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Floods in Mahanadi River, Odisha, India: Its Causes and Management

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***Abstract*— All the major rivers of Odisha after attaining their old stage in the coastal plain fall into the Bay of Bengal. Most often the rivers including the biggest river Mahanadi brings flood calamity in the region. The coastal districts of Odisha particularly the Mahanadi Delta region has been victimised in the flood in terms of loss of lives of human being and domestic animals, damage of house properties, roads and bridges, crops etc. The article discusses the causes of the floods and management practices for controlling them.**

***Index Terms*— Flood, Mahanadi River, Odisha, Management**

I. INTRODUCTION

Odisha is one of the coastal states lying in the eastern margin of the Indian Peninsula that shares 480 km of coast line with the Bay of Bengal [1]. Natural disasters are the frequent visitors in Odisha designating it as the land of disasters. Last one decade or a little more period than that tells the devastating stories of extreme climatological events in the region. After the super cyclone in 1999, the state has suffered many times from the flood disasters. It has witnessed severe floods in the year 2003, 2008, 2011 and 2013 besides many small ones. The catastrophic nature of such floods in Odisha has brought immense sufferings for the inhabitants of Odisha particularly in the Mahanadi delta region.

II. FLOOD DAMAGE

Flood is one of the natural disasters that creates enormous havoc and myriad miseries in the affected area. It causes loss of life, disruption of human activities , damage to properties ,agricultural crops and health hazard [2]. During the last few monsoon seasons almost all the districts of Odisha have witnessed flood disaster and suffered a lot from it. It has become a routine that severe floods in the Mahanadi river system devastates the downstream areas particularly the Mahanadi Delta area in the coastal tract of Odisha. This affects the districts like Jagatsingpur, Kendrapada, Puri, Boudh, Subarnapur, Cuttack, Nayagarh and Sambalpur (Fig-1). On analysis of the past and the present flood scenarios of Odisha, it is found that the Mahanadi river causes the maximum numbers of floods with high magnitude and massive loss factors. The Mahanadi river transects Odisha along the central graben area (Mahanadi Graben) running in E-W direction. The coastal plain that constitutes the Mahanadi delta in the old stage, the segment of eastern sector of the Basin receives the maximum threshold of flood devastation.

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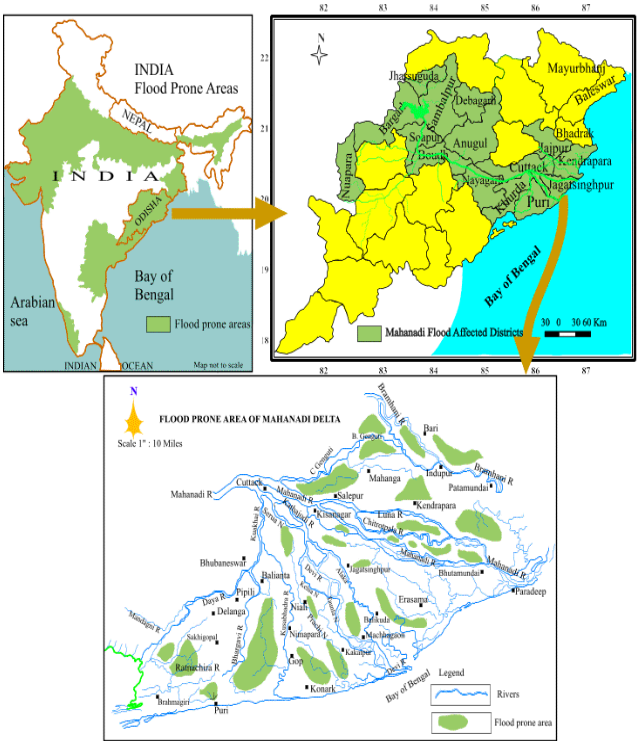

Fig-1 A. Flood prone areas of India
B. Mahanadi flood affected districts of Odisha
C. Flood prone areas of Mahanadi Delta

III. CAUSES OF FLOOD

The simple and common reason for river flooding is the overbank flowing of water due to heavy rainfall at the upper end and catchment areas of the river [3]. It depends upon the amount of water collected at the river course, the carrying capacity of the river, the river run off to the ocean at the mouth and the flow dynamics-morphological setting system. All the major rivers of Odisha after flowing in the varied terrain attain their old stage in the coastal region of flat and low relief nature. They fall in the Bay of Bengal forming network of distributaries and varieties of landforms. Mahanadi river having vast catchment could supply huge amount of sediments to be deposited in the coastal basin to form the arcuate delta [4]. Mahanadi and its distributaries most often cause flood in the low level landforms like delta, peneplains and natural levees along with the adjacent areas of the entire river courses.

A. Mahanadi Basin Architecture

The river Mahanadi flows in NE-SW direction along an important tectonic division of Odisha, which is known as the Mahanadi graben. During the Precambrian times it remained in continuation with the Lambert Rift of Eastern Antarctica

[5]. The Mahanadi river and so as the Mahanadi graben crosscut the main physiographic divisions like the west Odisha upland, the central axial highland, east laterite peneplain and the coastal plains. The Mahanadi graben cuts across the NNE-SSW trending horst and graben structures [6] is therefore sandwitched between the Eastern Ghats horsts and western Odisha graben on both the sides (Fig-2). The Mahanadi river main, its tributaries and distributaries coalesce to constitute the Mahanadi Basin (Fig-3). It lies between 80^0 30' and 86^0 50' East longitudes and 19^0 20' and 23^0 35' North latitudes. The basin has an area of 1,41,600 sq. km. and is broadly divisible into three distinct zones, the upper plateau, the central hill part flanked by Eastern ghats, and the delta area [7].The flow mechanism is controlled and guided by the landform configurations, structural setting and slope factor of the basin in the graben and adjacent areas.

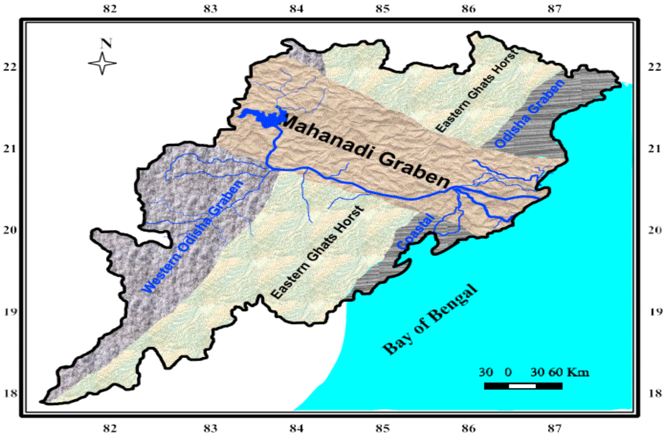

Fig-2 Mahanadi graben cutting across the alternate horst and graben structures

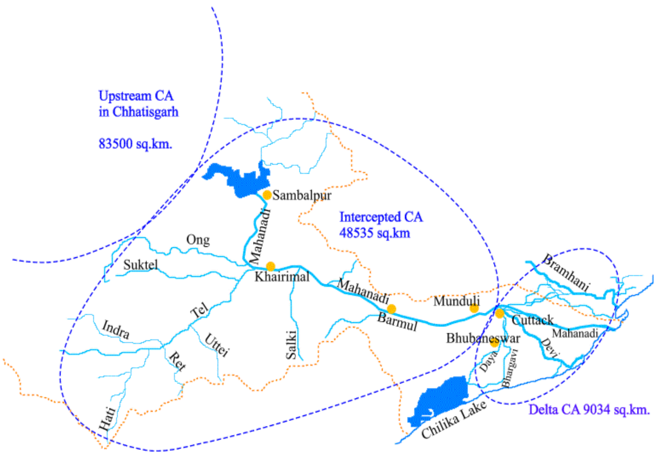

Fig-3 Mahanadi basin with catchment area segments

B. Sedimentation potentiality

The entire Mahanadi basin spreads over catchment areas in two states, Odisha and Chhatisgarh. The Chhatisgarh part of the Mahanadi basin has a catchment area (CA) of 83500 sq. km., which is maximum over the Odisha part consisting of 57,570 sq.km. (Fig-3). The amount of sediments that has been carried by the Mahanadi from Chhatisgarh is checked by the Hirakud dam over it at its entry point in Odisha. The siltation of the Mahanadi in down line of Hirakud dam depends upon the sediments supplied by the catchment area in Odisha only. The catchment area beyond the Mahanadi delta CA has an upland terrain, the rocks of which belong to the Eastern Ghats rock type like khondalites, charnockites, migmatites and Western Odisha Granites and gneisses. The CA is traversed by numerous structural elements like Faults, lineaments and shears of varying dimensions. The topography, lithology and structural network of the CA facilitate the erosion process. The erosion process in the CA is however supported to a greater extent by heavy deforestation, changing scenario of land use pattern and climate change. Now the accelerated process of erosion supplies huge amount of sediments to the Mahanadi river course and engulfs the depth of river. This creates a deceased carrying capacity in the river and produce swelled water flow.

C. Role of Hirakud dam

Mahanadi is the sixth biggest river system in India having the largest basin area in the state of Odisha [8]. It has a total length from its origin to confluence of the Bay of Bengal is about 851 km., of which, 357 km. is in Chattisgarh and the balance 494 km. in Orissa . It has a catchment area 48700 sq km [9] in the entire deltaic region beyond Munduli Barrage, which gets affected by medium to severe flood almost often causing immense loss to life and property. The problem starts when the flood at delta head of Mahanadi (Munduli) exceeds the safe limit of 24600 cumecs. Three reservoirs were proposed originally in the [10]. But in 1956 Hirakud dam was build up on the Mahanadi at Sambalpur to cater the irrigation, hydroelectricity generation mainly. Along with these purposes, it acted as a major check point for flood control in the downstream. The schematic diagram of Hirakud dam and downstream (d/s) of the dam is shown in Fig-4. Mahanadi river along the d/s at Naraj starts dividing into a number of distributaries to form the delta (Fig-5). If we see the past records, before the construction of Hirakud dam the delta area had witnessed 27 years of flooding during 90 years (1868-1957). But in the post-construction period during the last 53 years (1959-2011), the floods in the delta have been reported in only 9 years. Even though the frequency of floods in Mahanadi downstream has been decreased substantially by Hirakud dam, there are lot of peripheral activities and climatological factors emerging day by day to concern the flood possibility. The Chhattisgarh part of Mahanadi was free from any reservoir before the Hirakud dam came up. Thereafter a number of reservoirs were constructed in Mahanadi's upstream in Chhattisgarh. The purpose of those reservoirs is to hold water for irrigation purpose without concerning the flood control system. Normally what happens including the present case of discussion that the excess water they release is added to the heavy rain water in the catchment areas in Odisha region. Obviously the situation becomes unbearable for Hirakud dam and it becomes one type of compulsion to release heavy water at stretch. Of course there should have been proper coordination mechanism between Odisha and Chhattisgarh towards gradual release of water through the dams for flood management in downstream. On the other hand there is heavy soil erosion in the catchment area because of lack of vegetation cover there. The Mahanadi river receives heavy amount of sediments from upstream and tributaries. Some of them are settled down in Hirakud reservoir and a big amount carried to its old stage of flow in coastal plain. Here the river losses the energy level of carrying sediments and substantial siltation has been going on since long. The river course as well as the mouth is buried by sediments and hence the river run off is hampered. Moreover there is an increasing trend of unethical and illegal encroachment of flood plain areas of major rivers particularly the Mahanadi river that decline the carrying capacity. With global warming and climate change, the monsoon has turned ineffective and the rainfall happens to be unequally distributed within the stipulated period. Less rain for quite a long period cause drought in the region while it rains heavily within a short span to invite flood situation. The rise in sea level due to global warming does not allow a free river discharge to sea. In one side there is the dam factor and the other one is the agglomeration of above discussed factors that cause flood in the Mahanadi. With a little impact of Rengali dam, the other described reasons hold good in causing flood in the Bramhani, Baitarani, Subarnarekha etc.

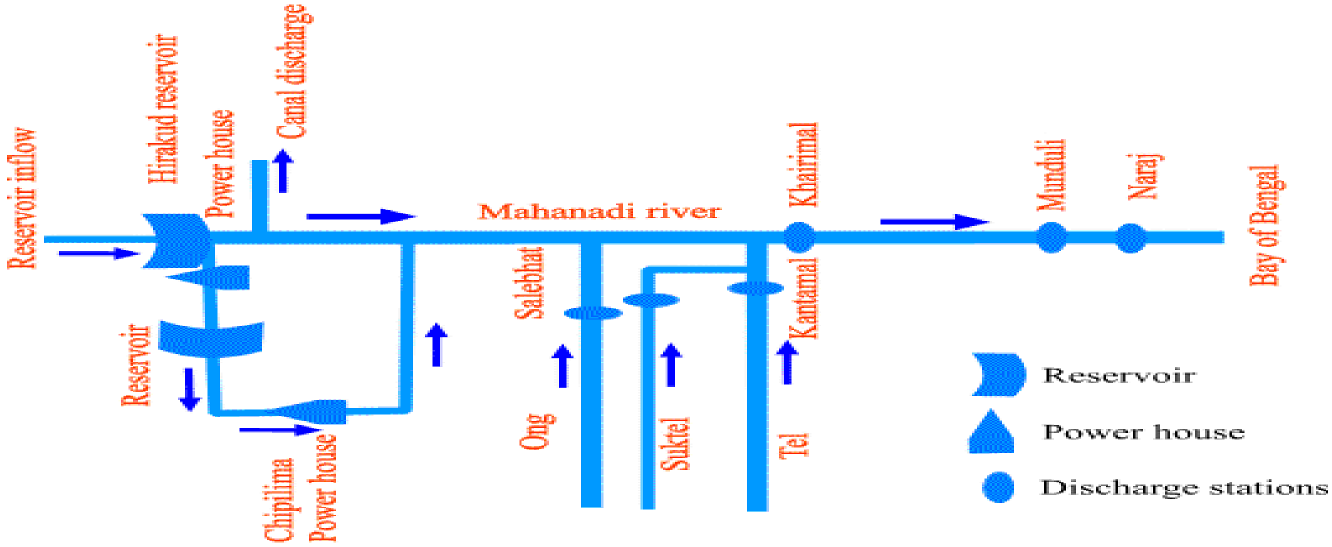

Fig-4 Schematic diagram of Hirakud reservoir and downstream (d/s) flow

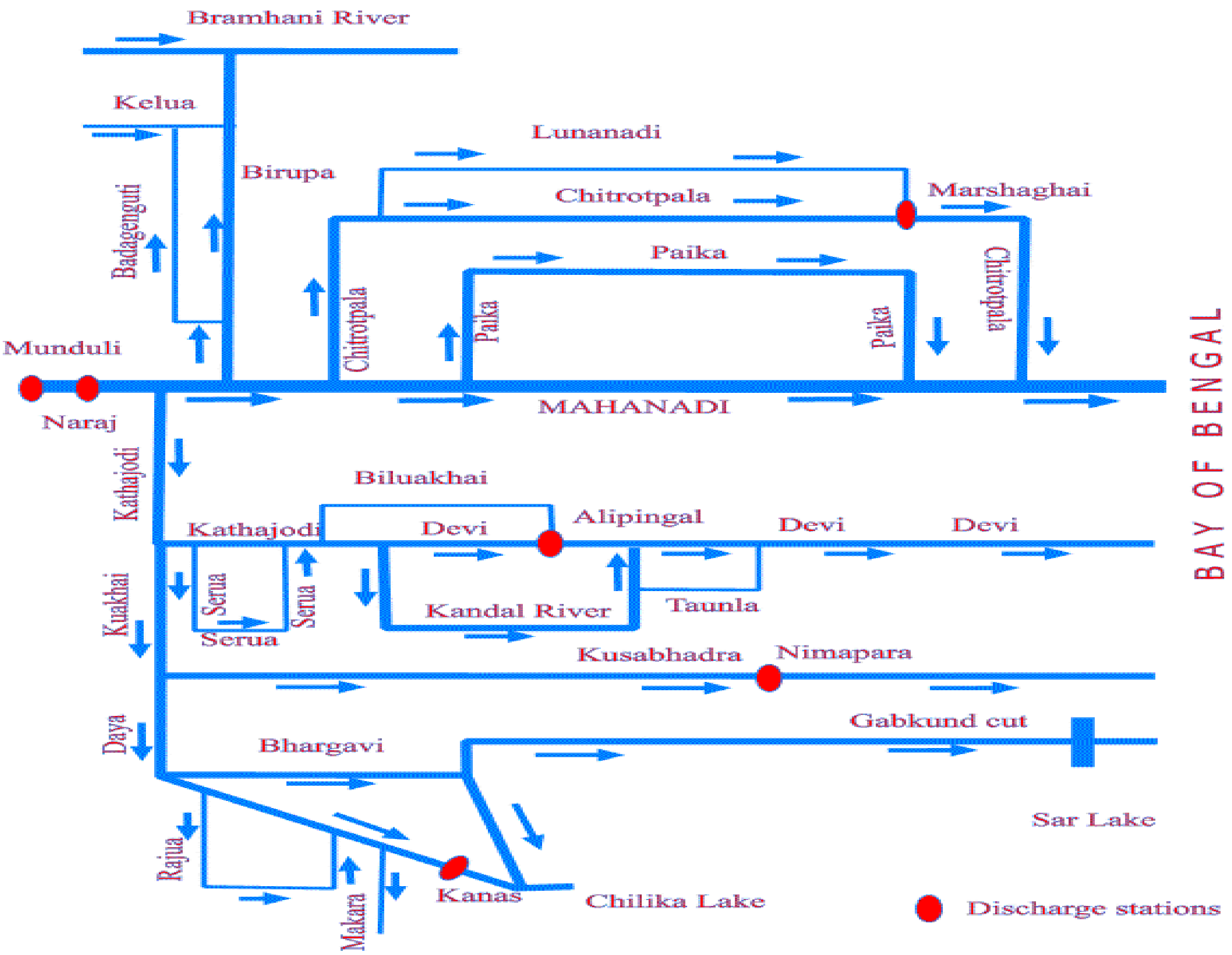

Fig-5 Schematic diagram of distributaries network of Mahanadi river in the delta area

IV. FLOOD MANAGEMENT

The flood management in Odisha particularly in the Mahanadi downstream has become a challenging job since long. The present day status of flood management is still in tune with the traditional way of tackling the distress. Of course there is lot of improvement in real time operational activities when the lives of people matter. A long term and permanent solution of the flood disaster is yet to be executed. The action plan for the flood control has been formulated on time scale basis, the short term management and the long term management.

A. Short Term Management

As normal practice the flood situation including both pre-disaster and post disaster events were handled with the short term management tools. The short term management played an important role in providing the emergency services in the real time havoc [11]. In the previous floods in Odisha, the short term management activities including the prediction system, preparedness programme, warning system and evacuation process were taken up promptly but, in some fields accuracy level of functioning and coordination mechanism were failed. In some cases scanty monsoonal rain for quite a long period and prevailing drought in Odisha had brought poor inception in predicting a sudden flood and preparedness actions. That is why Hirakud reservoir, in spite of attaining gradual release, accumulated the water to handle the dry situation. In such case the flood controlling system and the management team failed to achieve a tough preparedness programme. In the said years, as has been discussed, long period heavy rainfall in the upper end of the Mahanadi and an uncoordinated dam release of water from Chhattisgarh could have left no other way for Hirakud dam but to quit the surplus receipt through maximum number of gates. In almost all the cases, floods warnings to the public have been proved to be effective because of the present day vibrant public communication system. Evacuation of people from flood risk zones and their displacement to safer places have reached a better level than in previous disasters. It is because of the increasing trend of the public awareness effort.

Short term management during the real time and post disaster devastation was operated including two important and challenging activities like rescue operation and relief operation [12]. The recent floods in Odisha have witnessed improved systems of carrying out both rescue and relief operations. The lives of the victims during the disaster can be saved by adequate and properly trained rescue team. Similarly a wide network of relief distribution can sustain the existence of the victims. This needs sufficient amount of infrastructural facilities, commodities and their transportation to the affected areas.

B. Long Term Disaster Management

Some precautionary measures are required to control the flood on long term basis. Action plans are made for the flood prone areas without waiting for the disaster to happen. This has been proved to be the best management practice in annulling the catastrophes of flood disaster. In view of the past floods, some of the long term courses of actions are discussed below.

Construction of reservoirs- Hirakud is the largest among the reservoirs present on rivers of Odisha. Hirakud reservoir on the Mahanadi has been catering the flood control since its construction. Due to heavy siltation the water bearing capacity of the reservoir is decreasing day by day. Live storage capacity of Hirakud reservoir is getting reduced from 5818 MCM (million cubic meter) in year 1956 to 4823 MCM in year 2000[13], because of sedimentation, which needs improvement. The rainfall pattern in the context of global climate change has also been changed. Continuous heavy rainfall within a short period pours water, which can neither be hold in a single reservoir nor channelized by the highly silted river course. Hence at least one big reservoir on the Mahanadi downstream at a sufficient distance from Hirakud and number of medium to minor dams on its tributaries [14] could be constructed. The excess water released by the Hirakud dam can be retained in the second dam for some time and within that span river can easily pour down water to sea.

River bank treatment- The existing embankment on both sides of the rivers in the command area of Mahanadi delta and other rivers in coastal plain are in risk condition to protect the habitat from flood water. The existing embankment system in Mahanadi Delta is capable of carrying only 24660 cumecs of flood against the highest flood peak experienced during last 50 years of 44785 cumecs [15]. This shows the insufficiency of existing embankment system to carry the design flood. Even though they are raised time to time, every time the flood water flows much above the danger level. There are certain vulnerable points on the embankment where the flood water most often washes away and enter the inland do not get routine attention for their maintenance. Only before the monsoon or just before the probable flood the earthwork in those places are taken up on war footing. That leads to a poor supporting strength. Hence long term preparedness with respect to the construction of high rise embankments and their proper maintenance should be done on continuous basis.

The coastal plain constitutes alluvial deposits through which the rivers attain their old stage. So the rivers receive lot of alluvium as a result of huge amount of soil erosion and land slide from the banks. The rivers, therefore, lose their water discharging capacity and create acute flood situation. Therefore, the river banks should be protected by construction of spurs and widespread plantation programme.

Provision of drainage channels- Most of the drainage channel have been silted up, cross bonded or encroached for other purposes. These channels were used to diverting a substantive amount of water from the river and disposing either to sea, lake or low lands. In this way the pressure of flood water on river could have been managed naturally [14]. Looking at the emerging situation of floods, the natural drainage channels have to be recovered and new channels should be dug up. The possibility of non discharge of drain water may occur due to tidal fluctuation of levels; therefore control structures [16] for preventing ingress of tidal water into channels at suitable points of drains may be constructed.

Cross river structures- To facilitate the communication system and to reduce the inter-territorial distance, there are lot of traditional cross river bridges constructed across the Mahanadi and its distributaries. They have much more impact on blocking the water and hence the flow of water is reduced. It is high time to think upon the traditional bridge population and go for the hanging bridge. At least in wide rivers, the number of pillars can be reduced through alternate technology.

Cuts and escapes- In the coastal plain most of the rivers and their distributaries have undergone meandering before falling in the Bay of Bengal. In such condition the length of the rivers increases and the discharge rate becomes slow. In order to increase the flow of flood water in rivers the lengths are decreased by cuts at meanders[17]. Similarly excess of flood water from the river can be diverted through escapes in which the water is spread away on both sides without continuous embankment. The entire deltaic stretch of 7000 km2 requires improvement in surface runoff and integrated sub-surface drainage as suggested by [18].

Siltation free beds and mouths- The beds of Mahanadi river system are buried by the sediments that have been carried from the erosion prone catchment and flood plain areas. The land use patterns of those areas are modified by heavy deforestation, industrialisation, mining and urbanisation activities. Similarly the coastal Odisha comprising of alluvium and soil are eroded by different geological agents and mostly transported to the mouth region. Due to sea level changes and behavioural changes of ocean currents the sediments are deposited in the mouths to form spits and sand bar. As a result the discharge rate of the flood water is reduced. The river beds and the mouths should be regularly dug up to clear the channel. The erosion free land use pattern in the catchment and flood plain areas should strictly be implemented. Extensive plantation programme is to be executed and existing forest covers are to be preserved in such areas.

V. CONCLUSION

Odisha has occupied the most vulnerable place in the hazard map of India. Over the years particularly after the super cyclone in 1999, the disaster management has gained top priority in Odisha. But maximum controlling measures are short term in nature. To operate the disaster action plan, a statutory body namely Odisha State Disaster Mitigation Authority has been set up. Similarly Odisha Disaster Rapid Action Force has been created to assist in search and rescue operation, relief line clearance and other disaster related activities. All such set ups are engaged in prediction and preparedness programme, communication and evacuation process, relief and rescue operations etc. The recurrent disasters like flood in Mahanadi river need a long term controlling measures to reduce the flood devastation in which available flood space in the Hirakud reservoir (4345 MCM) (Das, 1998) may be increased reasonably to accommodate the design flood volume during end part of monsoon.

REFERENCES

[1] Beura, D. 2009. Cyclone Disaster Management with Special reference to Orissa Coast, India. Chaper in book ‘Geological Hazards’by New India Publishing House, New Delhi: 133-153.

[2] Khatua, K. K. and Mahakul, B. 1999. Flood in Mahanadi delta stage II area - A case study. Proc. Nat. Sem on Disaster Management, UCE, Burla, Orissa.

[3] Alexander, D. 1993. Natural Disasters. UCL Press Limited, London.

[4] Maejima, W. And Mahalik, N.K. (2000) Geomorphology and land use in Mahanadi Delta. Mahanadi Delta-Geology, Resources and Biodiversity: 41-51.

[5] Hofmann, J.1996. Neues J. Geol. Pala¨ontol. Abhandlungen, 199, 33.

[6] Mahalik, N.K. 2006 Structure and Tectonics, in Geology and Mineral Resources of Orissa, p.27

[7] Kumar, D. N., Baliarsingh, F. And Raju, K. S. (2011) Extended Muskingum method for flood routing. Journal of Hydro-environment Research, Vol.5: 127-135.

[8] Behera, S. (2008) Water Resource Planning for Mineral Based Industries in Orissa. Requirement of Water for Mining and Mineral Based Industries in Orissa, SGAT: 23-32.

[9] Mishra and Behera. 2009. Development and Management of Water and Energy Resources. 7th International R& D Conference, Bhubaneswar, Orissa.

[10] Patri, S. (1993) Data on Flood Control Operation of Hirakud Dam. Department of irrigation, Government of Orissa, India.

[11] Beura, D. and Singh, P. 2006. Disaster Management in Orissa coast- An Information Technology Vision. SGAT Bulletin 7 (1): 27-36.

[12] Beura, D., Singh, P. and Acharya, A. 2002. Role of Information Technology in Disaster Management. Nat. Sem. Role of IT in Geo. Sc., GSI: 106-108.

[13] Pattnaik, A.B. 1999. Flood flow prediction and pre-depletion of Hirakud Reservoir - A Means for Moderating Monsoon floods: 80.

[14] Das, R.C. And Mahalik, N.K. (2000) Floods and Cyclones: Recurring disasters and their management. Mahanadi Delta-Geology, Resources and Biodiversity: 77-87.

[15] Parhi, P.K., Mishra, S.K., Singh, R. And Tripathy, V.K. 2012. Floods in Mahanadi River Basin, Orissa (India): A Cricital Review. India Water Week 2012 – Water, Energy and Food Security : Call for Solutions, 10- New Delhi

[16] Linsley, R. K., Franzini, J. B., Freyberg, D. L. and Tchobanoglous, G. 1992. Water Resources Engineering. 4th edition, Mc Graw Hill International Editions: 841.

[17] Khatua, K.K and Patra, K.C. 2004. Management of high flood in Mahanadi and its
Tributaries below Naraj. 49 annual session, IEI, Orissa State Centre

[18] Das, G. 1998. Flood Management in Mahanadi Basin. Water Resources Dapartment, Orissa