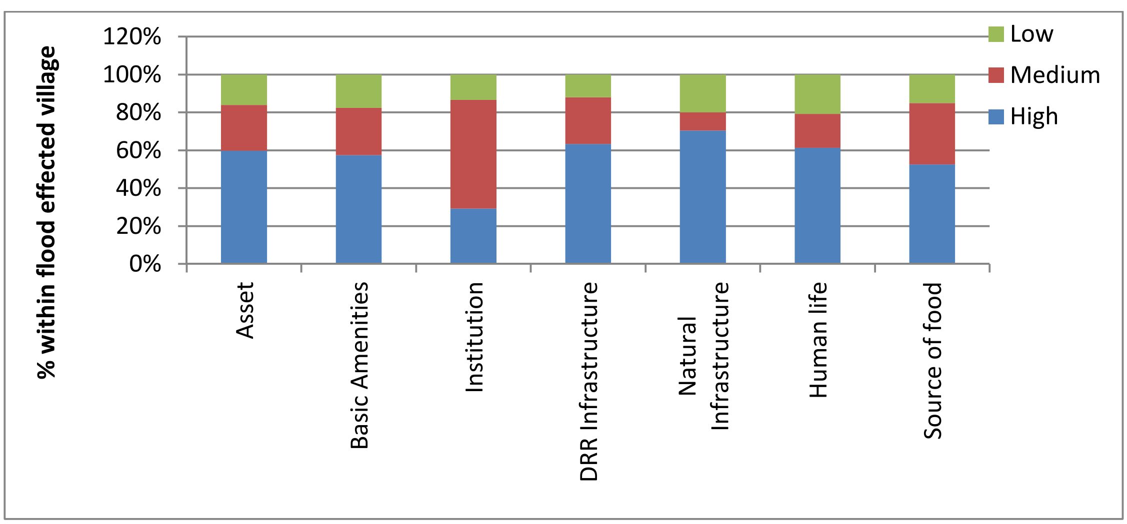


Fig. 6: Elements at risk during hazard in Gandak- Kosi floodplains

Source:Authors own calculation

9. Coping mechanisms

9.1 Prevention and Mitigation

Embankment repair, repairing pond dykes and repairing of access road are three main prevention and mitigation measure undertaken in Gandak- Kosi floodplains (Fig. 7). In Ganga-Kosi cluster only embankment repair (50%) and repairing access road (50%) are taken up as prevention and mitigation measures. In Gandak cluster the major mitigation measure is repairing of access road (41%) followed by embankment repair (29%) and repairing of pond dykes (6%).

Agriculture and wage labour being weak asset base and limited membership in community institutions has led to seasonal migration as one of the options to overcome the stress period during monsoon and post-monsoon season. More that 60% of the respondent households undertake migration wherein, individuals from 71% of households within Gandak cluster migrate during post-monsoon and individuals from 60% of households within Ganga- Kosi cluster migrate during monsoon (Fig.7).

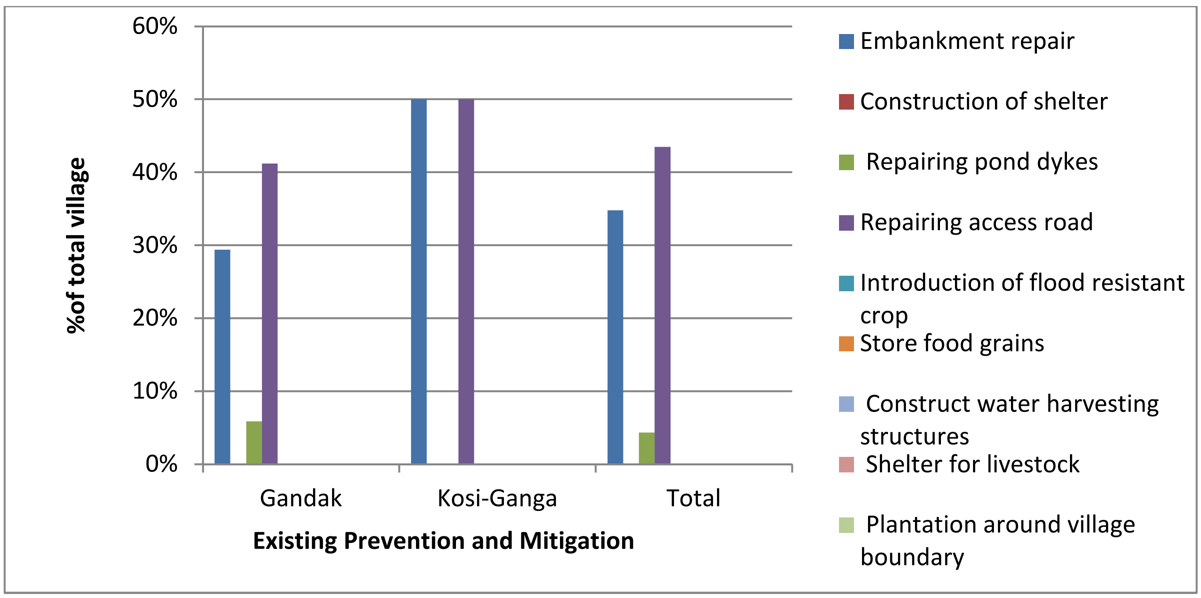


Fig. 7: Existing prevention and mitigation measures in Gandak- Kosi floodplains

Source: Authors own calculation

9.2 Individual survivability

Use of individual coping mechanism differs greatly among communities in Gandak-Kosi floodplains. Grain banks and fuel banks are used as coping strategies by over 57% and 31% respectively, wherein Gandak cluster shows highest use of Grain bank (61%) followed by Ganga-Kosi cluster (37%). Similarly fuel banks are maximally used as coping strategy in Gandak cluster (~33%) whereas in Ganga-Kosi cluster it is ~18%. Investment in disaster funds for use during stress period was observed to be marginal, rported in ~6% of households in Gandak- Kosi floodplains. However, use of insurance as risk transfer mechanism specifically life insurance was observed in 91% of households. Gandak cluster showed maximum coverage of life insurance (~93%), followed by Ganga-Kosi cluster (81%). In Gandak floodplains 5% and 2% of households were reported to use of crop insurance and accident respectively, whereas, in Ganga-Kosi cluster 14% and 5% of households were reported to use assets insurance and livestock insurance respectively (Fig.8).

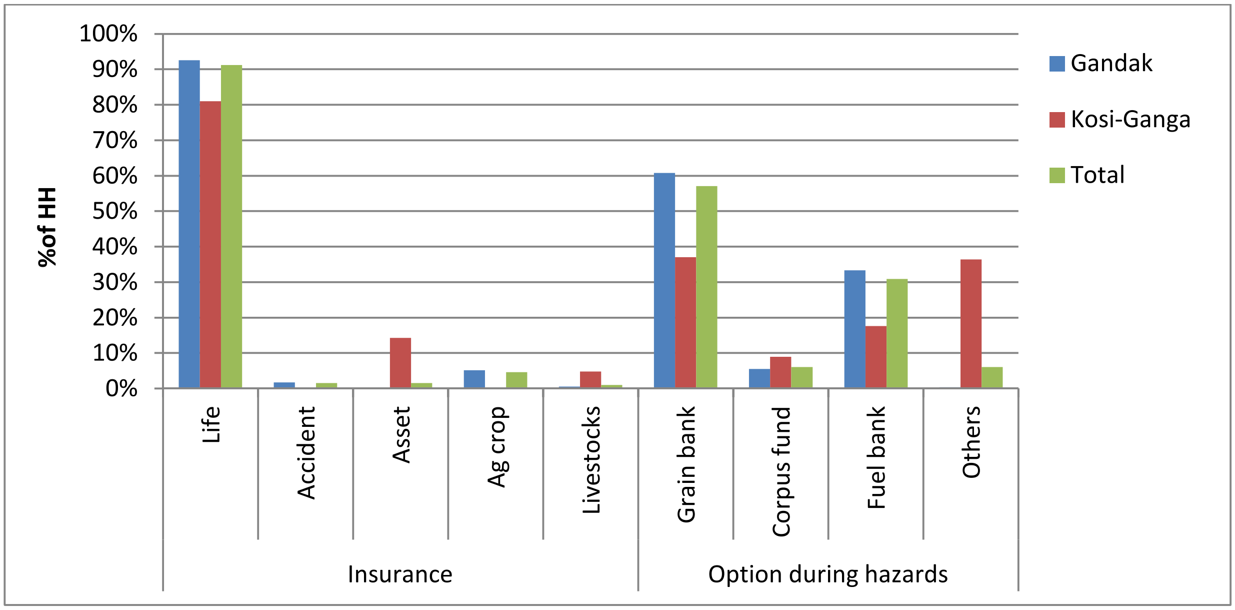


Fig.8: Measures for individual survivability within households of Gandak- Kosi floodplains

Source: Own source based on survey

9.3 Early warning systems

Various forms of early warning system are used to varying degrees in the Gandak-Kosi floodplains. In Gandak cluster, diversity and sophistication in using different technologies as a means of early warning was found to more than Ganga- Kosi cluster. Radio and television were used by majority of the villages (34%) followed by information from block office (12%) and meteorological station by state level (3%). In Ganga- Kosi cluster radio and television were used as the only source of information for early warning and early action (Fig.9).

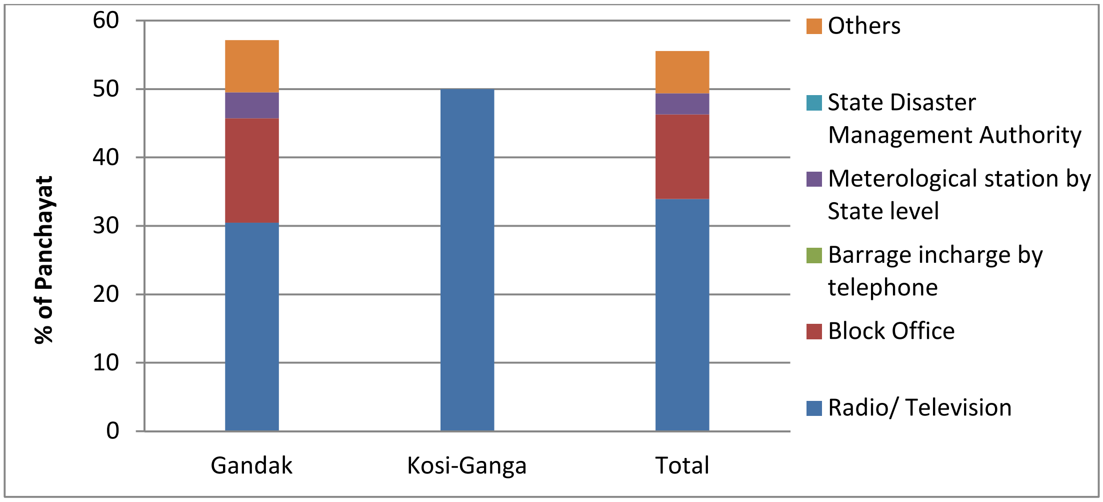


Fig.9: Available early warning systems in Gandak- Kosi floodplains
Source :Author's own calculation

Conclusion

The present study indicates that communities in Gandak- Kosi floodplains are exposed to water related hazards which are attributed to the geographical location of villages. Steeper gradient of the area and alluvial nature of soil affect infiltration of water and cause peak discharge in downstream areas. The characteristic floodplain wetland system of Gandak- Kosi interspersed with *Mauns, Chaurs* and *Tals* which acts as efficient flood buffering system has been fragmented by structural engineering measures. This has further aggravated the situation by trapping the sediment load within river channels and making the river bed shallower which limits the capacity of holding large discharge and causes overbank flooding.

In addition to the exposure in terms of location and geomorphology, communities inhabiting the sample villages in Gandak- Kosi floodplains have weak physical and financial asset. Since, majority of the community depend on wage labour, migration has been adopted as a response strategy for livelihood as well as for coping disaster in periods of stress. Limited availability of early warning systems and lack of capacity to translate sophisticated weather information restricts early action and response during hazard. In addition to this, some of the inherent factors contributing to vulnerability include lower individual survivability, community readiness and representation in community institutions.

In view of the above, the following measures are suggested to improve livelihood resilience in Gandak- Kosi floodplains

- Enhance hydrological connectivity within floodplain wetland system
- Rejuvenate water bodies to act as buffers for storage of flood waters
- Provide alternate livelihood options
- Increase disaster preparedness at individual and community level
- Install early warning systems
- Build community capacity to translate sophisticated weather information
- Increase representation in community institutions
- Promote mechanisms for risk transfer

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Declaration of Conflict of Interest

The authors have duly acknowledged the funding agency and organization where the project was operational. Both the authors i.e Dr. Pranati Patnaik and Dr. Anita Chakraborty were working on the project "Partners of Resilience" as Project Coordinator and Project Officer respectively. They were responsible for collecting, compiling, and analyzing the first-hand data of the project. Apart from Dr. Patnaik and Dr. Chakraborty, Mr. Satish Kumar also worked as a Technical Officer for the Partners of Resilience Project, however he left us for heavenly abode during the year 2020.

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