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A Study on Bank Erosion by the River Baralia (Bhairatolajan) in Melkipara Village of Hajo Revenue Circle, Kamrupdistrict, Assam, India

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Abstract- Among the various hazards created by nature on the earth's surface, the one caused by flood and river bank erosion is more common and quite devastating. Like, earthquake and volcanic eruptions, it also affects human activities in various ways wherever it occurs. Erosion, transportation and deposition are the main functions of a river. Through these activities, it creates different landforms and brings about changes in its course. When it overflows its banks, it creates natural calamities, like flood, erosion and sedimentation, which adversely affect human occupancies of the floodplain. The economic activities carried out in floodplains largely dependent on the nature and frequency of these hazards. In some parts of the floodplain tract bank erosion may create serious problem for the people living there destroying their homes and hearths and damage their crops. The degree of damage depends upon the degree of its magnitude, intensity and duration.The study areas provides a typical example of this dynamicity and devastation where large tracts of fertile agricultural land and densely settled villages have been eroded away, thousands of people are rendered homeless and forced to migrate to other areas – both in the immediate neighbourhood and quite a far.

Index Terms- Bank Erosion, Flood, Socio-economic Impact.

I. INTRODUCTION

Flood and bank erosion both are related natural hazard. Erosion has been a part and parcel of the flood hazard. There may be heavy bank erosion during and after the flood which will lead to bank line migration.Bank erosion is a geomorphic process through which there takes place changes in channel dimensions by lateral widening. The lateral widening which occurs spatio - temporarily is generally caused by braiding. Generally bank erosion is a process commonly associated with migrating meandering streams or laterally shifting streams. Migrating streams tend to erode the banks and widen the channels by undercutting and bank caving the eroded material is then washed away by the flow. Bank erosion may also occur when a streams shift laterally along the dip of the rocks leading to concentrated erosion on one of the channel banks. The textural and stratigraphical characteristics of the material, as well as the presence of vegetation determine the bank resistance and stability.

The formation of sandbars within the river bed due to flood deposits may cause intense braiding of the channel. Such braiding process may further enhance lateral erosion and channel widening also in the case of a meander river the flood sometimes causes heavy erosion along the bank which is already active in erosion. Bank erosion seems to be a function of hydraulic character of flow and engineering properties of bank materials. Shear failure in the upper bank materials appear to be by far the most widespread mode of bank failure in the river. These are caused either by undercutting of the upper bank materials by channels during the high flood producing an overhanging cantilevered block that eventual fails in by over steeping of bank materials due to migration of the thalweg to the bank during the falling stages. Large scale slumping of bank observed during the falling stages of the river may be associated with return flows in the permeable alluvium. High moisture content, low proportion of clay and good sorting of bank make the bank highly susceptible to erosion by the river. The drastic changes in channel configuration observed in the erosion prone areas along the river indicate the dynamic nature of river morphology and the intense of erosion caused by it.

The pattern of human occupance of a floodplain in thereof heavily dependent on the magnitude, extent and frequency of flood and erosion of the particular river. Enquiries pertaining to river - man relationship as depicted on settlements and landuse patterns are thereof of great interest to the social scientists as well as planners and engineers. A major consideration in selecting the topic for the present study is the systematic study of bank erosion and also the shifting courses of the Baralia River. This study, therefore, examines and analyses a vital problem that plagues this region.

The shifting bank line of the Baralia River basically controls the location and distribution of settlement and landuse of the study area.The magnitude of the erosion hazard has a great influence on the pattern of occupance of the floodplain.

II. OBJECTIVES OF THE STUDY

The study area is situated along the bank of Baralia River in the district of Kamrup. As it is a highly erosion prone area, it is selected to examine effects of river erosion on human occupance of the floodplain viz, its settlement and landuse. The study is confined mainly to the period .Principal objectives of the present study are:

i. To study the migration of the Baralia River bank line in the study area.
ii. To examine the effects of erosion on the study area.

iii. To analyse the pattern and process of erosion hazard.
iv. To examine the protection measure taken by the government.

III. METHODS OF STUDY AND DATA BASE

Both empirical and field survey is done for collecting various types of data. There were two principal sources of data Viz, secondary data comprising maps, statistics, official reports etc and primary data obtained from direct field observation and survey.

In the first stage of the work, available literature on the subject have been studied for a good background and better understanding of the problem. For the purpose, the university as well as the departmental library facilities have been used. Then the data from secondary sources such as census reports, distinct gazetters, maps and statistical handbooks etc are collected from various government departments and private agencies like the water Resource Department, Brahmaputra Board, the Revenue Department, E & D office, census office, ARSAC (Assam Remote Sensing Application Centre) etc.

Finally, direct field observations were made and data collection out and also for photographs of erosion prone site. The data collected from both primary and secondary sources are then processed, tabulated, analysed and interpreted.

IV. SIGNIFICANCE OF THE STUDY

River bank erosion has great impact on floodplain occupance. It effects adversely the settlements, landuse, culture and economy of the area, as well as the economy of the country. As already mentioned due to availability of fertile lands for agriculture and other facilities it always attracts people to settle on it. The area covered by the present study is a highly flood and erosion prone belt along the river Baralia. The area is important for high agriculture productivity and is thickly populated. After the construction of Bhairatola Jan in 1985 to reduce the effect of Baralia river near Bhairatola, Bijulighat, the study area faces, heavy erosion in the area resulting in heavy loss of agricultural land and settlement areas. The suffering of the people in these areas knowns no bound. The rationale behind selecting this area for the present study is to examine the effects of bank erosion on land use and settlement pattern and the nature and level of adjustment of the people to the hazards of erosion in this area. As large parts of the floodplains area in Assam is affected by river erosion, this research represents a case study, the findings and the data of which will provide guidelines for such studies elsewhere in the valley. The study is a modest attempt to find of generalized conclusions regarding intensity of the hazard and human adjustment to the erosion problem in the flood prone areas along the Baralia River in Assam.

V. GEOGRAPHICAL ACCOUNTS OF THE STUDY AREA

Physiographic Conditions:

The study area lies between latitude 26^{o} 17'02" N to and91^{o} 28' 86" E .The study area lies to the left bank of Bhairatola Jan (Baralia river), under Saniyadi G P, of Hajo C. D. Block in the Kamrup District of Assam. It is about 2 km from Hajo-Mukalmua PWD road. It covers an area of 2 Km^2 with a population of 600.The Baralia river originates from the Bhutan hills. The river has all the characteristics of a flashy river like Pagladiya.It also meanders freely and has many loops, the slope being somewhat flatter in the lower reaches. In the upper reach the Baralia river bed is built up of boulders, shingle and sand with steep slope, while lower down it is in the alluvial stage.The area is a riverine tract along the Baralia River .The Baralia River has developed a crescent shaped relief particularly on the area from Bhutan foot-hill to the Bhabar alluvial zone. Relief characteristics of the study area is almost plain. The maximum is 50m from the mean sea level and the lowest elevation is only 45-48m.The slope is decline from north to south.

The Baralia river has four physiographic division from upper to lower part. These are-

- Bhutan foot-hills Belt
- Bhabar- Tarai Belt
- The North Built-up strip
- The active flood plain zone

Physiography of the area is characterised by plain topography. There is no very complexity of physiographic feature and there is not any physiographic division. The altitude of study area is comparatively high to north and slope gradually decreases towards south.The area under investigation is a floodplain which mainly composed of tertiary alluvium.

Geologically the Baralia – River especially its northern margin is closely linked with Himalayan geology .The Baralia river is mainly composed of recent and sub-recent deposits. It can be sub divided into

(i) Older alluvium
(ii) Newer alluvium

The Newer alluvium consists of sand, silt, shingle and clay in the alluvial plains at the lower reach of upper basin .The northern part of the basin shows a distinct layer of tertiary mainly used for bricks making .Like the rest of Assam , the area lies in the tectonic zones . Amongst the recorded earthquake the most important ones are the earthquake of 1897 and 1950.

Floodplain is a highly dynamic topography surface .So, the floodplain may be of as both a product and functional part of the whole stream environment .The study area is basically controlled by the river Baralia .The river originates from the Bhutan hills, and it flows in a southern direction for a few km and it takes westerly turn and after winding its way falls into the Pagladia river .Due to severity of flood hazard in the areas like Dusutimukh, Boulighat,Bhairatola, a jan of about 15 km was constructed in 1985 from Bhairatola to the Velkar and the jan falls into the Puthimari river.

The climate is the important phenomena of the earth atmosphere. The different area enjoys the different climatic condition on the earth surface .The climate of the study area is intermediate between those of the South Bhutan and Assam valley. While the former has a distinct hot season with the day

temperatures in April and May higher than in the rest of the year, in the Assam valley the South West monsoon season is the hottest season the year.

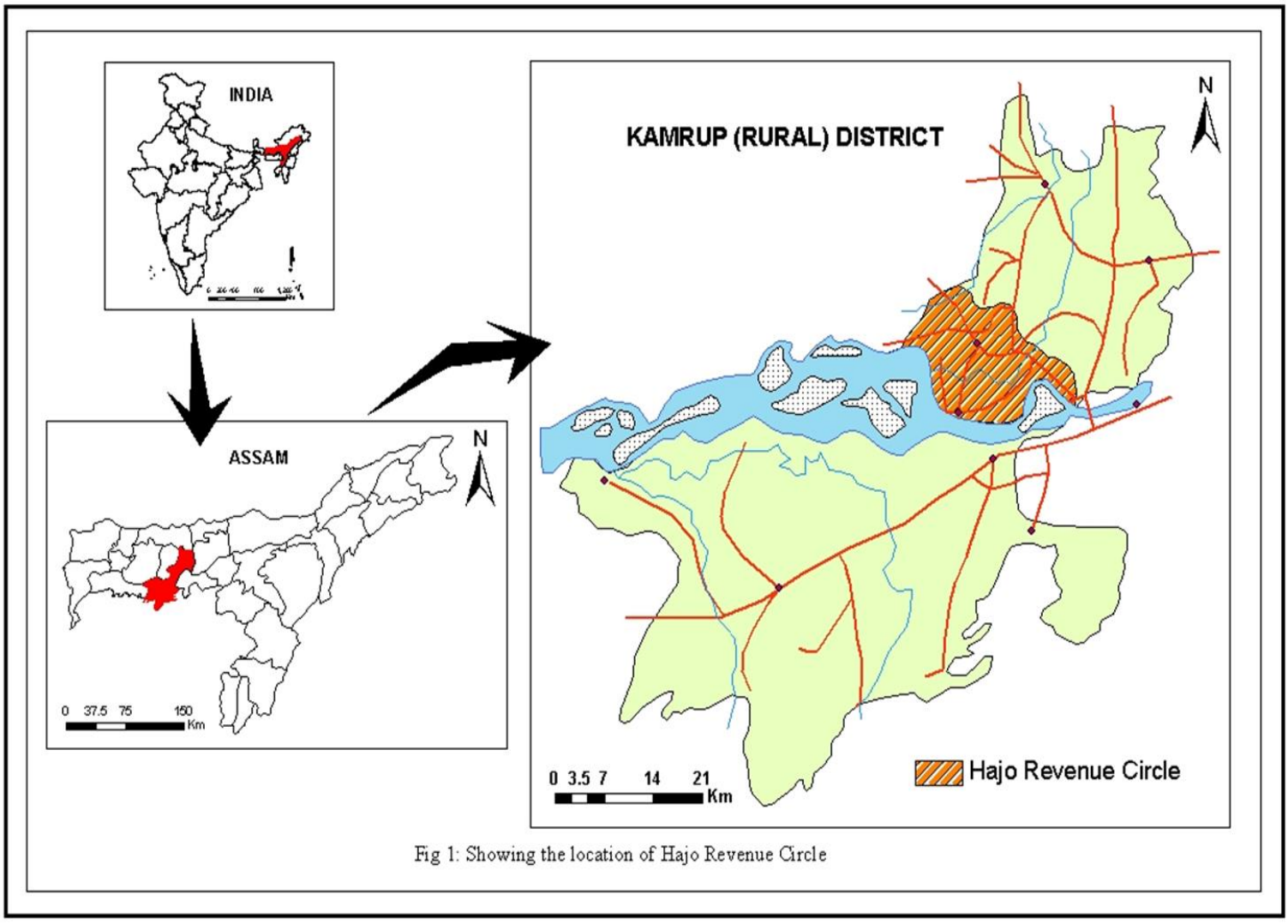

Fig 1: Showing the location of Hajo Revenue Circle

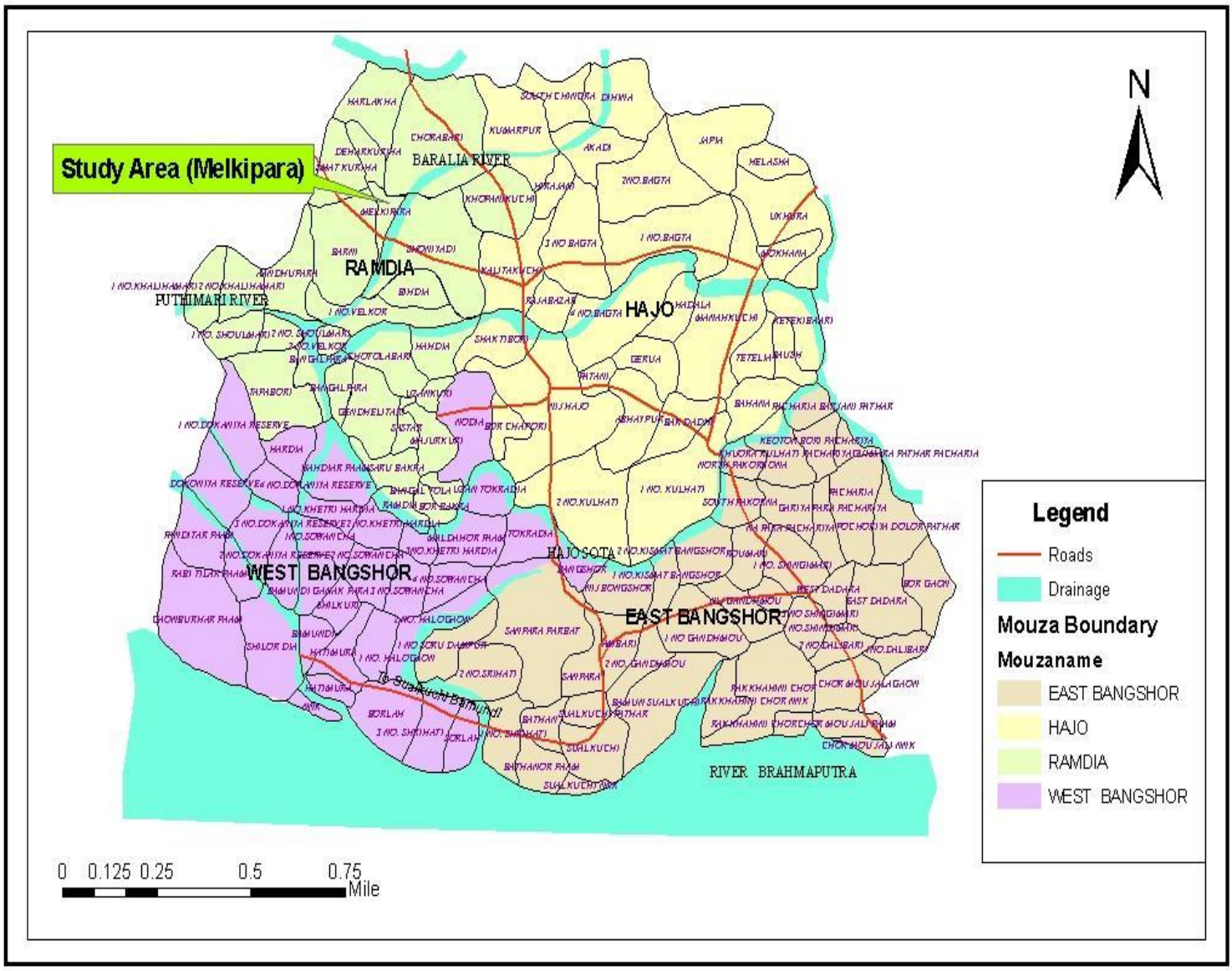

Fig 2: Showing the location of Study Area in the Hajo Revenue Circle.

Socio-Economic Conditions:

Our study area is Melkipara village of Hajo Revenue Circle of Kamrup District. The total population of village is about 600 and the number of household is 180.According to our convenience we selected randomly 30 household for our study. The total population from 30 household is 142. The male population is 76 and female population is 66 as shown in **Table 1 (Fig.3)**. Study area has a literacy rate of 77 percent.. The percentage of educated people below matric level is about 45 percent, Matric,H.S and college level are 21percent,8.5percent and 2.8 percent respectively. There is no person having master degree and only person have professional degree. The village is dominated by muslim community, the percentage of literacy is generally high. Their economic conditions of the village are severely affected by erosion. The age wise distribution of population of the village is shown in the **Table 2.**

Table1: Age group wise population structure of the Melkipara village

Age Group	No. of Male	No.of Female	Total
0-15	19	20	39
15-30	16	18	34
30-45	26	18	44
Above 45	15	10	25
Total	**76**	**66**	**142**

Source: Field Survey Data

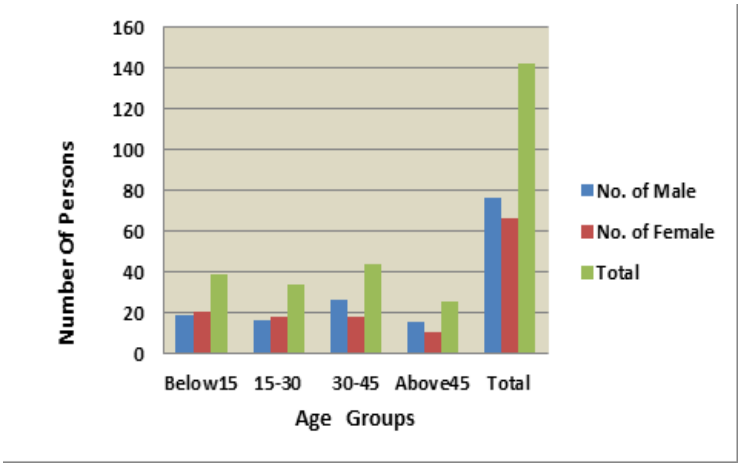

Fig 3: Showing the Demographic Structure of the study area

Table2: Educational Status of the Melkipara village

Sl No.	Qualification	M	F	Total	Percentage
1	Below Matric	31	33	64	45.07042254
2	Matric	19	10	29	20.42253521
3	H.S	6	6	12	8.450704225
4	Degree	4	0	4	2.816901408
5	Masters	0	0	0	0
6	Others	1	0	1	0.704225352
7	Illiterate	15	17	32	22.53521127
8	**TOTAL**	**76**	**66**	**142**	**100**

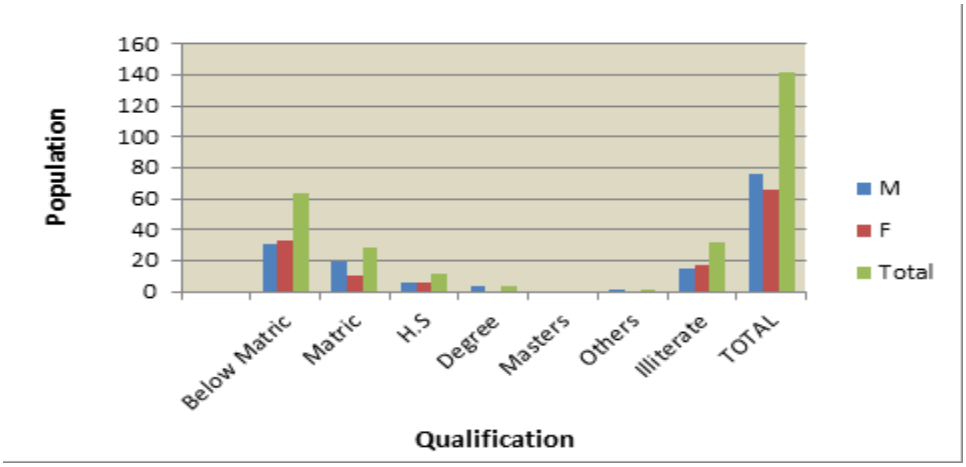

Fig 4: Showing the Educational Status of the study area

The village is mainly dominated by the muslim population. In the study area most of the people are dependent on agriculture. They cultivate on the alluvial tract of the river Baralia which was badly affected due to erosion. Few people are engaged in secondary and tertiary activities. Primary activities like fishing are also seen in the area.

In the Melkipara village houses are Assam type and few houses are also made of bamboo and thatch. The area is poor in respect of transport and communication facilities. The Hajo-Mukalmua road is about 2km away from the village. The PWD road connecting village to the Hajo-Mukalmua road is badly affected due to river bank erosion. In the village few kaccha roads and cart tracks are also seen.

The economic condition of the village is severely affected due to river bank erosion. Erosion of agricultural land compels the villagers to settle in the government land. Many villagers shifted to safer places and engaged themselves in other secondary and tertiary activities.

BANK EROSION SITES AND THEIR DISTRIBUTION

The morphology and behavior of river Baralia undergo drastic changes in response to various flow regime.After the diversion of Baralia river from Bhairatola upto the Velkar the river falls into the Phutimari river whereas earlier it falls into the Pagladiya rivers which falls ultimately into the Brahmaputra River. Due to severity of flood and Bank Erosion of Baralia river in Uttarkuchi, Simula, Deharkuchi, Balikuchi, Bar Bukla, Bar Gachha Bhairatola jan was constructed in 1985 to divert the excess water from the Bhairatola point upto velkar. The jan is approximately 15 km long and it falls into the Phutimari river.

As a result the entire Baralia River change its course and flows through the Bhairatola jan and during the monsoonal seasons it flows tremendously from Bhutan Hills and flows through the Bhairatola jan and causes severe flood and bank erosion in the areas like Melkipara, Dhina, Hainadi, Akadi, Dakhin Singra,Chorabari, Andhupara, Borni. Erosion has been a part and parcel of the flood hazard that gives rise to a miserable situation in the study area.Though it is possible to adjust with flood; it is not same in the case of erosion hazard. It is thereafter after the construction of Bhairatola Jan the erosion becomes a chronic problem. Moreover due to erosion, number of times engulfing a vast agricultural and homestead land.The entire area from Akadi to Velkar is under the grip of erosion of river Baralia (Bhairatola jan) River.

EXTENT AND MAGNITUDE OF THE EROSION

For a riverine location flood and erosion is a common phenomena. But it becomes a matter of serious concern when it takes the form of disaster. The study area also suffers from devastating flood. But the situation in the area is more grave due to severe erosion along with flood. The study area lies in the left bank of the river Baralia .During the monsoon season, enormous amount of water and sediments comes from the rivers coming from Bhutan hills and the entire channel area becomes full of water. Due to creation of the chars it affects the stability off the channels and the bankline.The erosion in this reach is quite intensive. Large scale displacement of people due to bankline recession is still going on in the area. From 1985 to 2012 as many as 17 villages were partly eroded.The heavy erosion started in the area after the construction of Bhairatola jan which carries enormous water from Baralia river flowing from the Bhutan hills. About 10,000 families of Dhina, Hainadi, Akadi, Dakshin Singra, Bagta No-2, Bagta No-3,Hirageni, Kumarpara, Sonarbari, Khuponikuchi, Saniadi, Deharkuria, Borni,Bihdia, Bhalkor No-1, Bhalkor No-2, Andhupara.

PATTERN OF BARALIA BANKLINE SHIFTING

The bankline of the Baralia River in study area is extremely stable and bank failure rampant in numerous vulnerable section along the river during the monsoon season. These failures seem to be a function of hydraulic character of flow and engineering properties of bank materials. Shear failure in the upper bank materials appear to be by far the most widespread erode of bank failure in the river. These are caused by undercutting of the upper bank materials appear to be by far the most widespread erode of bank failure in the river. These are caused either by undercutting of the upper bank materials by channels during the high floods producing on overhanging cantilevered block that eventually fails or by oversteepening of bank materials due to migration of the thalweg closer to the peak during the falling stages. Large scale slumping of bank observed during the falling stages of the river may be associated with return flows in the permeable

alluvium. High moisture content, low proportion of clay and good sorting of bank materials make the bankline highly susceptible to erosion by the river. The drastic changes in channel configuration observed in the erosion prone areas along the river indicate the dynamic nature of river morphology and the intensity of erosion caused by it. The drastic shifts of the river bankline at Melkipara during the period 2008-09 through 2012 are shown in Table 4:

EROSION IN TEMPORAL PERSPECTIVES

Channel migration of the river in the study area is drastic. Generally during the falling river stage bank line erosion becomes heavy. The most important reason responsible for heavy erosion in the study area is that the soil forming the bank of the river is mostly fine sand and silt, that cannot resist erosion. The study of bank position of 2008-09 and present one i.e. , of 2012 (Fig.5) , it is found out that about 14 meters had been eroded away in the upstream and about 17 meters in the downstream section.

Table 3: Erosion Chart of Melkipara Village during different period

Name of the River	Location	Depth of Erosion	
		Year	Depth in meters
Baralia River (Bhairatolajan)	*Melkipara U/S*	2008-09	4.00
		2009-10	3.00
		2010-11	2.00
		2011-12	5.00
		Total	**14.00**
	Melkipara D/S	2008-09	5.00
		2009-10	3.50
		2010-11	2.50
		2011-12	6.00
		Total	**17.00**

Source: WRD, Ghy West Division

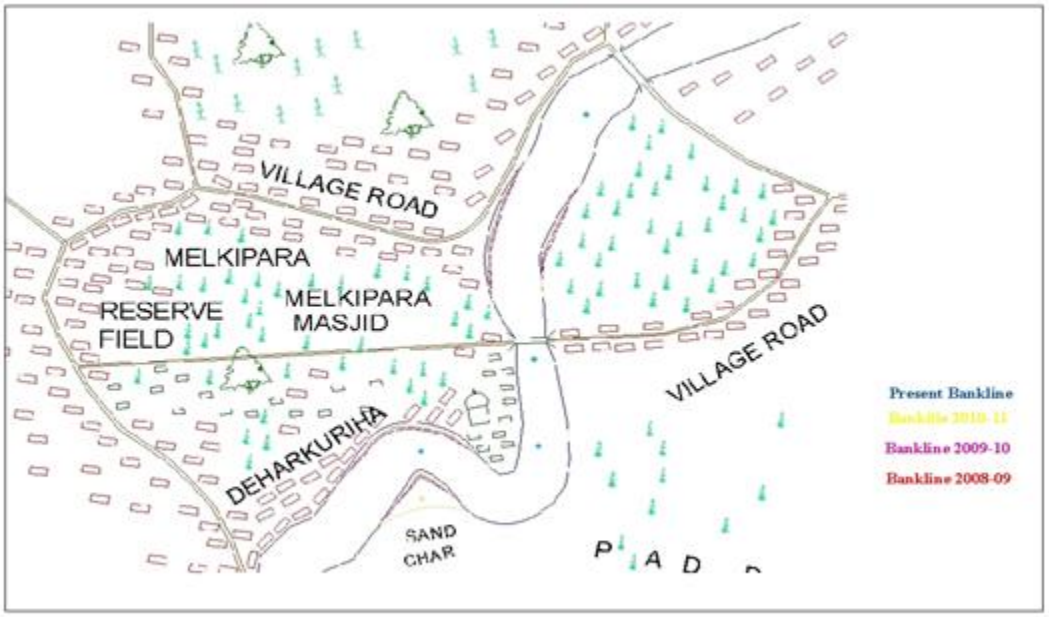

Fig. 5: Composite Bankline of study area from 2008-2012

MECHANICS OF BANK EROSION

Bank erosion is geomorphic process. Bank erosion is a process through which there takes place changes in channel dimensions by lateral widening. Bank erosion is severe in the study area and due to migrating Streams River tends to erode the banks and widen the channel by undercutting and bank caving. The bankline in the study area is extremely unstable and bank

failures rampant in various areas along the river Baralia during the monsoon season. The causes of failure of river banks can be seen by the following ways:

- Underwater erosion along the toe of bank during the falling stage of the river.
- Direct erosion of the river bank
- Sloughing of saturated bank caused by rapid drawdown.
- Liquefaction of saturated silty and sandy bank material.
- Erosion due to seepage from banks at low river discharge.
- Scour along waterline due to wind or wave wash of passing vessels.

IMPACT AND CAUSES OF BANK EROSION

Hazard implies the probability of a destructive phenomenon occurring at a particular place. If the destructive phenomena are a product of nature such as a landslide, a flood, erosion and a volcanic eruption, it is a natural hazard. The most conspicuous factor revealed by this investigation is that heavy erosion in the study area has been a part and parcel of the flood hazard that gives rise to a miserable situation . Generally, the sudden reduction in the gradient of the river drastically reduces the flow velocity causing massive aggradation of the river bed, extensive undercutting of river bank and frequent shifting of river channels. This area is subject to annual inundation by the river Baralia. Of course, the occurrences of heavy flood do not show any regularity. Some of the devastating floods, for example, occurred during 1931, 1933, 1946, 1954, 1962, 1973, 1988 and 2004 in this region. These floods caused great damage to crop lands and settlement areas of this region and triggered heavy erosion of the river bank. Thousands of people have been rendered homeless, thousands of acres of fertile croplands were destroyed and scores of cattle and even human lifes were lost. Acute shortages of food stuff and diseases gripped this region and forced many people to moves out of the area in their quest for survival. The large majority who are still clinging to their fast vanishing and highly unreliable little chunks of land have hardly anything as their own except the terrible hunger and the grinding poverty.

EFFECTS OF BANK EROSION

The erosion in the study area is quite intensive and its effects on the people of the area is quite severe. From the study of bank position of 200-8-09 and the present one i.e., of 2012, it is found out that 5 to 17 metres width of fertile land had been eroded away in this area. Actually the heavy erosion started in the area after the construction of Bhairatola jan and convert the direction of Baralia river in the year 1985.The area eroded away by the river was thickly populated and higly fertile. It is worth mentioning that the area was in fact a granary of food crops. According to 2011 census the area was inhabited by about 600 people, it is impossible to estimate exactly the number of people that are rendered homeless due to erosion from 1985.

For empirical observation as well as from personal experience in the field, it is seen that a heavy influx of population is taking place in the neighbouring erosion-free villages. Many people are rendered homeless most of whom have moved out of this locality to resettle in different villages and urban places both far and near such as in Hajo, Nalbari, Kalitakuchi and Guwahati etc and in the reserve lands allocated by the government. Bank by the Baralia river has thus created an acute socio-economic problem in the study area affecting thousands of people. The socio-economic dimension of the bank-erosion problem is therefore need a fairly thorough treatment.

Table 4: Severely erosion affected Household in the study area from 2009-2012

Categories	Name of the Village (Melkipara)	
	No.of Households	**Percentage**
Nil	15	10.563
Less than 1 Bigha	29	20.422
1Bigha-2.5 Bigha	25	17.60
2.5Bigha-5 Bigha	31	21.83
Above 5 Bigha	42	29.58
Total	**142**	**100.0**

Source: Field Survey Data

CAUSES OF BANK EROSION

It is noteworthy that devastating floods are always accompanied by severe erosion. Since time immemorial, the flow of excess water from the Bhutan hills in the monsoon season in the Baralia River causes serious havoc in the areas like Uttarkuchi, Simula, Deharkuchi, Balikuchi, Bar Bukla, Bar Gachha Bhairatola jan was constructed in 1985 to divert the excess water from the Bhairatola point upto velkar. The jan is approximately 15 km long and it falls into the Phutimari river. As a result the entire Baralia River change its course and flows through the Bhairatola jan and during the monsoonal seasons it flows tremendously from Bhutan Hills and flows through the Bhairatola jan and causes severe flood and bank erosion in the areas like Melkipara, Dhina, Hainadi, Akadi, Dakhin Singra,Chorabari, Andhupara, Borni. Erosion has been a part and parcel of the flood hazard that gives rise to a miserable situation in the study area.Though it is possible to adjust with flood; it is not same in the case of erosion hazard. It is thereafter after the construction of Bhairatola Jan the erosion becomes a chronic problem. Moreover due to erosion, number of times engulfing a vast agricultural and homestead land.The entire area from Akadi to Velkar is under the grip of erosion of river Baralia (Bhairatola jan) River.

The other possible causes of bankline migration may be summarized as follows:

- Rate of rise and fall of waterlevel in the river.
- Rate of scour and deposition that occurs during flood.
- Formation and movement of large bedforms.
- Cohesion and variability in composition of bank materials.
- Intensity of bank slumping.

MEASURES TAKEN TO CHECK BANK EROSION

The study area which is an extremely flood and erosion prone reach of the Baralia river demands urgent remedies. The measures taken to protect the area from the hazard are not seems to be adequate at all. Unabated erosion is going on still which makes adjustment meaningless for the poor erosion affected people. Although the measures adopted by the government to protect the area from flood and erosion, are not truly effective in most of the cases (Fig 18). Revetment, impermeable spurs, are

used at various vulnerable point but most of them are eroded away by the flood water. Porcupines madeof bambooand concrete was constructed as anti-erosion measure. Also additional protection is necessary to protect the shank against outflanking by embayment.

FUTURE GOVERNMENT PLAN TO CHECK BANK EROSION

The Water Resources Department, Govt. of Assam has been adopting a policy to take up flood control measures such as construction of embankment, anti-erosion measures etc. in the study area.No central agencies or aid are playing any role so far in construction of the embankment, anti-erosion measures etc which probably are the most important aspect to be attended for backward and flood prone state like Assam. The state Govt. of Assam and Central Govt. of India are the only agencies involved in the process of embankment activities.

Another important measures to check erosion is floodplain joining. The study area which is frequently visited by devastating flood and erosion cause tremendous damage to crop is a regular feature. So, floodplain zoning is very important which includes regulation of landuse, changing of crop pattern etc.

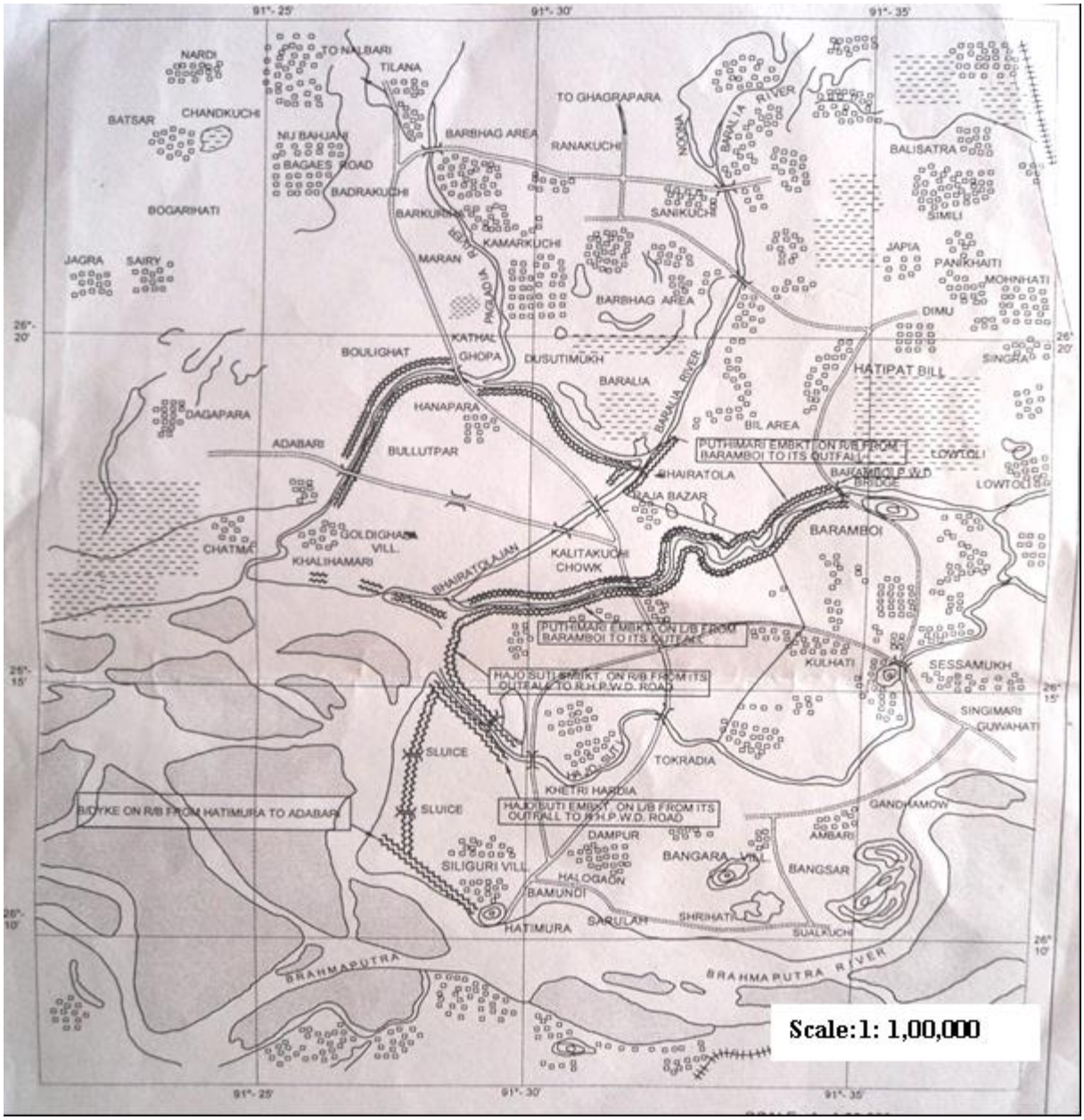

Fig 6: Anti erosion and flood measures taken by government in and around the study area.

The ravaging flood and erosion hazard always causes great damage to standing crops. The changing in the cropping pattern and proper land use regulation may be a suitable strategy to adjust with hazard. The area may be divided into some regions according to hazard intensity.

- Erosion free area.
- Slightly erosion affected area.
- Moderately erosion affected area
- Severely erosion affected area.

Besides these other measures used to check bank erosion are boulder protection, solid stone spurs, timber pile spurs, river revetment, marginal embankments, porcupine made of bamboos and other short term devices.

VI. CONCLUSION

The foregoing study concludes that the position of the study area is severe. Erosion here is quite intensive and thousands of people are rendered homeless. Bankline migration of the Baralia River (Bhairatola Jan) has thus created an acute socio-economic problem in the study area. Anti-erosion measures adopted by the government are proved to be not truly effective.

Some suggestions may therefore be forwarded along with the concluding remarks. The first and foremost strategy is developing strong awareness programmes about importance of trees, afforestation and reforestation. Afforestation reduces soil erosion and as a result accumulation of sediment on the river bed reduce, which lessen the effects of flood and bank erosion. Adequate attention must be paid while taking up developmental activities so that natural catchments areas and drainage systems, including wetlands, are not disturbed. Haphazard development must be replaced by power planning.

Approximate soil conservation measures to check bank erosion need to be intensified .Involvement of the community will help in achieving success in such measures. Although embankments/bunds have led to more problems than solutions, yet it would be helpful if embankments are made stronger. The most plausible measure for control of floods and bank erosion stated to be the construction of dams and taming of rivers. Studies are needed on the rivers and the tributary systems in the state for taking up such projects.

The suggestion discussed above in Assam alone will not solve the problems. The cost involved will be enormous. The Central Government will have to take the major initiative and tackle these issues. It must be treated as a crucial national problem. A rational co-operation among general people, N.G.Os and the Government is very much needful for a co-hesive as well as integrated development of the study area. Relief and rehabilitation works during and after bank erosion and flood is an emergency service for the affected people. But this is not a permanent solution. An effective disaster management programme as per the Disaster Management Act, using the latest technologies, is an emergent need. The need of the hour is to prepare flood and drainage congested area mapping, flood forecasting, identification of erosion prone areas ,flood and bank erosion damage assessment and relief and others by using the remote sensing satellite data.

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