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Environmental Impact of Embankment Breaching: A Case Study along Lower Reaches of Ajay River, West Bengal, India

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ABSTRACT:

Embankment construction is an important structural measure to prevent vulnerability of flood in lower reaches of Ajay river. Taming of river has huge negative impact on floodplain as well as entire riparian environment. With the growing need for protecting people's properties, agricultural land and crop earthen embankment and flood control embankments is getting importance. The total length of the Ajay embankment is about 136.16 km, out of which the right bank accounts about 80.97 km and left bank comprises about 55.19 km. Embankment breaching, an episodic process in fluvial dynamics, is affecting a wide range of physical, ecological and socio-economic issues in the fluvial environment. The total area protected by the right bank embankment is about 37040 hectares and the left bank embankment protects about 29785 hectares. Present condition of left embankment (mainly found in Khoyrasole, Bolpur, Illambazar, Nanur and Katwa.) is not so good. The embankment on the left bank remains most vulnerable. The present work involves with the enquiry of stability of the embankments, nature of breaching, extent of the sand incursion over the agricultural fields and micro-topographical changes brought into the lower reaches of the Ajay river basin.

Keywords: *Embankment Breaching, Sand Incursion, Scooping Pool, Basin, Fluvial*

INTRODUCTION

River impoundment is one of the important anthropogenic processes. River impoundment is an ancient idea. Egypt king *Means* impounded Nile river with clay and stone for prevent flood hazard and use floodwater for irrigation. The morphology and dynamics of rivers are not only related to each other but also dependent upon environmental variables such as climate, lithology, topography, landuse and vegetation. One of the most effective agents of change in a watershed is human. Humans have utilized water resources for millennia by modifying natural river courses and such interventions have greatly influenced not only river flows and sediment fluxes, but also the overall river morphology Land use change in fluvial environment effect on channel morphometry hydrological properties and flow regimes of a natural river. About 10,000 year BP alteration of natural morphology/landscape started due to anthropogenic transformation. Agricultural practices, urbanization, industrialization effect on natural landscape. Grorgy Perkin Maroh wrote a book "*Man and Nature*" in 1864, the title of this book was change and new title was "*The Earth as modified by Human Action: a new edition of Man and Nature*". Marsh point

out how much erosion and sedimentation had to increase due to Anthropogenic action Main cause of landform transformation are deforestation, landuse change, urbanization, river impoundments. Changes in water and sediment input can result from a wide variety of land uses, including mining operations (Gilbert, 1917; Pickup and Warner, 1984; Higgins et al., 1987; Knighton, 1989; James, 1991), agriculture (Happ et al., 1940; Costa, 1975; Knox, 1972, 1977, 1987; Trimble and Lund, 1982; Jacobson and Coleman, 1986; Jacobson and Pugh, 1992; Jacobson, 1995; Knox and Hudson, 1995; Ruhlman and Nutter, 1999), urbanization (Wolman, 1967; Wolman and Schick, 1967; Hammer, 1972; Fox, 1974; Park, 1977; Ebisemiju, 1989), or mixtures of different land uses (Miller et al., 1993). Local landlords in the nineteenth century constructed embankment to protect their land and property from floods along the Lower Bengal River (Gastrell 1863; Bhattacharyya 1998; 1999–2000a). These embankments were intended to save the paddy crop, the main crop of Bengal, as well as to protect the towns and villages (Sengupta 1951), these embankments are 4,000 years old. (Kapil Bhattacharyya 1959). Before British period embankment were constructed by Zamindars. (O'Malley and Chakravarty 1909; Bhattacharyya 1998, 1999–2000a). In zamindary period embankment were mainly was very much sporadic in nature. With the growing need for protecting people's properties, agricultural land and crop earthen embankment and flood control embankments is getting importance. However, in India embankment breaching is a big threat. Irrigation and Waterways Department, Government of West Bengal, has made extensive attempts to control flood of Lower Ajay Basin. Embankments can protect only from low intensity flood but it is neither possible to control the flood totally by embankment. River embankment has huge negative impact on floodplain as well as entire environment. Occasional breaching of the embankment is a common phenomenon in the lower reaches of the Ajay basin as far as the poor stability of the embankment is concerned. For the stability of the embankment, soil texture, bulk density, compressive strength and safety factor are most important geotechnical parameters. The balance among the geo-technical parameters are considered as the most important potential cause of the embankment breaching against the flood condition. The earthen embankments of River Ajay breached maximum during rainy seasons. Embankment breaching in lower reaches of Ajay river, highly affected the cultivable land and human habitation.

REGIONAL SETTING OF LOWER AJAY BASIN

Ajay is a perennial, tropical meandering river that flows for a length of 290km covering a catchment area of 6095sq km in the north-eastern part of India. At first it passes through the Archaean gneissic complex(biotite – gneiss, hornblende gneiss, pryroxene- graulite, basic intrusive, pegmatite & quartzite) for 32 km ,over the older alluvial (Bolpur sandstones, shales, laterites) & recent alluvium for the rest of the lower course. Elevation range varies from less than 10 meters to 20 meters. Pre-Cambrian rocks containing variations of granitoid and schistose structure occur to the western part of the study area. In the Archaean formations, sedimentaries also occur. These sedimentaries were originally deposited as sandy, clayey and calcareous sediments of more or less impure quality and subsequently these were consolidated as sandstones, shales and limestone by diverse composition (Banerjee et.al 1973). The studied segment of The Ajay river basin located from Illambazar (23°36'17.60"N & 87°32' 05.40"E) to Katwa (23° 39' N &88° 08'E)(fig 1). Embankment found both side of the river at lower reaches. Discontinuity of embankment creates several problems for the floodplain areas of Ajay. The area

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received an average rainfall of 150-200 mm. Flow regimes of Ajay river is diverse in nature. Mean Discharge rate varies from 278 mm to 525mm.

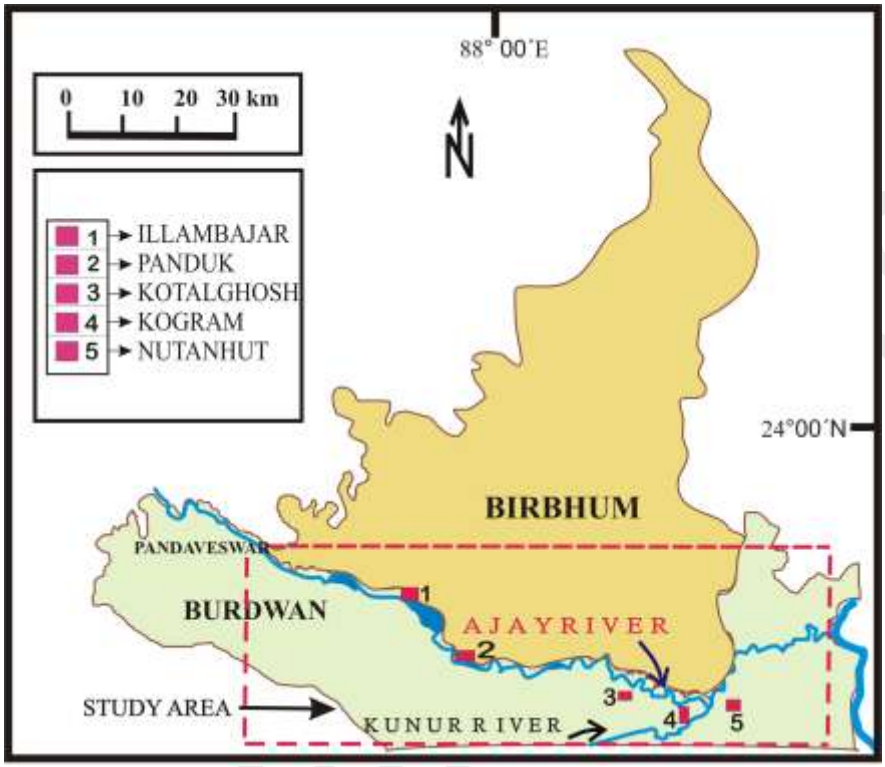

Fig: **1 Location Map of Study Area**

MATERIALS AND METHODS

The work was carried out on five Survey of India (SOI) Topographical Sheets (No's 73M/6, 73M/10, 73M/14, 79 A/2) of various editions with scale 1:50.000 helping to create a base map. Data has been collected from published as well as unpublished sources. Satellite imageries (Google earth, Bhuvan) are used for mapping present and paleo setting of river course. Flood intensity map developed using TNT MIPS (Basic-2014) RS/GIS integrated Software photo editing software like Corel Draw and Adobe Photoshop are used for photo editing and lateral sifting of river course. Topographical sheet and satellite images were geocoded to extract past status of embankment and tried to co-relate with the present situation. GPS (Handheld-Germin etrexH-20), fiber tape, were used as necessary tools in the present study. For the interpretations and presenting, the fieldwork as converting into the technical work the whole work has been went through some technical and computer-software support. The main objectives of the present study are to evaluate the impact of embankment breaching on riparian environment and cultural landscape and to detect the change of micro topography in the lower reaches of the Ajay river basin.

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DISCUSSION

As a rain fed and bedrock river, the discharges of the Ajay increases from the month of June due to huge monsoonal rain and it generally lasts up to the month of September and then falls down. Among the flood affected area of the lower Ajay river basin the spatial variation of sand incursion have been seen in two directions. One is East-West variation or spatial extension of flood is confined along the narrow strip of the two banks at the Western part of the basin. Below Illambazar to Bolpur and Bhedia much wider areas are affected by new sand or sand encroachment of coarse grain, another is Bank wise variation or the right bank of the river is more floods affected than left bank.

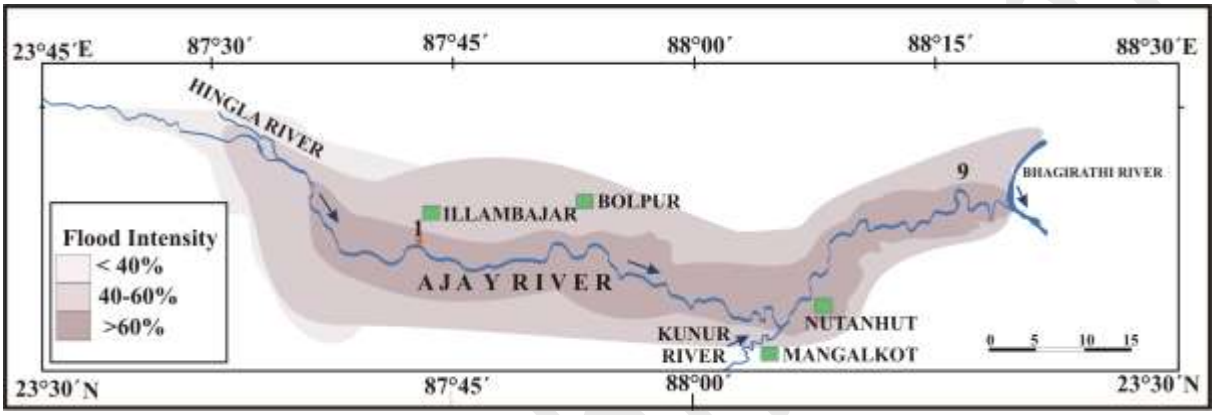

Fig*: 2 Flood Intensity map of lower ajay basin (1956 to2012)*

From the records of irrigation and waterways Department, Govt. of WB, it is evident that the major floods occurred in the river basin in the year of 1956, 1959, 1970, 1971, 1973, 1977, 1978, 1984, 1999, 2000, 2005, 2007 and 2010. Before the Independence of India, in British period, high floods occurred in this basin in 1913, 1916, 1938, and 1942 and so on before two century, devastating floods occurred in 1730, 1750, 1816, 1856, and 1885.

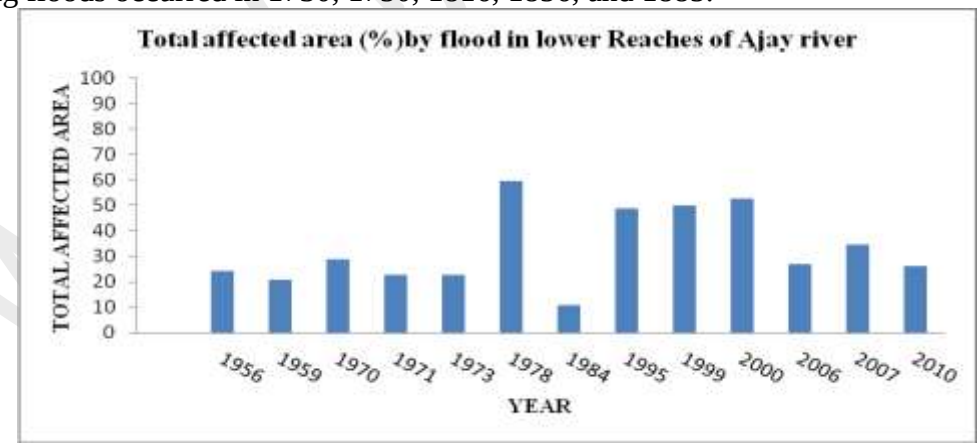

Fig*: 3 Irrigation and Waterways Department, Government of West Bengal*

In the flood year of 1978, the maximum area (59.64%) of the Ajay river basin was affected by the severity of the flood followed by the year 1995 (48.99%), 1999 (49.98%) and 2000 (52.82%).

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Comparatively, least affected by the flood was 1984 (10.85%). Mainly, the lower reaches of the basin comprising the Bolpur, Nanur, Mongalkot, and Ketugram-I & II CD Blocks.

HISTORICAL INCIDENCE OF EMBANKMENT BREACHING

Embankment breaching, an episodic process in fluvial dynamics, is affecting a wide range of physical, ecological and socio-economic issues in the fluvial environment. In developing countries embankments are mainly earthen but riprap blanket, trench fill, GI wire mesh, sacks, Boulders are use as a material of embankment. The main causes of embankment breaching are the use of low quality, unstable material, faulty construction, toe erosion, illegal sand mining as well as inadequate maintenance and improper planning of land use. Maximum embankment breaching occurred during rainy season. The river maintains a high discharge of 15000-20000 cusecs during August and September (freshets) of every year**.** The river level rises 3.2-5.0 m above the thalweg during periods of high discharge. Maximum height of the embankment is near about12-14 meter. These include the establishment and evolution of river and floodplain morphology and their associated habitats (Darby and Thorne, 1996a; Barker et al., 1997; Millar, 2000; Goodson et al., 2002), turbidity problems (Bull, 1997; Eaton et al., 2004), sediment, nutrient and contaminant dynamics (Reneau et al., 2004), loss of riparian lands (Amiri-Tokaldany et al., 2003). The breaching of embankment is recurrent phenomena in various blocks of Burdwan and Birbhum since long back. In recent year, there have been various examples of embankment breaching in the lower Ajay drainage basin. Over the last few years there are records of at least 6 major failure events that caused flooding and extensive damage in lower reaches of Ajay river area. There are reports of failure event on the river Ajay causing extensive damage during 2000, 2001, 2006 and 2007 in 30 Mouza of 7 gram Panchayats which are situated on the right bank(RB) of Ajay. In 2010 Rosui, Teora are highly affected. Embankment burst threatens towards people of Manghalkot block. In 2007, Konarpur mouza was highly affected by embankment breaching. Sagira, Konarpur and Dhanyarukhi are distressed every year by water logging and deluge due to breaching of embankment.

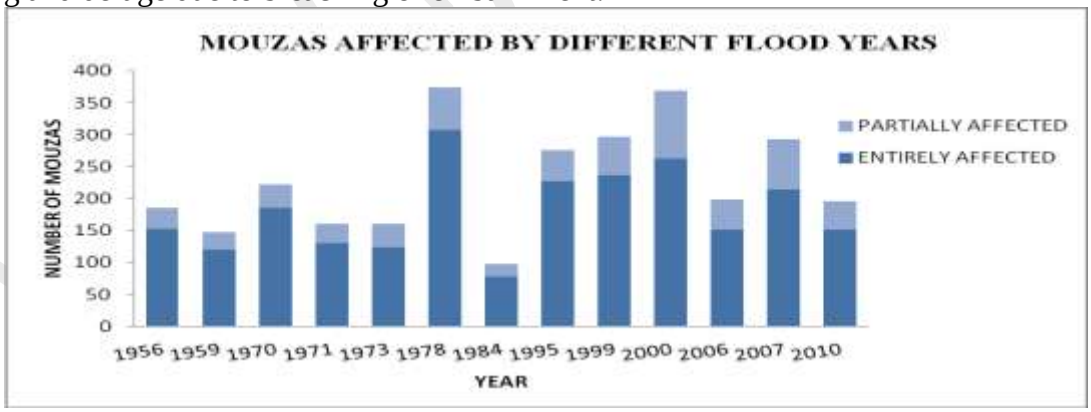

Fig*: 4 Irrigation and Waterways Department, Government of West Bengal*

From the Fig No.4 it is clearly showed that the number of flood affected mouzas (374) is maximum in 1978 and in this year out of 374 mouzas, 307 mouzas were entirely affected by the flood. In 1984, only 98 mouzas were affected and out of that 78 mouzas were severely affected. In 1995, 279 mouzas were affected and out of that 227 mouzas are entirely affected. In 1999, 297

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mouzas were affected and out of that 237 mouzas are entirely affected, In 2000, 369 mouzas were affected and out of that 263 mouzas are entirely affected, In 2007, 293 mouzas were affected and out of that 214 mouzas are entirely affected,

PRESENT CONDITION OF EMBANKMENTS

S.C.Majumdar (1945) warned about the long term effect of embankment and stated, "construction of embankment as flood controlling measures would be like mortgaging in future generations to derive some temporary benefits for the presents generation". Sir William Wilcox (1930) while dealing with the flood problem of in Eastern India, accused the river side embankments as the 'Satanic Chains' . Embankment found in both left and right side of lower reaches of Ajay River. The crown width varies between 2 and 3 meter and basal width varies from 5 to 30 meter. In Mongolkot block basal width near about 22 meter but in Ketugram block basal width varies from 14 to 17.5 meter. The total length of the Ajay embankment is about 136.16 km, out of which the right bank accounts about 80.97 km and left bank comprises about 55.19 km. The total area protected by the right bank embankment is about 37040 hectares and the left bank embankment protects about 29785hectares.Present condition of left embankment (mainly found in Khoyrasole, Bolpur, Illambazar, Nanur and Katwa.) is not so good. The embankment on the left bank remains most vulnerable. Generally these embankments are made by sandy soil, boulder, GI wire mesh. Right embankments cover the blocks, Kanksa, Ausgram and Mongalkote. The right embankments from Sathkhonia to Kogrma, is long about 47 km., presently it is long, and continuous embankments primarily made with earthen materials. The embankment was regularly breached in some places like Malancha, Maliara, and Kogram of Bhedia and Mangolkot blocks upto 2000. After that the irrigation department repaired the embankment with boulder with weir crate wall and iron made mesh. The result was that from 2005 onwards, the embakment attained a stable condition by changing its geo-technical composition and ultimately, there was no breaching occurred. At Rosui, Billeswar areas of Ketugram-II block, embankment became unstable because of toe erosion and soil piping.

IMPACT OF BREACHING

The river embankments bring adverse impact on the riparian environment by hampering the natural evolution of the floodplain of by interfering with the geomorphological processes of the river. The quality of construction of such embankments is never uniformly good, and the

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embankments themselves deteriorate with time due to erosion by rainfall, interference by humans (e.g., cutting embankments to allow for the passage of irrigation water in the dry season), burrowing of animals, and road or other traffic along and across the structure, etc. There is range of constructions and repairing of embankment in lots of areas under study.

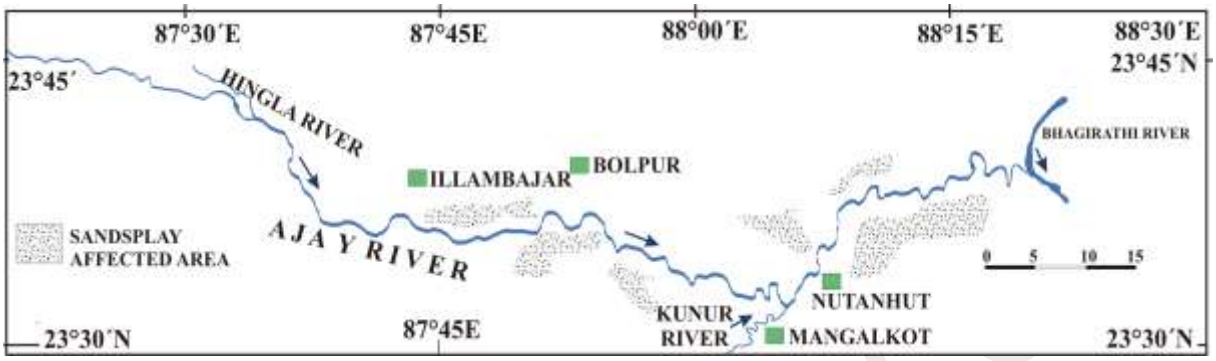

Fig: 5 Status of sandsplay after breaching of Embankment in 2010

(Birbhum and Burdwan Zila Parishad, Govt. of West Bengal, 2012)

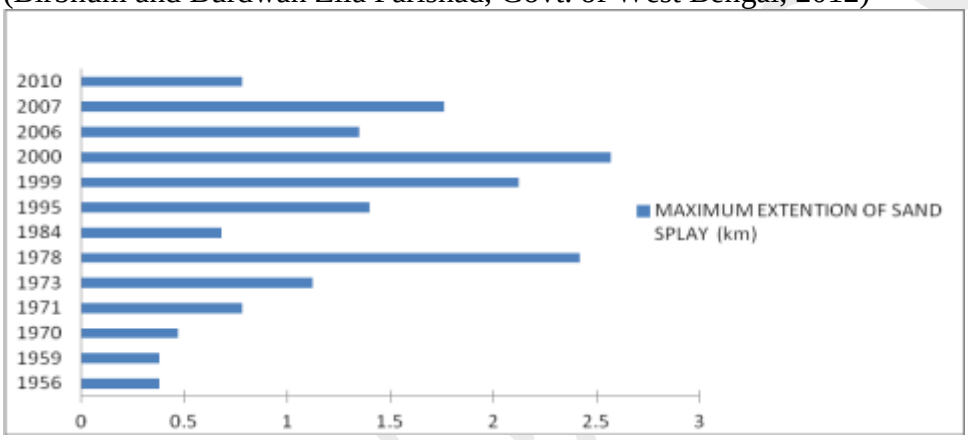

Fig: 6 Showing the maximum extension of sand incursion over the field or settlement from flood year 1956 to 2010

From fig 6 it is clearly showed that from flood year 1956 to 2010 maximum affect of sands playing experienced during flood from its breaching point to the maximum extension of sand incursion over the field or settlement has been displayed. In the year2000 and 1978, the maximum distance covered by the sand incursion went up to 2.57 km from its source. The minimum affect of sand incursion had been experienced in the year 1956 and 1959 and the maximum effect extended up to 0.38 km from its breaching point. Once, the agricultural land is covered by the sand and sediment, it lost its fertility at least for ten years. The reclamation process is a cumbersome to the farmer and that lead to temporal unemployment and poverties.

MICRO-TOPOGRAPHICAL CHANGE

There is a little relation between lateral sifting of channel and embankment loss. Micro topographical change occurred due to lateral shifting in basin area and by embankment failure. Micro topographical change occurs through various ways like overtopping, meandering nature of

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the river, alignment of embankment, poor maintenance of the embankment and other anthropogenic activities. In Ajay River Basin, it has been found that the breaching tendency of embankment is more on the right bank from Illambazar to Bhedia. Bhedia to downstream the breaching tendency is more on the left bank of the river.

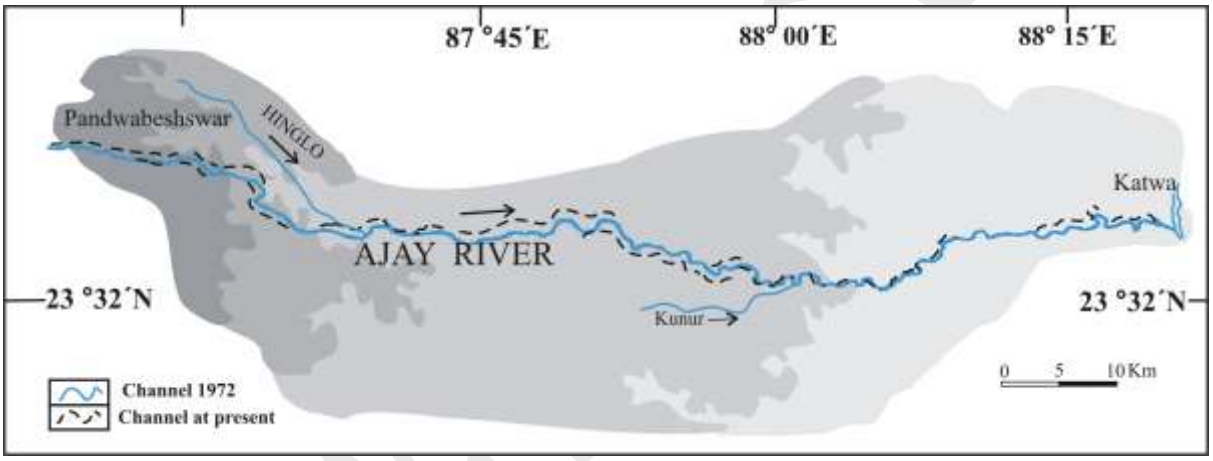

Fig: 7 Showing the Lateral shifting of Ajay river and present condition of channel (Source: Google Images)

The most prominent effect of the breaching of embankment and the occurrences of flood is the sandsplay as post flood hazard (Mukhopadhyay, 2010). The depth of the river has been reduced significantly as a result of siltation on the river bed. From historical satellite imageries it is clearly found that bed level of the river is higher than its pre-flood condition mainly in flood year 1978 and 2000. Bhedia the bed level of the river is higher than the adjacent floodplain. Swampy depressed land is formed by spilled water. Alluvial riverine land modified by sandsplay both in short term and long-term basis. The grain-size of sand become coarser near breaching places of embankment and become finer towards the countryside. Grain size varies from 0.2 to 1.0 mm in sandsplay-affected land. Basically, the embankments are breached due to the piping process and that has ultimately give rise to the development of temporary scooped pond or plunge-pool just below the breaching point. After that the huge flood water rushing through the agricultural field and settlements and also has given rise to the sand incursion over that fertile agricultural fields making them sterile.

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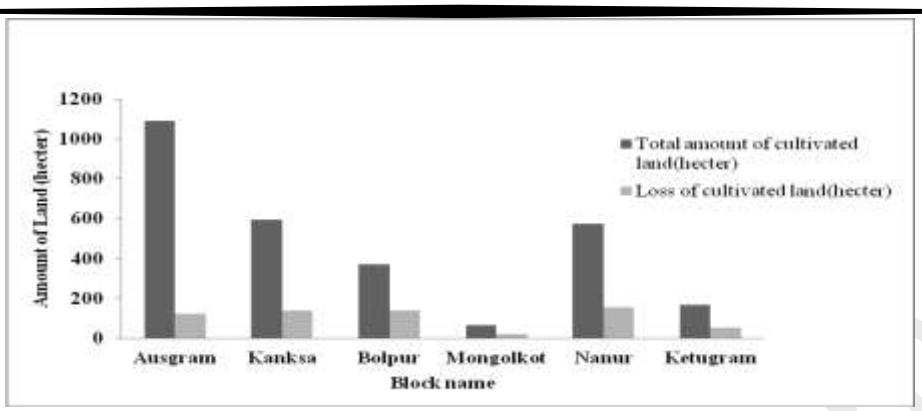

Fig: 8 Effect of sandsplay in cultivable land

(Source: Irrigation and Waterways Department, Government of West Bengal.)

Fertile cultivable land highly affected by Sandsplay in Nanur, Bolpur, Ketugram and Kanksa blocks followed by Ausgram and Mongolkot blocks. In post, breaching period cultivable land became unproductive for at least seven to ten years and land has been reclaimed through crop rotational method. Generally, the rate of damage is comparatively low in case of the Ausgram block by the embankment breaching in the year 1978 and 2000.

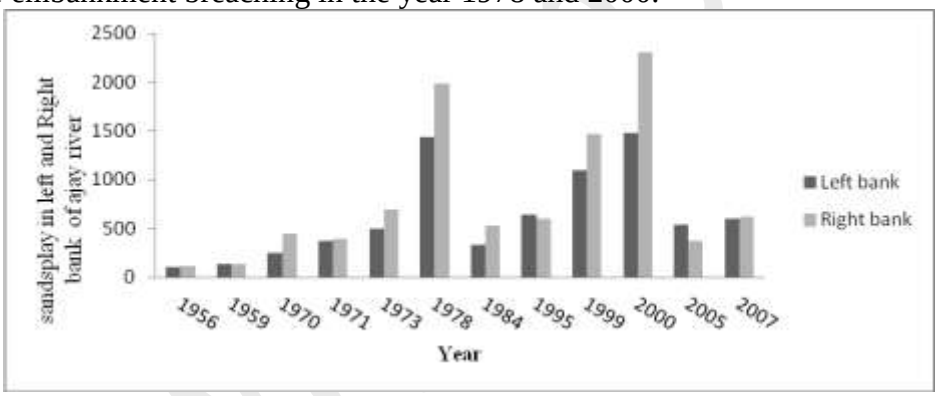

Fig: 9 Sandsplay in left and right bank of Ajay river

The most interesting observation is that related to the occurrence of the breaching of embankment of the river Ajay is that the Right bank is more vulnerable than its Left bank. From 1956 to 2007, in every flood year, the right bank had been breached consistently and damage done accordingly. On the other hand the left bank also beached in every flood year, but in the year 1978, 1999, 2000 and 2007 the rate of breach was high. In the year 1995 and 2005, the rate of left bank breaching exceeded right bank and caused a devastated damage mainly in Ketugram-I and II blocks.

CONCLUSION

The study has revealed that the either low intensity high frequency flood or vice-versa ultimately lead to the either over topping or breaching of embankments in the lower reaches of the Ajay river in its both side of the banks. The embankments are poorly stable because of its geo-technical properties along with rampant anthropogenic activities in the form of legal or illegal

sand queries. The sand mines actually altered the flow regime along with the morphometry of the river channel. Ultimately, the people used to experience either inundation or due to embankment breaching loose of fertile tract of their livelihood. Flooding is a regular phenomenon in this region in almost every season. The most painful effect is that the lands which are covered by the sand is very difficult to reclaim its fertility for long time. In this time the affected people compelled to migrate from one occupation to other.

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