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MANAGEMENT OF HIGH FLOOD IN MAHANADI & ITS TRIBUTARIES BELOW NARAJ

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Abstract

Mahanadi is an important river in India. At its delta head at Mundali, it has branched into several rivers and drains its water to the Bay of Bengal. The deltaic region is affected by flood, drainage and salinity problems almost every year due to presence of low level escapes.. These escapes start functioning with a flood of 17000 *cumecs of undivided flood in Mahanadi at Naraj . Some part of the deltaic region is safe up to a flood of* 28300 *cumecs due to presence of double continuos embankments. The flood at the delta head has crossed* 28300 *cumecs eight times between* 1958-1998 *and made serious problem to entire delta command area. The annual flood damage of the deltaic region is 37 crores of rupees* (1992 *base*). *Drainage problem also poses a major constraint to agricultural development of the area. Out of total CCA of* 3.03 *lakh hect. more than one third suffers from ill drainage. In the present context it is advocated to provide and improve the structural measures and to provide some special treatment to the affected area to check the major floods up to* 35000 *cumecs. Structural measures to high flood is not feasible and these are proposed to be mitigated by Non structural measures .*

INTRODUCTION

The river Mahanadi branches off to several courses at its delta head, Naraj. The entire delta area is largely affected by flood and drainage almost every year. Floods play havoc at the deltaic region and causes untold miseries. It causes immense loss of life, disruption of human activities, damage to properties, agricultural crops and poses serious health hazard. The problem starts when Mahanadi flood exceeds the limit of 17000 cumecs.

After the devastating flood of 1855 a spur was constructed at Naraj. Later it was modified to a weir which functioned for more than a century. Now a Gated barrage[1] is constructed at the downstream of the old dying weir to control the flood and provide irrigation to its command area. The flood and drainage problems in the deltaic area are mainly due to following

1. Precipitation in the command area, **2**. Floodwater entering the doabs through low level escapes in the river embankments, **3**. Irrigation water through canals and over irrigation, **4**. The other causes which enhance the problems inside the doabs like (a) The delta rivers are at higher level than the valleys inside the doabs**.** (b) Delta country is very flat, (c) Construction of cross bunds by local people, (d) Encroachment in bed and berms of drainage channels by local people, (e) Inadvertent leasing of berm lands of drains by the Government, (f) Construction of bridges and culverts and other cross drainage works without provision of sufficient water ways, (g) Lack of proper maintenance of the existing drainage channels, (h) Insufficient spacing of both the embankments of double embankments, (I) Absence of sluices and tidal structures at the outfalls .

The problems become more acute when floodwater combines with rainwater .The observed maximum value of precipitation is shown in Table -1. River Mahanadi draws water from a catchment area[1] of 1,32,197 sq. km at Naraj. Out of this catchment the uncontrolled catchment of 49250 sq. km, which are below Hirakud, experiences heavy rainfall during south west monsoon in view of its location just south of tracks of monsoon storms and these floods cannot be controlled by Hirakud. In 1980 such a flood, which came at a later part of monsoon (August & September) was routed by Hirakud reservoir partly to produce a flood of 34753 cumecs at Naraj. This also happened in 1982, when practically no contribution was there from Hirakud for the highest flood. In between (1926-1940) and in the post Hirakud period (1958-1998) twenty seven major floods[4] occurred when the regulated flood peak discharges at delta head exceeded 28300 cumecs twenty times. The flood peaks and Return periods at the delta head are shown in **Figs 3 and 4**. Once the river water enters the doabs it doesn't get drained out easily. More and more lands are subjected to continuos poor drainage conditions and get water logged. The area affected by poor drainage is 2.695 lakh hectare out of C.C.A.of 3.19 lakh hectare. The poorly drainage areas can be divided into the following four catagories[3].

1. **Area unsuitable for cultivation throughout the year**: These areas of 0.132 lakh hectare are marshy and swampy lands, remain submerged throughout the year and are unsuitable for growth of any type of crops. Provision for surface drainage will retrieve the area.

2. **Unsuitable for cultivation in kharif**: These are lowlying lands with poor land grading and land shaping. They remain waterlogged for most part of kharif. Only Rabi cultivation is practised in these 0.421 lakh hectare area. The problem can be solved if appropriate drainage facilities are provided.

3. **Area unsuitable for cultivation for both seasons but with low yield**: The problem is due to high water table. Drainage facilities are required for these areas of 0.553 lakh hectare

4. **Area which can not be economically retrieved**: These area of 0.036 lakh hectare contributes to central and deep portion of swamps.

The annual loss[1] due to flood damage alone is 37 crores of rupees(1992 base), is shown in **Table 3.** The indirect loss suffered by inhabitants in the area is also very high and retards the economic growth of the entire area for several years.

HISTORY

In the original project report of Hirakud dam no proposal was given to delta irrigation, instead in the revised project report [1,3] (1952) it was proposed to bring under irrigation in stage II with total closure of Kuakhai at its off take. Later the Majumdar committee (set up by government of India) recommended to construct a new barrage across Kuakhai river. The then Chief Engineer of Orissa proposed to have double embankments with high level escapes instead of Barrage at Kuakhai. In practice none of the above steps had been taken up. A proposal of a storage dam at Naraj has subsequently been dropped and a high level dam at Tikarpara came as a next proposal. This is also shelved. Now another Dam at Manibhadra at the upstream of Naraj has been proposed, which is awaiting sanction at different level.

The following alternative method of studies[3] over last several decades for flood control in Mahanadi delta area has been suggested.

Method I: Diversion of Mahanadi flood from upstream of Hirakud through Tikara river to Brahmani valley by providing additional spillway capacity at Hirakud and an escape channel. It is not desirable as Brahmani valley has its own acute flood problems every year.

Method II: Diversion of flood to Chilika lake through a pilot cut. Sir M. Viswesray has suggested to construct a dam across d/s junction of Mahanadi and Rana nallah to reduce the depth of the cut and to have some flood stored in the reservoir. It may ecologically and hydrologically disturb the lake Chilika and also is quite costly.

Method III: In 1945, Dr. A. N. Khosla proposed three storage reservoirs in Mahanadi, i.e., at Hirakud, at Tikrapara, and at Naraj. Out of these three only Hirakud has been constructed.

Method IV: To remove drainage congestion is to improve the drainage channels inside the doabs. But it is not practicable as it amounts to excavation of very big rivers. Also drainage channels may not fulfil the purpose due to poor out fall condition. So flood control is proposed in rivers. Drains with some tidal structures and embankments are designed to take care of local rainfall flood.

RIVER BASIN CHARACTERISTICS

Kathajuri is a major branch that off takes from the river Mahanadi at its delta head. The details of Mahanadi river and its branches are shown in **Figs**. **1 and 2.** The total length of river Mahanadi[2] is 858 km and it has 437 numbers of tributaries. Kathajuri, which has branched off from Mahanadi was widening alarmingly by 1855 and drawing more water than Mahanadi. The branch Kuakhai takes off from Kathajuri just down stream of Naraj with poor carrying capacity and its riverbed at the off take is about 2.5 m higher than its parent river. The river Kuakhai bifurcates into three rivers, viz. the river Kushabhadra, Bhargavi and Daya. The river Bhargavi has branched into several small rivers before joining the lake Chilika. Kushabhadra has out fallen into the Bay of Bengal and the rivers Bhargavi and Daya have out fallen into the lake Chilika. Water levels of Chilika is about 1.5 m higher than the mean sea level resulting the flood discharge is not quick and causes inundation on the upstream reaches. The river flood in delta area in the river Kushabhadra is also blocked as sand bars tends to form across mouth due to littoral drift. These sand bars show a clear tendency to grow in a easterly direction up to the coast as a result of coastal process. The river Bhargavi, runs a considerable length almost parallel to sea due to high sand spit condition in the shore. The rivers are badly silted up and do not have important function of discharging Mahanadi flood into the sea.

The rivers flowing in the command area are almost flat in character. The average ground profile and bed slope of the river[1-3] varies from 1 in 5000 to 1 in 6000. The doabs in the delta areas are intersected by several drainage channels and are draining either to the main stream or to the sea. The doabs tend to slope down from the river to the interior and from the top near the delta apex to the bottom at the coast. Flatness at the ground helps the low-level flood escapes to function at different stages of Mahanadi flood. The bed of river is full of sand and at the upstream reaches followed by clayey deposit at the downstream reaches nearer to the sea. The side slope of river are very much steep and almost 1V:1/2H. Rivers are more straight in the upstream than nearer to the sea. They through up their branches to their sides again branches combine to form loops and the process continue with the branches almost flowing at a redial pattern creating the actue delta in Mahanadi.

FLOOD CONTROL

Embankments:

In the command area of Mahanadi delta, river embankments[3] exist on both sides of rivers to protect the irrigated land from river floods. The existing embankments are of five types **1**. Capital embankments (1038.10kms), **2**. Other agricultural embankments (403.19 km), **3**. Saline embankments (261.01 km), **4**. Test relief embankments (48.73kms) **5**. Protective gherry bundh or Rising bundh .The first two are the river embankments and are continuos on both sides. These embankments have been raised from time to time. At present these are able to withstand a flood up to 26,900 cumecs and a flashy flood of 28300 cumecs at Naraj. Top levels of embankments at present are fixed with free board of 1.2m. The carrying capacity of the rivers with these embankments are only of a flood of 5 year return period but at some reaches these embankments are not continuos through out with some low level escapes. Saline embankments have been constructed in the Chilika lake area and in down stream of Mahanadi delta nearer to sea to prevent saline waves and tidal action to ingress into land excepting the cases when surge height is exceptionally high during cyclonic storms. The test relief embankments have been constructed by revenue authorities some times past, which can only protect the local area against low floods. The last varieties are small embankments constructed around the villages to protect them from flooding. In delta irrigation project report (1957) there was no proposal to construct gherry bundhs in various islands but later it has been constructed at different islands.

River training works:

The rivers are flowing through alluvial deposits. Therefore erosion to banks are usual and is more acute at d/s reaches. In delta area very thickly populated villages have grown by the sides of rivers, in many villages flood plains have been encroached upon by villagers. During high floods breaches or scouring of embankments occur.

River training works are[3] mainly spurs, revetments and launching aprons which are extensive and scattering in nature, have undergone improvement from time to time.

These have been done throughout the year in order to maintain for the better discharge, as and when required depending upon the funds available. Sand screen has been executed in some low level escape channels to arrest the sand out of the flood water entering into irrigated land. Generally 0.3m toe wall has been provided in the reaches of embankments to protect it from seepage and wave scour of rivers.

Escapes:

Escapes are provided for diverting excess flood water from main river and these excess water are disposed off finally to sea ,or to rivers in d/s reaches or to lakes. At the same branch rivers these escapes have no continuos embankments on both sides and create inundation.

Drainage channels:

The rainfall and floodwater are carried through the drainage channels and disposal is made either to sea, lake or to major rivers. The carrying capacity of these has been deteriorated due to silting up. The mouth of channels are silted up and shifted too much northward due to littoral drift. The existing drainage channels inside the doabs have aggraded, silted up, cross bunded, full of weeds and sometimes considerably encroached upon. Therefore, their carrying capacity is deteriorated to a great extent. Very inadequate provision of waterways in the construction of bridges and other cross-drainage structures has resulted in unexpected afflux. Non-availability of field drains and link drains aggravate the situation by prolonging the retention of water in the fields. The sediments carried in the drains get deposited in the channel and reduce the section of flow, raising the bed levels due to inadequate slope. The slope of some outfall channels ranges from 0.007% to 0.03%, which induce a velocity of 0.2m/s.

Reservoirs[2]:

Hirakud reservoir is constructed just at the entry of river Mahanadi into the Orissa region. Had there been no Hirakud dam in Mahanadi the flood problems would have been more acute. Besides Hirakud reservoir, there are other small reservoirs in the tributaries of Mahanadi. But its moderation of flood in later part of monsoon is poor and free catchments below Hirakud may produce high floods.

Naraj barrage[1]:

The Gated Naraj barrage constructed at the off take of Kathajuri protects the area in monsoon against the flood arising between 17000 to 28300 cumecs. This barrage also diverts a discharge up to 17,370 cumecs to Mahanadi and Birupa, which is their design discharge and they provide irrigation to the command area. In case undivided flood in Mahanadi becomes more than the safe limit all the gates of the barrages (Naraj, Mahanadi, Birupa) are fully opened and the normal discharge shall pass in the respective rivers. If the flood exceeds the safe limits, then there is possibilities of breaches causing severe damage.

SPECIAL WORK OF FLOOD CONTROL.

1.Cuttack city protection work: Cuttack is the most important city in Orissa, which lies at the head of the Mahanadi delta. The city is protected by reverted ring embankments in river Mahanadi and Kathajuri up to flood of 42470 cumecs with free board of 1.9m to take care of high floods.

2.Clearance of River mouths: A strong littoral drift carrying nearly one million cubic meters of sediments pass along the eastern coast of India in the Bay of Bengal from south to north every year. Under its influence the sediments carried by rivers are deposited in northern side there by lengthening the river course. This formation of spit in the mouth of river Devi, Mahanadi, Kushabhadra reduces discharge capacity of floodwater into sea and consequently the rivers remain full. It has been attempted[3] many a times in the past to clear the mouth of river Devi, Mahanadi, and Kushabhadra.

3. Cut to sea from Daya and Bhargavi mouth (Diversion)[3]: Rivers of Mahanadi delta meanders for a considerable distances at d/s reaches due to poor outfall conditions at mouth there by increasing the length of the river. The discharge rate becomes less and slow and causes afflux at u/s reaches and inundates vast cultivated areas. To avoid this and quicken discharge, straightening of meanders has been attempted. The river Daya at its off takes from Bhargavi travels for 67.3 kms again and merges with Daya and falls into Chilika lake. Due to poor drainage parameters it creates serious drainage problems. Therefore, a pilot cut from left bank of Bhargavi has been proposed to reduce the length by 45 km called **Gobkund cut**[3]. It is proposed to divert the balance water of river Bhargavi after Gobkund cut through river Dhaudia called **Mangala cut**[3], shown in **Fig-2.**

A PRAGMATIC APPROACH

Embankments:

The existing embankments are not adequate to the higher floods. Allocation of adequate funds is vital for raising and strengthening the embankments. Raising and strengthening of embankments up to 35000 cumecs (5 year flood) may be provided with the following specification[5] in phases.

Crest width = 7.5m in place of 4.5m

River side slope = 3:1

Country side slope = 2:1 with 8:1 berm and 0.6m H.G.cover

H.G. = 8:1 and free board = 1.5m

The above specification should be adopted taking the following parameters.

1. To keep the seepage gradient inside body of embankments with minimum cover 0.6m

2. The alluvial soil recommends seepage gradients from 1:6 to 1:8

3.Sufficient crest width to make it road cum embankments on socio-economic consideration

New embankments are advocated on consideration of socio-economic and technical aspect of locality but priority must be given for the rehabilitation of damaged/dilapidated embankments with impervious blankets on upstream slopes.

Bank protection:

For bank protection under short term measure, scour depth on dominant discharge of channel is most important factor for adopting the following specification[5] of continuous revetments and apron for river bank stabilization

1. Bank slope (earth cutting) 1:2
2. Bank revetments = two man size stone material over metal filter (1.25 cm to 1.85 cm broken stone material)
3. Toe wall of 0.3m may be provided to protect from seepage and wave scours of rivers in embankments
4. Launching apron in cages of wire-nets.

Execution of high level and low level spurs, launching aprons, stone revetments and construction of new embankments are suggested to prevent further scours of high amounts.

Treatment to weak points:

The embankments are considered weak points where no adequate free board, no minimum H. G. line for the berm of the embankments and Lacey's width is available. Even after raising and strengthening the embankments and providing necessary river training works there are 60 nos. of reaches out of 210 reaches remains as weak points. Weak points may be due to **1**. Previous breach section, **2**. Non availability of side berms, **3**. Higher wave length, **4**. Greater wave heights due to abrupt reduction of river section. The treatment [6]of weak points will be done by

1. Providing dowel banks

2. Revetments

3. Widening the crest

Drainage development (Channel improvement):

Out fall drain, secondary drains link drains, collection drains and field drains, are to be excavated to its full design section with a requisite slope and carrying capacity. No filling up of portion should be done as it may be maintained naturally by silting up. Additional vantage will be provided for the road bridges, which decreases the sufficient waterways.

In d/s and at tidal reaches marginal embankments along the drains are required. One side of embankments of the outfall drains may be provided with necessary widths and surfacing so as to serve as service path. At the junction of link drains with secondary drains hume pipes or masonary control structures are to be provided to control the ingress of drainage water from secondary drains into link drains. At the junction of secondary drains and out fall drains gated sluices are to be provided on secondary drains to control the water levels in secondary drains. The possibility of non discharge of drain water may occur due to tidal fluctuation of levels therefore control structures[6] for preventing ingress of tidal water into channels at a suitable points of drains may be provided. This will obstruct the tidal entry into land and will accelerate discharges of drains as there will be no saltwater wedge requiring removal before the drainage water is released. This will also help in preventing saline ingress in to channels.

Tidal structures:

Tidal control structures at the outfall points of all drains may be provided to prevent tidal ingress and spread of salinity. Tidal structures with marginal embankments constructed above high tide levels will prevent saline water at u/s and reduce saline inundation and hence reduce salinity of soils for better cultivation. These structures will check the receding flow of tides with much lesser distances. Cyclonic storms at Bay of Bengal are very common. During each storm, tidal waves rise several meters and inundate the coastal land making unsuitable for cultivation.

Soil conservation measures[6]:

Contour bunds, terraces, vegetative cover (strip cropping), afforastation, land management and stream bank protection may be undertaken to control soil erosion where the out fall drains meet the river with in tidal reaches, sea or lakes. Surface vegetation increases infiltration capacity and reduces surface runoff. Vegetal cover removes moistures from soil by transpiration and it promotes loose organic soils, which is favorable for infiltration of rainfall .It act like a sort of retarding basin.

Diversions:

Any diversion cut proposed in the coastal area is to be approached with extreme caution. It is necessary to provide judicious river training works for these cuts to maintain the diversion channel for better flood discharge and to avoid retrogression .

NON STRUCTURAL MEASURES:

The proposed structural measures can control the flood up to 35000 cumecs (5 year flood). The structural measures for the highest flood are not feasible. High floods are unpredictable and therefore non-structural measures are the only alternative. All the area should be under the flood insurance program[6]. If all areas of country joined the flood insurance program, the need for disaster relief from flood in theory be eliminated because all properties would be covered by flood insurance. All property owners lying within 100 years return period flood plain[7] are required to be covered for flood insurance. The flood plain [6]should be restricted by zoning, i.e., restricting any human activity in the flood plain of rivers. For regulating land use it has been envisaged that industries, public utilities, electric installation, telephone exchange, should not be as far as possible, located in 100 year of flood or maximum observed levels. Government offices, public institution, residential areas are envisaged to be located above 25 year flood. Park, play ground have been put under least priority and are to be located in vulnerable part of flood. Raised platform [8]are to be constructed for distress mitigation to give emergency shelter to flood affected lives during high floods. Such measures consist of raising of some chronically flood affected villages above predetermined flood levels and connecting them to adjoining roads or high lands. Also the drinking water facilities can be provided with shallow tube wells. The temporary kutcha lavatories need to be constructed in the linking roads with embankments at a quite safe distance apart from tube wells. Forecast of flood by remote sensing and advance warning is a must. A good flood forecasting can often provide adequate warning in advance to permit orderly and complete evacuation. One of the most effective means of flood damage reduction is the emergency evacuation of threatened area. Besides breach to embankments and washing out of anti -erosion schemes may easily be averted if prior knowledge of impending flood is made known to flood control field officials.

CONCLUSIONS

Effective enforcement of non-structural measures is essential besides, the absolute functioning of structural measures to reduce the flood damages and loss of properties and lives. Besides, structural measures and the river training works, afforestation and soil conservation program in flood prone areas are required. It should be clearly understood that both effective structural, and non-structural measures can only reduce the flood damages to an acceptable level. The works of flood control measures are to be started just at the end of flood season. The flood management[7] authority should have broad knowledge of **1**. The existing flood control structures and their conditions. **2**. Flood prone/ disaster areas. **3**. Pattern, magnitude and frequency of the flood. **4**. Post flood situation. Effective and scrupulous flood managements with more scientific and technical acumen have now been observed to be the only viable alternative towards attainments of socio-economic development of the command areas.

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Table1: Observed maximum value of precipitation

Period	Ist day	2nd day	3rd day	4th day	5th day	6th day	7th day
Maximum rainfall in mm	402	629	671	678	678	681	741

Table2: Annual flood damage[1]

Year	Crop damage in lakh Rs	House damage in lakh Rs	Public utility damage in lakh Rs	Total in lakh Rs	Average annual flood damage (1992 base)
1977	76.99	1.21	72.72	150.92	
1978	133.68	11.22	320.50	465.35	
1979	N . A	N . A	N . A	N . A	
1980	802.87	78.67	146.46	1026.99	
1981	N . A	N . A	N . A	N . A	
1982	1237.48	304.48	507.44	2049.40	37 crores
1983	N . A	N . A	N . A	N . A	
1984	869.91	35.15	1472.34	1877.40	
1985	935.79	218.77	713.34	1867.90	
1986	368.10	12.86	125.23	506.19	
1987	Drought area	-----------	------------	-----------	-----------
1988	Drought area	---------	---------	--------	-----------
1989	Drought area	---------	---------	--------	-----------
1990	412.57	78.36	227.64	718.51	
1991	6000.0	165.94	2275.43	8441.37	
1992	4394.0	55.35	2496.18	6945.53	

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