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Analyzing River Bank Erosion Vulnerability of Sadiya Region, Assam, India

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ABSTRACT

The most common and regular hazards of fluvial environment are flood and associated erosion. Floodplains are densely populated areas and as such people living in these areas are exposed to these hazards. The channel migration zone has become an important tool in the US to identify the areas at risk of flood and erosion. Vulnerability on the other hand is determined by a number of factors like demographic, social, economic and environmental. These concepts are combined together to analyse the vulnerability to flood and erosion in Sadiya, a highly flood prone area of Assam. It has been found that 20 per cent of total population of Sadiya subdivision lives in the channel migration zone. The social and economic characteristics of the population make them differently vulnerable to these hazards.

Key words: *Channel Migration Zone, Flood, Erosion, Vulnerability*

Introduction

Flood and erosion are the most regular and important geo-morphological phenomena in floodplain areas of the world however the nature and consequences may vary from region to region (Das *et al.,* 2007; Pati *et al.,* 2008; Debnath *et al.,* 2016). People living in floodplains are therefore exposed to these hazards. The impact of hazard is not equal on all as demographic, social, economic and environmental condition of the people or a community are not same everywhere. Vulnerability to river bank erosion and flood is not only more severe by physical forces but also influenced by demographic and socio-economic variables (McBean *et al.,* 2009). The impact of a disaster is largely determined by human factors (Bishop, 2001). There are different approaches to vulnerability, one of which considers 'vulnerability as a social condition' and is a result of 'relation between hazard and social condition' (Pine, 2015). Alluvial rivers erode banks during flood, a process by which rivers migrate to and fro in its floodplain. The rate of migration is aggravated by the process of avulsion. 'Channel Migration Zone' has been identified to assist as a tool in flood management in USA. The purpose of delineating Channel Migration Zone (CMZ) is to predict areas at risk for future channel migration (Rapp and Abbe, 2003). This concept of CMZ is adopted in the present study to analyse vulnerability of people of Sadiya region in Assam, India.

Materials and Methods

Sadiya region in Assam is a subdivision in the district of Tinsukia of Assam. This small administrative unit has unique physical condition and development status in the district and therefore considered

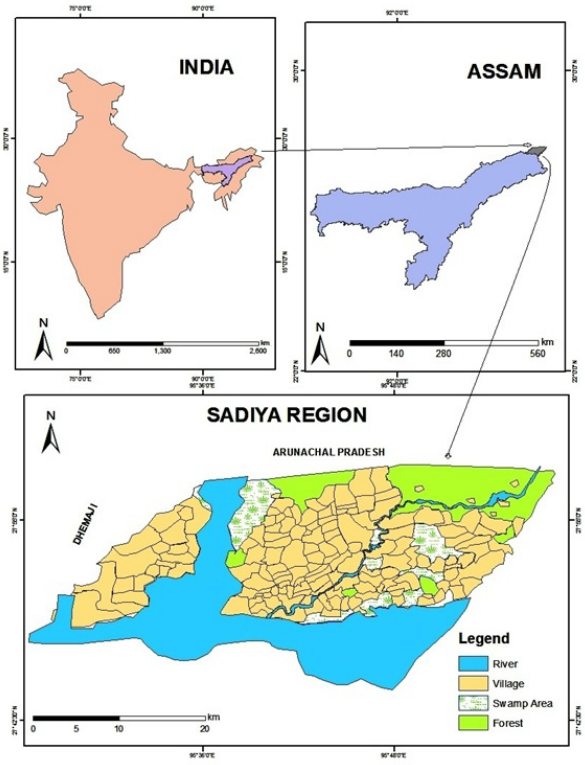

Fig. 1. Location of the study area

as the study area. The absolute location of the region extends from 27° 45′N to 27° 59´N latitude and 95° 25´E to 95° 58´E longitude (Figure 1). The most striking geomorphic condition is that it is drained and bounded by three major rivers of the state viz., the Lohit, the Dibang and the Dihang. The average annual discharge of Lohit River varies between 1627 cumec and 4625 cumec in the period 1998 – 2018 (USGS). The total area of the region is 789.95 sq. km, the maximum north-south extent is 16 km and east-west extent is 42 km in and around which rivers with width 500 to 600 meter flow. The area lies along the foothills of the Eastern Himalayan ranges. The joining of three major rivers to form the Brahmaputra in the region gives it the shape of a 'delta in reverse' (Khullar, 1999). In addition to these rivers, there are some small rivers of which the Kundil is found to have a migrating nature due to its meandering pattern. The Dibang, Lohit and Dihang also cause flood and bank erosion which exhibit braided pattern.

The population in Sadiya accounts for 7.7 percent of the total population of Tinsukia district. Of the total population 102434 in 2011, 90 percent is rural and it had no urban population till 2001. The growth rate of rural population is only 0.13 during 2001-2011. The region is inhabited by different socially weaker section such as scheduled tribes and scheduled castes, accounting for 24.5 and 2.9 percent of the total population respectively.

The Channel Migration Zone (CMZ) is delineated following the method of Rapp and Abbe, 2003, which involves delineation of Historical Migration Zone (HMZ), Avulsion Potential Zone (APZ), Erosion Hazard Zone (EHZ) and Disconnected Migration Zone (DMZ). These zones are identified on the basis of topographical maps of 1945 (US army Map Service) and 1963 (GSI) and satellite imageries from 1976 to 2016 available at USGS site (Table 1).

Socio-economic condition of a region determines the vulnerability or resilience of the community to a disaster. That age and gender influence vulnerability has been acknowledged by many such as, Pine (2015), Blaikie *et al.* (1994), Cutter *et al.* (2000) and empirically proven their significance in USA by Cutter *et al.,* (2003). However, the significance of such factors varies geographically and from community to community.

To assess the vulnerability, the settlements within CMZ are identified and certain indicators of different dimensions of vulnerability are considered (Table 2).

Table 1. Details of topographical and satellite data base

Data Type	Source	Resolution/ Scale	Year	Details
US Army Toposheet	USGS	1:2,50,000	1945	NG 46-4
Toposheet	SOI	1:50,000	1963	83 M/5, 9, 10, 13, 14
MSS	USGS	60m	27th Oct 1973	Path/Raw 144/41
TM	USGS	30m	23rd Nov 1986	Path/Raw 134/41
TM	USGS	30m	16th Nov 1995	Path/Raw 134/41
TM	USGS	30m	11th Nov 2005	Path/Raw 134/41
OLI-TIRS	USGS	30m	11th Dec 2016	Path/Raw 134/41

Table 2. Indicators of different dimensions of vulnerability considered in this study

Dimensions of Vulnerability	Indicators/parameters
Demographic	Children aged 14 years or below
	Elderly population aged above 60 yrs
	Widow Population
Social	Education
	Female headed households/widow with Minor children
	Social Bonding
	Experience
	Knowledge
	Perception, beliefs and customs
	Adaptation measures
Economic	Income
	HH below poverty line
	Occupation
	Land holding size
Environmental	Assets available like
	1. Wetlands
	2. Open lands
	3. Forest

As secondary data and information of many of these parameters are not available, a field survey was conducted in 18 (45%) villages of the 40 villages partially or wholly in AHZ and EHZ. The total population selected for the filed survey was 1633 persons and 423 household. The sampling was random.

Results and Discussion

Flood and Erosion as hazards in Sadiya

The maximum part of Sadiya subdivision is a flood prone area. Records show that 65 villages of total 174 villages are affected by flood during the period 2002-07. Of these 65 villages 10 villages are regularly affected by flood while 21 villages are also frequently affected. Area and number of villages and people affected by flood in the month of July during 2002-12 are shown in the following table (Table 3).

This Table shows the impact in one month only for which data are available. Every year usually several floods occur in the months of July and August, and sometimes even in the months of September and October. These floods also cause severe erosion. In 2012 July flood 4421 houses were damaged of which 423 were fully damaged amounting to a value of several lakhs of rupees (Circle Office, Sadiya). According to the same record 1204 hectares of standing crops were damaged in 2007, data for the same is not available for 2012. The Lohit, the Dibang and the Kundil rivers have been eroding land areas continuously. An analysis of their bank erosion and lateral migration for about 71 years from 1945 to 2016 using both Topographical maps and satellite imageries shows that both banks of Kundil, Dibang and Lohit rivers have eroded large areas (Figure 2 and 3).

Identifying the Vulnerable areas

There are 52 villages in the Channel Migration Zone (CMZ) of Sadiya the people of which are exposed to the risk of river flood and erosion (Figure 4). Within this zone, risk is high in Avulsion Hazard Zone

Table 3. Areas and villages Affected by Flood in Sadiya

Impacts	July, 2002	July, 2004	July, 2005	July, 2007	July, 2012
Area Affected	3.36 sq. km	98.2 sq. km	13.5 sq. km	18.07 sq. km	DNA (Data Not Available)
No of Villages	10	49	11	28	65
No of People	2035	19000	4210	9500	37076

Source: Circle Office, Sadiya

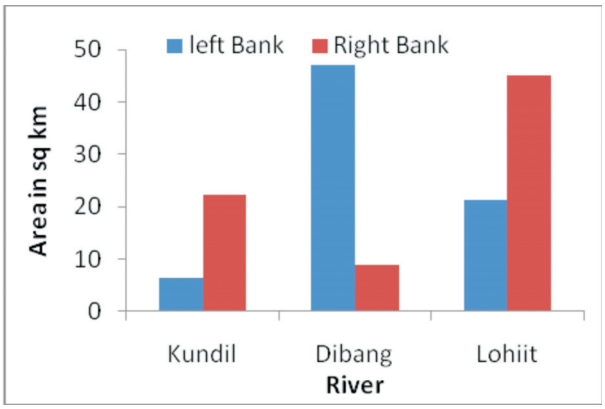

Fig. 2. River bank erosion in Sadiya, 1945-2016

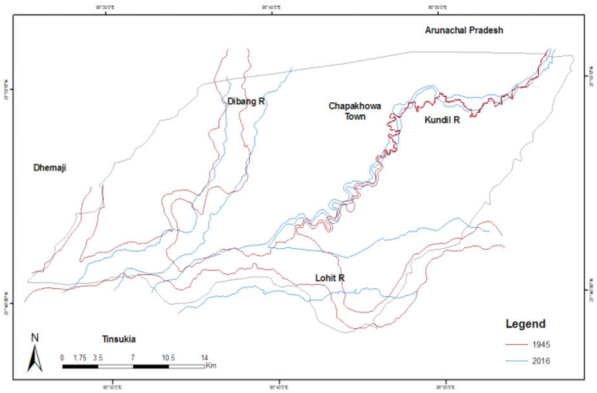

Fig. 3. River bank migration of rivers in Sadiya, 1945-2016

(AHZ) and Erosion Hazard Zone (EHZ). There are 15 villages in AHZ and 37 villages in EHZ of which 13 villages fall in both the zones. Thus there are 40 villages in total in both these zones. The total population in CMZ is 21044 which is 20 per cent of the total population of Sadiya and the total population in AHZ and FHZ account for 15 per cent of the total population of the sub district.

Demographic Vulnerability

Demographic composition of a population group determines the vulnerability of the group to a hazard. Age and sex are two important demographic attributes considered in this study to find the vulnerability of the people in the study area. In 2011, 15 per cent of the total population was in the age group of below 6 years and 48.34 per cent is female population (COI, 2011) in the AHZ and EHZ. The females and children are more vulnerable to flood hazard and to the after effects of land erosion. All the 18 villages and 423 household surveyed with 1633 population are vulnerable to flood and erosion of which 21.2 % aged below 14 years and 6.1 % aged above 60 years are comparatively more vulnerable because of physical weakness and lesser coping capacity to a hazard condition. In addition to this 2.26% of surveyed population is widow (Table 4).

Social Vulnerability

Social characteristics like family type, education, female headed households, social bonding, experience, knowledge, perception, adaptation measures are considered relevant to the study area. In rural Assam joint family structure still prevails and it is more resilient to hazard in an agricultural community. There are more adults to share the losses and to build strategy for economic revival of the family. So, the nuclear families are more vulnerable than the

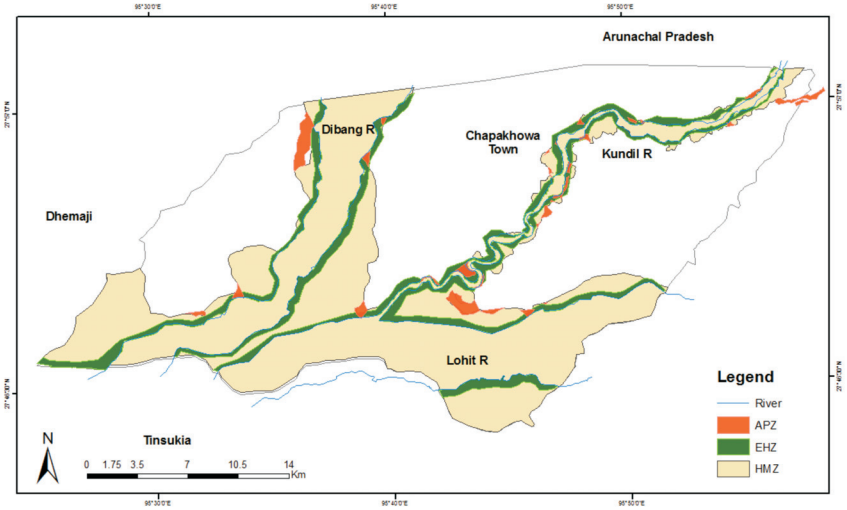

Fig. 4. Channel Migration Zone of Sadiya

Table 4. Demographic and social vulnerability in Surveyed villages of Sadiya

Type	<14 yrs	>60 yrs	Females	Widow	Nuclear	Joint	Female headed
N0	347	100	783	37	346	77	37
%	21.20%	6.10%	47.94	2.26	81.79	18.20	8.74

Source: Primary Survey, 2016

Table 5. Level of Education in Surveyed Villages

Type	Population	Primary	Secondary	>Secondary	Illite rate(s)	Highest education level	
No	1633	493	685	234	43	MA (1)	BA (6)
%	100	30.18	41.94	14.32	2.63	0.06	0.36

Source: Primary Survey, 2016

joint families, however it may be counter balanced by occupation and economic condition of the family. On the other hand vulnerability of female headed households with minor children is always high. In the study area 8.74 % households are female headed household (Table 4). Education is an important social condition as it affects knowledge, awareness, and perception as well as adaptation strategy of a community. In the study area level of education of the community is very low as 30.18% of population has education limited to primary level only (Table 5). Persons with graduate and post graduate level are also very few with 0.36 % and 0.06 % respectively; it may be expected that the presence of educated people can create awareness within the community. Modern knowledge and awareness on hazard management is largely absent in the community. Almost all people perceive flood and erosion as natural and therefore accept it as their part of life. However they have the experience of these hazards generation after generation and have developed traditional adaptation strategy. Being an agricultural community they have certain verities of rice that can be grown in deep water or that mature in short period of time. Social bonding plays a significant role in adaptation against erosion. In case a family lost its all land due to erosion, wealthier families with sufficient land provide a small plot of land to that family to build a shelter. Friends and relatives also provide succour to such families. Many families migrate to other areas where their relatives and friends have already migrated. Migration has been found to be the most common adaptive strategy to erosion in Sadiya. This is the reason why some villages disappear and new villages appear in different census reports in Sadiya. The service holders usually migrate to urban areas. Due to growth of population, open lands are decreasing in the region and therefore choice to migrate to an erosion free area is decreasing gradually. As such many erosion affected people are migrating to urban areas in recent times where they ended up being daily labourer because of lack of education and skill.

Economic Vulnerability

The economic condition and occupation are two very strong determinants of vulnerability of a community. The poor are the most vulnerable in a society; wealthier the people more resilient to a hazard (Cutter *et al*., 2000). Diversity of economic base reduces vulnerability at local level (Pine, 2015). The main economic activity of the study area is agriculture, that too mono cropping agriculture. There is diversity of livelihood among the rural people in the form of rearing of birds and animals like duck, hen, goat, pig, cow etc., and handlooms and handicrafts. The economy of these activities is not enough to revive the loss after erosion but these provide some

Table 6. Occupation structure in surveyed villages

Type	Households	Cultivation	Service	Cultivation & service	Daily Labour	Others
No	423	212	20	40	64	87
%	100	50.11	4.72	9.45	15.13	20.56

Source: Primary Survey, 2016

relief after flood. The people who are solely dependent on agriculture are therefore more vulnerable to both flood and erosion.

In the study area 50.11 % households are solely dependent on agriculture and are therefore the most vulnerable among others (Table 6). The service holders and households with both farming and service occupations are the least vulnerable economically to flood and erosion in the region. Land holding size also plays an important role. With larger land holding the farmers can cope with the hazard or disaster in a better way. Moreover the families with larger land holding usually have plots at different locations some of which are less affected by flood and erosion. In the surveyed villages 8.51% households do not have any cultivable land and these are land less cultivators (Figure 5).

The economically most vulnerable people are those below poverty line. According to the Planning Commission of India, 2014 the income poverty line in Assam is Rs 9936 per month per family. Thus 26.71% family in the study area lies below poverty line (Table 7).

Environmental Vulnerability

'Environmental capital is a key contributor to the sustainability of communities and human well-being' (Pine, 2015). Environmental assets to a great extent assist a community in coping with a hazard. Forests, wetlands and open land are three important environmental capital observed in the study region. There are 5 reserved forests in and around Sadiya. The people of Sadiya had easy accessibility to forest products till those were declared as reserved forest, the last being declared in 1995. Since then accessibility to these forest by villagers is restricted to great extent. There are a number of wetlands in the region which serve as fishing ground for local communities. However, some of these wetlands are also given on lease by the Fishery department of Govt. of Assam to certain persons due to which local community do not have accessibility to those. Open lands exist near forest and in newly developed bars and river islands. These open lands are used to build new settlements by the population displaced by river erosion. Due to growth of population and migration from other areas availability of such areas is decreasing gradually.

Conclusion

Flood and river erosion are perennial issues in Sadiya. The people living in the area accept this hazard and have developed their own adaptive strategies. However these strategies are becoming less viable day by day due to several reasons. Population growth is a major reason due to which open land is declining in the region, where people can migrate if built up areas are eroded by rivers. Changing policy of the government on natural resources has made those less accessible to the masses reducing coping capacity of the rural poor. The concept of common

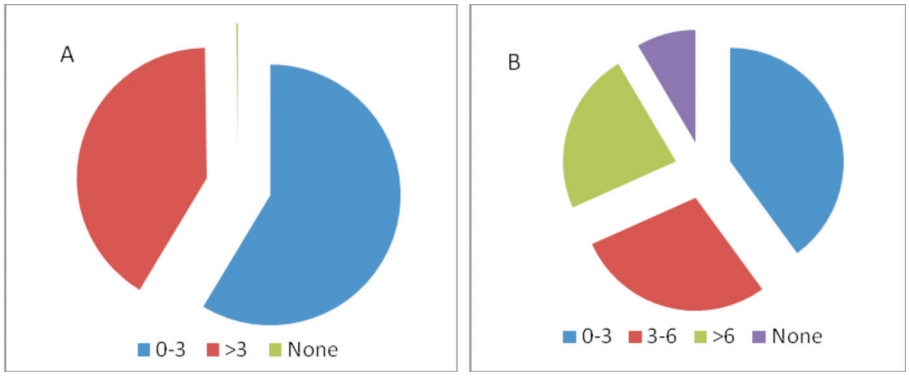

Fig. 5. Land holding size pattern (acre) A) Homestead and B) cultivable land

Table 7. Income per year (in rupees)

Entity	Households<9936	Income	9936-100000	>100000
No	423	113	244	66
Per cent	100	26.71	57.68	15.60

Source: Primary Survey, 2016

property resources is not found to be well developed in the region. Due to declining rural economy people are becoming economically weak making them more vulnerable to hazard and disasters. So the people of this region are becoming more vulnerable with time. The measures adopted by the government to mitigate flood and erosion hazards are found to be minimal. In this study also vulnerability of the people of the region could not be assessed properly due to the lack of uniform secondary data.

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