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Adaptation Strategies for Flood Risk Mitigation in Lower Brahmaputra River Basin, Assam through Integrated River Basin Management

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Abstract

It has been experienced that flood occurs almost every year in one or other part of the lower Brahmaputra river basin, Assam with varying frequency and magnitude. During the monsoon season (June-October), floods are a common occurrence in Assam. However, the year 2012 is said to be the worst in this decade. The important factors causing floods in Assam are heavy rainfall, inadequate capacity of river, severe soil erosion, river bed silting, landslides, earthquakes, river capture, poor drainage, deforestation and practice of shifting cultivation or Jhoom as well as physical and anthropogenic causes. This paper analyses the evaluation of Vulnerability and Adaptation assessments determined mainly by a weighted matrix index value. The concept of vulnerability (in terms of loss) and adaptation (how farmers adapt to extreme floods) are crucial in understanding the past, present and future consequences of extreme floods. The evaluation of vulnerability and assessments is determined mainly by a weighted matrix index value, derived from questionnaire survey of over 150 households in Dhubri, Goalpara, Barpeta, Guawahati, Dibrugarh and Jorhat (Majuli) district, Assam. This paper mainly focuses on the literature of United States Country Study Programme (USCSP). It has given Vulnerability and Adaptation assessment process guidelines, described in six steps (Benioff et al., 1996). these have been adopted to assess vulnerability and adaptation assessment in the lower Brahmaputra basin, Assam in regard to three recent extreme flood events (EFEs) 1998, 2002 and 2012. The result highlights 26 issues as being of high vulnerability, 12 issues are identified as medium vulnerability and 2 issues are identified as low vulnerability. Adaptation assessment result shows 15 issues require urgent attraction. The paper provides various mitigation processes for the challenges faced by the lower Brahmaputra basin, Assam.

Keywords: *Integrated River Basin Management, Vulnerability Index, Assessment Index, Flood Mitigation, Sustainable Development.*

Introduction

Integrated river basin management is a tool to achieve sustainable development through the process of co-ordination, conservation, management and development of water, land and related resource. It has been the experience that flood occurs almost every year in one or other part of the lower Brahmaputra river basin, Assam with varying frequency and magnitude. The important factors causing floods in Assam are heavy rainfall, inadequate capacity of

river, severe soil erosion, river bed silting, landslides, earthquakes, river capture, poor drainage, deforestation and practice of shifting cultivation or *Jhoom* as well as other physical and anthropogenic causes. Sustainable development through flood management to be promoted through specific structural measures and non-structural measures. Flood management is more effective than flood control. Experience has shown that both structural and non-structural measures would optimise the benefits. While physical flood protection works will continue to be necessary, emphasis should be on non-structural works.

The Brahmaputra basin in India, particularly its valley in Assam, represents an acutely flood-prone region characterized by awesome hazards of flood and erosion that create an annual mayhem of devastations bringing untold miseries to the people and causing colossal loss and damage to public property and infrastructure. The Brahmaputra river is characterized by high intensity flood flows during the monsoon season, June through September, with an average annual flood discharge of 48160 m^3s^{-1} (Goswami and Das, 2003).

Vulnerability assessment helps to identify magnitude, extent and nature of threat posed by climate change (Singh and Kumar, 2010). Training and capacity building of the officials dealing with emergencies would be an important instrument of disaster reduction and recovery. While natural hazards cannot be controlled, the vulnerability to these hazards can be reduced by planned mitigation and preparedness measures. There needs to be concerted and sustained steps towards reducing the vulnerability of the community to flood disasters.

2. Study Area

The present study is carried in the lower Brahmaputra River Basin, Assam. It is located between latitudes of 24°08'N and 27°59'N and eastern longitudes of 89°42'E and 96°01'E. Assam is the most populous state in the North-East India covering an area of 78,523 sq. km. It is surrounded on three sides by hills and mountains with boundaries with Arunachal Pradesh, Nagaland, Manipur, Mizoram, Meghalaya, West Bengal, Bangladesh and Bhutan. The State of Assam consists of 27 districts for administration (Figure 1). The State can be divided into three distinctive geographic parts. The river Brahmaputra flows from east to west for about 700 km within the State and has great role in the land formation, hydrology, ecology, population distribution, culture and economy of the valley and the State.

The Assam plain or lower Brahmaputra plain is one of the major geological territories of India. The Brahmaputra plain is also known as lower Brahmaputra Basin. The lower part of the Brahmaputra river valley is a devastatingly flood prone region with severe outcome to the economy, society and public health. The lower Brahmaputra basin has a very steep gradient in the north and eastern sides but extremely gentle gradient in the south, falling at the rate of 13cm/km. The runoff generation processes such as infiltration and surface flows are qualitatively understood, however little

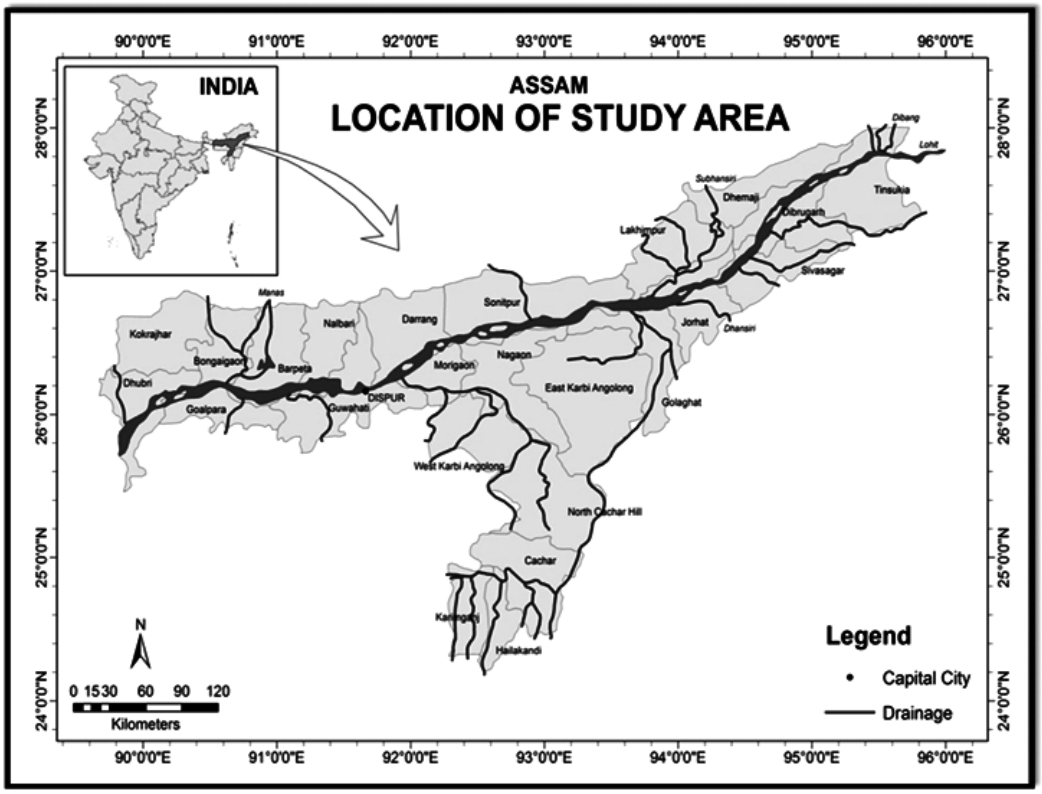

Fig.: 1

is known about how different processes combine to generate the extreme flood in the basin area.

During the monsoon season (June-October), floods are a common occurrence in Assam. Deforestation in the lower Brahmaputra river basin has resulted in increased siltation levels, flash floods and soil erosion in critical downstream habitat, such as the Kaziranga National Park in middle Assam. Occasionally, massive flooding causes huge loss to crops, life and property. On another hand, Periodic flooding is a natural phenomenon which is ecologically important because it helps to maintain the lowland grasslands and associated wildlife. Periodic floods also deposit fresh alluvium replenishing the fertile soil of the lower Brahmaputra River Valley. Thus flooding, agriculture and agricultural practices are closely connected.

3. Data Base and Research Methodology

Both qualitative and quantitative methods have been used in the study. The study is based on both primary and secondary data. Field investigation is the main tool for the collection of qualitative data and the collection of information on vulnerable farmers and their responses to natural hazards (such as flooding in lower Brahmaputra basin, Assam) in different extreme flood

events places of 1998, 2002 and 2012. The information on the perception of the local people regarding different aspect of the flood, livelihood and its management has been gathered through pre-structured questionnaire survey. Stratified Random Sampling has been used for primary survey.

The evaluation of vulnerability and assessments is determined mainly by a weighted matrix index value, derived from questionnaire survey of about 150 households in Dhubri, Goalpara, Barpeta, Guawahati, Dibrugarh and Jorhat (Majuli) district. A respondent has been selected by using stratified random sampling. About 150 respondents have been interviewed for primary data collection from 27 villages from the districts mentioned above.

Adopted vulnerability and adaptation assessment steps for Adaptation Strategies

Based on the literature (IPCC, 2007; UNEP, 1996, United State Country Study Programme, 1999 and Younus, 2010) the following steps have been adopted to assess vulnerability and assessment in the lower Brahmaputra basin, Assam in regard to three recent extreme flood events (EFEs) 1998, 2002 and 2012. The steps are:

1. Identification of the problem regarding vulnerability and assessment in the context of the study area through primary survey with questionnaire.
2. Define the objective within the environmental barrier/constraints (e.g. Extreme Flood Event).
3. Identify vulnerable and adaptation issues and options in accordance with the problem,
4. Quantify the vulnerability and assessment issues through a weighted index scale.
5. Classify and rank the vulnerability and assessment issues.
6. Measure vulnerability and define autonomous adaptation measures.
7. Recommend strengthening of the vulnerability and autonomous adaptation measures in the light of climate change.

4. Result and Discussion

Discussion on the Vulnerable and Adaptation Issues

The concept of vulnerability (in terms of loss) and adaptation (how farmers adapt to extreme floods) are crucial in understanding the past, present and future consequences of extreme floods and used in natural hazard and social science research. Vulnerability issues analysed in this paper and includes crop and agriculture related loss, farmer's household and agricultural assets, community infrastructure and other socio-economic activities in areas of lower Brahmaputra river basin, Assam devastated by extreme floods.

In the lower Brahmaputra river basin of Assam different issues were raised during flood and after flood. Some important issues have been discussed here in different categories during extreme flood years 1998, 2002 and 2012. The vulnerable issues has been measured using weighted matrix index given by USCSP, 1999 (Table 1).

Table 1: Category of vulnerable issues

Category of adaptation	Category of adaptation weighted index, calculated by per cent of respondent to yes reply	No. of Adaptation issues
Urgent	76-100	15
Intermediate	51-75	6
Low	26-50	2
Very low	0-25	1

Source: Primary Survey, 2012

In this vulnerability assessment matrix, 27 issues are identified having high vulnerability with highest scores (weighted index 76-100), such as one time entire crop loss, loss of stored seeds, seed bed erosion, occupational loss, primary, occupational loss, secondary, cattle loss, chicken loss, goat loss, poultry loss, plant loss, household damage related loss, livestock shed loss, cropland loss due to erosion, agriculture input loss, fertiliser, pesticide, labouring cost loss, land preparation cost loss, ploughing tools loss, loss of land due to erosion, homestead erosion related loss, injury related loss, village linked road erosion, school damaged related loss, utensil related loss, clothing loss, agriculture land loss due to flood, leave home during or after flood and vehicle, boat loss due to flood.

12 issues are identified as medium vulnerability with scores (weighted Index 51-75), such as three times entire standing crop loss, sand deposition on the agriculture lands, pond fish loss, storage place loss, watering cost los, crop land loss due to sand deposition, disease related loss (e.g. Diarrhoea, dysentery, gastroenteritis, fuel wood loss, main road erosion, school book loss, bedding loss and evacuation cost loss).

2 issues are identified as low vulnerability with score (weighted Index 26-50) such as latrine washed out/ loss (Plate 1). 1 issue is identified as very low vulnerability with score (weighted Index 0-25) such as tertiary-occupation losses and tube-well washed out/non functional loss (Plate 2). Tertiary occupation loss received a low weighted index because most farmers had no tertiary occupation. Tube well loss was relatively low in all flood years and so received a low vulnerability value.

Discussion on the adaptation issues

In the lower Brahmaputra river basin of Assam different issues were raised during flood and after flood. Some important issues have been discussed here below in different categories during extreme flood years 1998, 2002 and 2012. The adaptation has been measured using weighted matrix index given by USCSP, 1999 (Table 2).

Plate 1: Toilet washed losses has low vulnerability, before and after flood, Assam 2012

Plate 2: Raised hand pump before and after flood, June, 2012

Plate 3: Temporary migrations due to flood in Majuli (Jorhat district) Assam, 2012

Table 2: Category of adaptation

Category of adaptation	Category of adaptation weighted index, calculated by per cent of respondent to yes reply	No. of Adaptation issues
Urgent	76-100	15
Intermediate	51-75	6
Low	26-50	2
Very low	0-25	1

Source: Primary Survey, 2012

In this adaptation assessment matrix, 15 issues are identified having high adaptation issues with highest scores (weighted Index 76-100), such as look for loan for seeding from professional/lender/rich relative/bank/ NGOs, shifting house due to river erosion, to move temporarily to other cities in search of work, partial starvation (one meal per day instead of two or three), migration to other cities, need for immediate food (Puffed rice), need for immediate shelter, need local variety *Aman* seeding, need for meditation/ health care, need to establish dam for river flow control to prevent river bank erosion/ submerge, need to do river dredging for quick drainage of river water, to provide production equipments/seeds/fertilizers/ agriculture inputs through local agriculture officers, need for immediate relief facilities (by the army), need to ensure effective distribution of relief goods and need to establish flood shelter in flood free high lands, these should be multi- purpose.

Out of total 24 issues, 6 issues are identified having intermediate adaptation issues with scores (weighted Index 51-75), such as look for loan for immediate foods, change the occupation (rickshaw-pulling, day labourer etc.), need for money for next season/ transition period cropping and agriculture inputs, labouring/ land preparation and watering, rebuilding homesteads after floods, need for veterinary help (medicine and expertise) and need of material for building temporary shelter / bamboo plates on top of the roofs.

Out of total 2 issues are identified having low adaptation issues with scores (weighted Index 26-50), such as to look for small boats for transport and to look for fishing facilities. 1 issues are identified as being of very low adaptation issues with scores (weighted Index 26-50), such as need to raise the boundary of the ponds or need to put net around the boundary of bonds in order to prevent fish being carried away by food water.

Discussions on Adaptation Issues According to Vulnerability Issues

Adaptation involves adjustments to enhance the viability of social and economic activities and to reduce their vulnerability, including its current variability and extreme events as well as longer term (Smit et al., 2000). Adaptation is a key response to reduce vulnerability to climate change.

(1) Adaptation is a process by which vulnerable people seek to cope with environmental extremes. Environmental extremes tend to disrupt adaptation capability but it is the human nature to try and adjust to the changed environment in order to survive. The type of land and

the flood regime both control adaptation decision-making. For example in flood prone areas farmers usually choose to plant wheat on higher ground.

(2) Every extreme flood, some farmers are forced to sell their belongings and fixed assets such as land, stock, houses, trees etc. Thus with every major flood the number of poor and landless increases, making them ever more vulnerable and unable to cope with even moderate or low-level floods in the following season.

(3) Extreme flood events, force marginal farmers to migrate to urban centres, especially in cities. These flood victims lose their crops, sell land and other fixed assets, and finally, being unable to find a job work as labourers or as workers on other farms, have no choice but to migrate to cities for food and shelter. They ultimately become environmental refugees and live in slums, finding work as rickshaw pullers or day labourers (Plate 3).

(4) After every extreme flood reduces farmers coping ability to manage normal flooding for the following year. As they lose their crops and stored seeds they also lose their ability to afford, cultivation costs, irrigation costs and agricultural input costs for the next cropping season, so becoming even more vulnerable.

Crop diversification and change in land use pattern may help farmers to minimize risk arising from flood hazard. However, this has caused major changes in cropping patterns, use of agricultural inputs and management of soil erosion. High Yield Variety (HYV) crop cultivation has more useful in mitigation of livelihood and helps to change in land use pattern in different way of planning to protect from flood hazard (Figure 2 and Table 3).

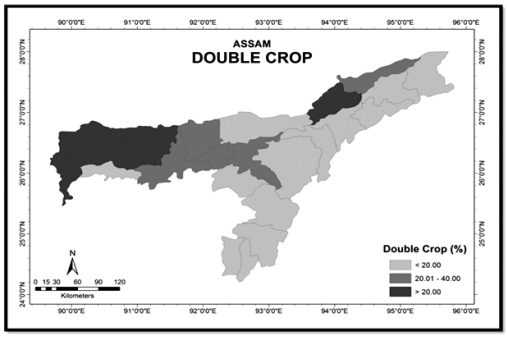

Fig. 2: Double crop area of Assam, 2010

The department of agriculture prepares a contingent crop planning to minimize the reduction in losses of production by way of selecting appropriate / alternate crop, suitable variety and by way of adopting appropriate production technology. The Assam Agriculture University organizes training on various aspects of agriculture in flood affected areas in its Krishi Vigyan Kendras (KVK) and Regional Research Stations. Net sown area and total sown more than one crop have increased and fallow land has decreased. It is helpful in adaptation from flood hazard events (Table 3).

Table 3 : Prevalent Pattern of Land use change for adaptation of Flood

District	Net Sown Area			Area Sown more than one			Fallow land		
	1950-51	1975-76	2010-11	1950-51	1975-76	2010-11	1950-51	1975-76	2010-11
Cachar	26.22	30.71	32.29	5.21	10.35	11.56	9.7	6.7	5.1
Goalpara	23.39	37.62	40.51	10.25	15.33	18.2	4.4	2.6	1.9
Kamrup	42.23	46	52.12	14.2	23.65	24.1	2.1	3.3	2.8
Darrang	30.46	40.44	42.4	4.2	9.4	10.16	10.1	3.4	2.9
Nagaon	43.37	45.41	48.14	5.1	8.61	10.2	5.5	2.8	2.5
Sibsagar	30.42	40.56	48.54	2.1	3.5	4.2	15.4	5.7	3.6
Lakhimpur	19.41	27.86	30.8	2	4.6	6.2	5.16	3.5	2.9
Dibrugarh	29.31	38.93	46.22	NA	NA	NA	7.26	3.86	3.2

Source: Statistical Handbook of Assam, 2012, Government of Assam

The *boro* paddy that is grown most successfully is water resistant and grows in water logged and marshy areas and some varieties can withstand strong currents. The practice of mixing *boro* and *ahu* cultivation ensures that at least one crop survives in the case of early or high floods. Cultivation of *boro* paddy is a suitable alternative for Assam's flood area and more people are expected to plant it to ensure food security in Assam.

Conclusion

The paper deals with the understanding of issues of vulnerability and assessment techniques in response to three EFEs 1998, 2002, 2012. The issues have been categorized on the basis of a weighted matrix index. Vulnerability issues has been classified into four categories according to their respective degree of severity and these together offered a genuine picture of vulnerability in their particular flood prone area. This type of information can be of immense value if it is incorporated into policy making and if it contributes to worthwhile action by authorities. Adaptation issues were classified into four categories and this revealed that some inbuilt, routine and tactical adaptation techniques are already being implemented, but there are other high priority adaptation techniques for which flood affected people need support. When the adaptation capacity threshold is exceeded, tactical interventions (adaptation issues) can be rapidly identified and adopted.

Flood risk mitigation strategies can be process in to long term and short term as structure and non-structure measurement.

There are two different ways to mitigate floods:

1. **Structural**
2. **Non- Structural**

Structural measures are in the nature of physical measures and help in **"modifying the floods"** in different ways:

a) Embankments

Embankments have been extensively used to protect important towns and low lands of Assam against floods. However, the embankments are now the best means of communication in the flood-prone areas. During floods, people migrate near to the embankments for temporary shelter and often settle down there for good. Thus, embankments and their slopes become permanent settlements to flood victims and their livestock. It messes up proper maintenance and embankments become susceptible to breaches during floods. Whenever there are lapses in maintenance, the protected areas are exposed to serious flood hazards.

b) Reservoirs

The entire natural water storage place should be cleaned on a regular basis. Encroachments on tanks and ponds or natural drainage channel share to be removed well before the onset of monsoon. Since Dibrugarh lies in a heavy rainfall zone, during the rainy season, water starts accumulating inside the town and the low-lying areas, as the embankment interfered with natural drainage, causing health hazards, especially in the north-western part of the town. To solve this new problem, a drain was dug through the length and breadth of the town. The canal served its purpose for some time but gradually became more of a repository for polluted water due to the deposition of debris and frequent blockages

c) Natural water retention basins

Dams and levees can also be constructed which can be used as temporarily storing space which reduces the chances of lower plains getting flooded.

d) Buildings on elevated area

The buildings in flood prone areas should be constructed on an elevated area and if necessary on stilts and platform.

However, complete flood control in terms of structural methods of flood protection are neither economically viable nor these are environment friendly. Therefore, **non-structural methods** are becoming popular in mitigating flood disaster. While non-structural measures are in the nature of planning and help in **"modifying the losses due to floods".** In the non-structural measures to try to keep the people from worst condition of flood through following method:

a. **Flood plain zoning:** Flood plain zoning, which places restrictions of the use of land on flood plains, can reduce the cost of flood damage. Local governments may pass laws that prevent uncontrolled building or development on flood plains to limit flood risks and to protect nearby property. Landowners in areas that adopt local ordinances or laws to limit development on flood plains can purchase flood insurance to help cover the cost of damage from floods.

b. **Flood Forecasting and warning:** These are issued for different areas mostly by the Central water Commission/Meteorological Department and by the State Irrigation/ Flood Department.

However, an effective Warning System is one that can release warning in advance, i.e. 72 hrs, 48 hrs and 24 hrs. It can change the existing scenario substantially and render informed decision making in adopting proper measures towards disaster preparedness, mitigation, control, planning and management. This kind of advance warning can help the authorities for better flood preparedness and also effective flood mitigation. Therefore, initiatives have to be taken to modernize the operation of flood forecasting and warning by adopting the state of art technology and integrating it into the forecast and warning dissemination process.

Adaptation issues must be given priority in policy making, especially in those district which are most affected. If today's policy-making takes into account the findings, it will help reduce vulnerability in the future. The study suggests that the community-based vulnerability and adaptations assessment awareness programmes, can deal at grassroots levels by helping farming communities adapt within a system near its thresholds, and it also indicates what those communities can do to recover from future flood events under climate change conditions.

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