FLOOD AND CYCLONE IN COASTAL ORISSA

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Abstract : *The flood and cyclone in coastal Orissa are the regular features. The rivers in the coastal region have the characteristics of deltaic rivers .The rivers and the existing escapes are without continuos embankments . The average ground profile and bed slope of rivers varies from 1 in 5000 to 1 in 6000.Therefore flood used to pass over plains and get released to sea with little submergence depths.When the rivers are in spate and there is even little rainfall in the locality ,than the protected areas get flooded by local rain water .The problem becomes more acute when the flood arises due to cyclonic storm. Coastal Orissa falls in the path of severe cyclonic storm originating in the Bay of Bengal , so there is concentration of run off due to heavy rainfall brought in by cyclonic storm in short duration. The unprecedented cyclonic gale ,torrential precipitation , high flood ,tidal ingress and stagnation causes untold miseries. Proposal of cyclone shelters, coastal highway , iridium-phones ,Conservation of declining mangrove and other forests , afforestation and drainage improvements are the main need in the area. Improvements of saline and other embankments , de-silting of the mouths of channels and rivers and additional ventage to the roads and cross drainage structures have been advocated . Proper forecasting and other curative measures with proper Disaster Management programme can mitigate the flood and cyclone to a great extent*

INTRODUCTION :

The state of Orissa is having a geographical area of 1,55,707 Sq. km with population of 31.512 Million according to 1991 census .Rice is the principal crop(53% of gross cropped area) followed by pulses (19%) and oil seed (10%). About 86% of total population of the State dependant on agriculture. The natural calamities adversely affect the agricultural production of the state.The state has tropical climate characterised by medium to high temperature, high humidity ,short and mild winter .The mean annual rainfall is 1503 mm .The coastal part of the state is frequented by natural disaster like flood and cyclone every year . Its flood prone area in coastal belt of 41,000 Sq.km .Out of total 31 districts 14 prosperous districts belong to its coast.The rivers in the coastal region have the characteristics of deltaic rivers , having the bank slopping inlands and consequently flood spilling over the bank flows away from the rivers side flooding vast stretches of lands .There was very little marginal embankment on any of these rivers , the flood use to pass over the plains and get released to sea with little submergence depth .Since the beginning of the century ,due to over increasing population there is rising demand of land for cultivation and to protect these lands from flooding marginal embankments have come up at many places encroaching upon the flood plains .These encroachments into the flood plains in turn , rises the flood stage , thereby increasing the depth of inundation in the unprotected areas.As Orissa falls in the path of severe cyclonic

storm originating in the Bay of Bengal .There is concentration of runoff due to heavy rainfall brought in by the Cyclonic storm in short duration .These cyclonic storm have been found to cause floods in more than one rivers simultaneously .

RIVER BASIN CHARACTERISTICS AND FLOOD:

The flood in coastal part is brought in mainly by the following important rivers and their branches.

1. The Subarnarekha
2. The Burha balanga
3.The Baitarani
4. The Brahmani
5. The Mahanadi

All the rivers originate from the Chhotanagapur Plateau and southern continuation thereof i.e. from eastern ghat and outfall into the Bay of Bengal .The easy release of the river flood is dependent upon the tide condition of the sea and duration of the flood .The coastal belt ,being the delta of rivers ,the general ground slopes downwards from the rivers edge inland as such when the rivers are in spate and there is rainfall in the locality protected areas also get flooded by local rain water as the same cannot get released into the rivers .The flood in coastal Orissa rivers occurs mainly due to rainfall in the upper catchments(up land) .The river flowing in the command area are almost flat in character . The average ground profile and bed slope of river varies from 1 in 5000 to 1 in 6000 . Flatness of the ground helps the low level flood escapes to function at different stages of river flood. The doabs are intersected by several drainage channels and are draining either to main stream or to the sea .The bed of river are full of sand at u/s reaches followed by clayey deposit at d/s reaches nearer to sea shore . The side slope of river are very much steep and almost 1V:1/2H.. Rivers are more straight in u/s than nearer to shores . They throw up their branches to their sides again branches combine to form loops and process continues with the branches almost flowing at a radial pattern .

The flood problems in the command area are mainly due to following

1.Overflowing of the banks of rivers and channels
2. Precipitation in the command area
3. Flood water entering the doabs through low level escapes
4.Irrigation water through canals and over irrigation

The other factors which enhance the problems inside the doabs are that

A. The delta rivers are at higher level than the valleys inside the doabs**.**
B. The 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 Govt.
F. Construction of bridges and culverts and other cross drainage works without provision of sufficient water ways
G. Insufficient spacing of both the embankments of double embankments.
H. Absence of sluices and tidal structures at the outfalls .

The problems become more acute when flood water combines with rain water . Once the river water enters the doabs it doesn't get drained out easily. More and more lands are subjected to continuous poor drainage conditions and get water logged. This situation also happens during cyclonic storm which brings intense and severe rainfall with a high cyclonic gale destroying lives and the properties of the area .

CYCLONE :

A Cyclone is a very large mass of air with low pressure surrounded by a high pressure air mass . Due to unequal heating of earth surface, pressure difference arises and when atmospheric pressure falls below 965 millibar at a place ,strong wind blow in a spiral motion towards that low pressure center from all direction because of rotation of Earth around its own axis. The large whirling mass of air at the center where pressure is low is known as Cyclone and acts like a chimney through which air gets lifted , expands ,cools and finally gets condensed causing precipitation and Cyclonic gale . If precipitation is caused by cold front it is very intense but for short period , while by warm front it is more continuous . Nomenclatures of the Cyclonic disturbances according to the wind speed used by IMD ,has been shown in **table no.-1** .The tracks of the various Cyclonic storms (**in fig-1&2**) in the Bay of Bengal between 1891-1997 also reveals that most of the cyclonic storms are crossing the east coast through coastal Orissa and East Godavari district of AP . Orissa on the east coast along with West Bengal and Andhrapradesh has the location disadvantage of being in the path of depression of severe cyclonic storms. Severe cyclonic storm occurs when the southwest monsoon recedes or just before the onset of monsoon in late April-May-June spell .At different times Orissa coast has been affected by Cyclonic storm which has been shown in **table no.-2.** Due to extensive and continuos heat of the sun in a particular place the pressure falls below 965 millibar and cyclone originates there.Particularly in some places like coast of Orissa,West Bengal,Andhrapradesh,Tamilnadu,Bangladesh and Southern America ,the heat of the Sun is more and so the chances of cyclone is more there .In summer the air above the Earth surface is more heated than that of sea .But in winter the process reverses.Therefore cyclone originates on Earth ’s surface in summer and at sea in winter .

Table-1 NOMENCLATURES OF THE CYCLONIC DISTURBANCES :

Serial No.	**Weather System**	**Maximum sustained surface wind speed(KMPH)**
1	Low	Less than 31
2	Depression	31-49
3	Deep Depression	50-61
4	Cyclonic Storm	62-88
5	SevereCyclonic Storm	89-117
6	Very Severe Cyclonic Storm	118-221
7	Super Cyclonic Storm	222 and above

Table-2 HISTORICAL SEVERE CYCLONE STORM EVENTS PASSING ORISSA COAST

Date	Type	Wind Velocity(Kmph)
9thNov. 1973	VSCS	209
30th Oct. 1971	VSCS	187
31st Oct.1912	VSCS	185
9th Nov.1995	VSCS	Nr
22nd Sept. 1972	VSCS	185
10th Sept. 1972	VSCS	176
12th May 1979	VSCS	170
16th Nov 1942	VSCS	168
17th Oct. 1999(Gopal pur)	VSCS	185
29th Oct.1999(Paradeep)	Super Cyclone(SuCS)	329

SUPER CYCLONE 1999 OF ORISSA:

During third week of October ,1999 the atmospheric condition of the Bay of the Bengal changed giving early indication of a cyclone storm .Gradual increase of storm intensity was observed by the IMD on subsequent days .The eye of the storm started moving towards Orissa coast by 25th October and had finally landfall at Paradeep on 29th Oct. morning . It penetrated up to 150 km inland and caused torrential precipitation over 45000 Sq. km from the 29th October to 1st November lashing practically the entire coastal stretch of Orissa with a cyclonic gale of 300 kmph .Incessant rain under the influence of depression over the Bay of Bengal , heavy down pour added to the miseries of the homeless people . The super cyclone of Oct. 29th devastated fourteen prosperous coastal districts throwing the lives of more than one crore of people out of gear . More than 10,000 people were declared officially deceased and three lakhs of cattle perished , nineteen lakhs houses were razed to the ground .Coastal Orissa which was full of greenery virtually turned barren with over 9 crores of trees getting uprooted .The Cyclone not only flattened out paddy crops but totally destroyed cash crops . The tidal surge of 6 to 7 m arising out of wind speed of 300 km/hr, on the morning of 29th October rapidly swept across a 100 Km of coastal stretch in Jagatsinghpur and Kendrapara districts, submerging the entire area and destroying all the houses and infrastructures .Saline inundation of 2,00,000 ha. of extremely fertile agricultural land struck a death blow to standing crops of the entire coastal area .As the rivers were overfill and strong unprecedented cyclonic gale of 200 to 300 kmph was blowing so large stretch of protective embankments and saline embankments received the massive scouring ,sloughing and overtopping .Therefore breaches in the dams, collapses of spillway structures occurred in all medium and minor projects of the state .The loss in super cyclone is estimated to be around 20,000 crores of rupees.The largest concentration of urban population of 1.5 million in Cuttack and Bhubaneswar suffered unprecedented

damage from intense rainfall of 500 to 600 mm and cyclonic gale of 200-250 Km/hr. The major cause of such damage was due to

a) Extremely intense rainfall from 400 to 960 mm in two to three days which occurred in the coastal districts accompanied by strong gale upto 300 km at Paradeep . The Isohytes of cyclonic precipitations are shown in **fig-3.**

b)The deltaic area from Mahanadi to Subarnarekha got submerged up to 3m depth by stagnation and impeded drainage ,extremely high flood occurred in all the catchments in all the basins that resulted highest ever flood of 5,00000 cusecs in Baitarani at Akhupada .

c)Grossly obstructed and poorly maintained drainage channels over 30,000 Sq.Km. of deltaic area caused high afflux and created submergence of agricultural land up to 10 days

d)Cyclonic gale caused a tidal wave of 5 to 6 m height to travel in land , submerging and severely scouring /breaching all the saline embankments .Saline inundation over 2,00,000 ha. is seriously affected the fertility .The restoration scheme (shown in **table-3**) is needed to be formulated by short term and long term proposals.

Table-3 BASINWISE DAMAGE AND RESTORATION DUE TO SUPERCYCLONE(29.1099--1.10.99)

Name of the basin	Irrigated area affected in lakh ha.	Flood protected area affected in lakh ha.	Canal damage in lakh rupees	Embankment damage in lakh rupees	Saline Embankment damage in lakh rupees	Building damage in lakh rupees	Total restoration in lakh rupees
Mahanadi	3.37	13.40	3584.73	4063.46	3552.00	1927.25	13127.44
Brahmani	1.03	4.40	4220.95	1757.60	540.00	583.20	7101.75
Baitarani	3.30	3.80	8124.43	3097.00	1000.00	155.50	12376.93
Burhabalanga	0.40	3.40	938.80	1208.00	111.00	59.40	2317.20
Total	8.10	25.00	16868.91	10126.06	5203.00	2725.35	34923.32

PRAGMATICAL APPROACH :

General flood control measures like catchment management (Afforastation,soil conservation, adoption of contour farming ,construction of check dams) should be adopted to tackle flood and drainage problem . The river mouth and channel should be dredged to its design discharge .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 . Additional vantage should be provided for

the road bridges which decreases the sufficient water ways .Cyclonic storms at Bay of Bengal is very common .During each storm , tidal waves rise several meters and inundates the coastal land making unsuitable for cultivation , killing several lives and damaging several properties. In d/s and at tidal reaches ,tidal structures with marginal embankments should be constructed above high tide levels which will prevent saline water at u/s and reduce saline inundation and hence reduce salinity of soils.In addition to this the increase of spillway ventage with ancillary protection of certain extremely unsafe dams should be provided. Raising of crest of saline embankments along the coast upto RL 4 to 5m in order to prevent over topping due to tidal surge is emergently required .

Raised platform 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 distances apart from tube wells . Forecast of flood by remote sensing and advance warning is a need to the area . A good flood forecasting can often provide adequate warning sufficiently far 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 . The flood plain should be restricted by zoning i.e.Restricting any human activity in the flood plain of rivers.

Daily rainfall of an intense storm events is now established as 400 to 500 mm anywhere along the coast with hourly intensity of 50 to 60 mm. wind velocity in the range of 100 to 200 kmph can also be considered as a likely annual event .Under these extreme combinations, a tidal surge of atleast 3 m height in the sea and stagnation at 1 to 2 m in the deltaic tract up to 60 to 70 km parallel to the coast is an extremely probable event .Therefore long and medium term action plan has to be drawn up and implemented in a 3 to 5 year time by critical hydrologic and hydraulics analysis as to why canals and embankments breach more frequently at certain locations. Proposals like formulation of well designed drainage plan for unirrigated river basins of Subernarekha, Budhabalanga,Baitarani and Brahmani which includes

(a) Raising the saline embankments close to the coast to a TBL of 5 m up to 15 km from the coast and 4 m further upstream .

(b) Protective pitching of rubble of 1.5 foot thickness over filters exposed to wave and scouring .

(c) The embankment in severely scouring reaches will have launching apron protection .

(d) Additional ventage in cross drainage structures in particularly for smaller steep catchments will have to be provided .

(e) Adequate ventage in all roads/Highways will have to be provided that are the main obstacles for flood flow and cause unavoidable afflux .

(f) It is also necessary to dredge river mouths, particularly for Subarnarekha,Mahanadi and its branches to facilitate quick flood out flow .

The cyclone and flood can be managed by adopting preventive ,cautionary and curative measures. It is high time to construct a chain of of Precast concrete/ RCC cyclone shelters on safe, high ground, equipped with basic amenities of life along the Countries Cyclone-prone coastal areas .The shelters can be used as Schools or community centers in normal times .The housing scheme in the area should also be encouraged for cyclone-resistant construction.Iridium is a global wireless communication system that combines world wide coverage of a network of 66 low-earth orbiting satellites .It provides reliable 2-way communication during disaster relief . The role of these instruments(Iridium hand sets i.e. phones and pagers) in disaster Management are reputed to be extremely durable, handy in bad weather and on rough terrains .It will caution the people in face of ensuing danger to shift to safer place.The track and intensity of killer cyclone can be predicted well in advance ,based on satellite and radar data and by using data interpretation & Mathematical models.

The dense Mangrove forests which grew naturally in the Orissa coast was providing a permanent barrier against cyclones and tidal surges .These were the largest deep forest of country .The unscrupulous clearance have made the coast bare and exposed to the vagaries of cyclones . Stringent laws to preserve forests and to increase it by afforestation,plantation of wind breakers like Casuarina and similar trees in the coast will go a long way to reduce the speed of wind . The proposal of construction of Highway between Gopalpur-Digha along the coast of 450 kms length and 7m high should be encouraged .The national Highway will join West Bengal ,Orissa ,and Andhrapradesh along the coast which will not only protect saline ingress due to tidal surges to delta but also will boost tourism .Intermediate escapes with sluices are to be provided along the raised high way to facilitate drainage of the river channels to sea .

CONCLUSION :

The Cyclone and flood are the regular features of the Coastal region of Orissa . Flood control measures like raising of the existing embankments , Afforestation ,Drainage improvement of both channels and rivers and construction of some tidal structures with sluices are to be implemented . Cyclone and flood are annual scourges and they may return next year too and none can predict the next scale of destruction .Therefore with adequate will ,with support of community , NGO and every department of Government , calamities can be faced and human miseries can be reduced to the minimum .Since the cyclone seasons is April-May and Oct.-Nov. committee has to be set up for a fresh look at disaster management and meetings are to be held in March and September to take stock of preparedness, supplies, rations.It would be worthwhile that both the center and state should have separate department of Disaster management .Immediate restoration,long and medium term action plan have to be drawn up and implemented by critical hydrologic and hydraulics analysis .The housing scheme like Pucca building should be encouraged for cyclone-resistant construction . Drinking water supply pipe line should be connected to all Flood and Cyclone prone villages from outside area .In delta areas wind resistant commercial plantation should be proposed in place of Banana ,Coconut and other similar trees .Provision of chain of cyclone shelters and provision of Iridium phone sets in Cyclone-prone coastal areas like Orissa ,West

Bengal ,and Gujurat are needed . Resources may be constraint on states so center should take up the matters .Besides structural measures non-structural measures like Forecast of cyclone and flood by remote sensing and advance warning is needed, which can often provide adequate warning far in advance to permit orderly and complete evacuation . Scrupulous flood and cyclone management with more scientific and technical acumen has now been observed to be the only viable alternative towards attainments of Socio-Economic development of the area.

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NON STRUCTURAL MEASURES :

The proposed structural measures advocated to control the flood up to 35000 cumecs (5 years of flood).The structural measures for the highest flood is not feasible .High floods are unpredictable so 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 programme,the need for disaster relief from flood in theory be eliminated because all properties would be covered by flood insurance . All property owners with in 100 years of flood plain[7] are required to purchase flood insurance .. For regulating land use it has been envisaged that industries ,public utilities , electric installation , telephone exchange , under priority I[8] should be 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 under priority II . Park,play ground have been put under priority III and are to be located in vulnerable part of flood .

1.Subarnarekha:The river originate s from Chhotanagpur plateau ,after leaving Bihar ,it forms a boundary between West Bengal and Orissa for a small stretch and thereafter naturally go through Orissa to sea .The river has got flat slope and has many bends before it falls into Bay of Bengal covering a length of 60kms in Orissa.This River has no branches .

2.Burha balanga:The river originates in the Similipal hill ranges of the Eastern Ghat and outfall independently into the Bay of Bengals without any branches .

3.The Baitarani:The river emerges from Eastern Ghat hill ranges and sprongs to plane near Akhupada where it divided into branch rivers namely Burha which joins another branch river of Brahmani.About 20kms of downstream it branches into Genguti and Kochila rivers which out falls into Baitarani again .The flood situation is aggravated by its three tributaries namely the Salandi,Reba and Kapali outfalling on the left bank of Baitarani.The river Baitarani outfalls into sea through Dhamara,which is common mouth for Baitarani,Salandi and Brahmani.

4.Brahmani:The river emerges from eastern Ghat hill ranges to the planes at Jenapur .It is divided into branches namely Patia,Kharsuan,Kimiria,&Kelua.Each of the branch rivers forms its doabs along with main rivers and again joins with main rivers .

Finally combine rivers fall into the Bay of Bengal .

5.Mahanadi: The river emerges from eastern Ghat hill ranges to the planes at Naraj and divides into several branches and sub branches i.e Kathajuri,Kuakhai,Devi,Biluakhai,Kushabhadra,Bhargavi,Daya , Birupa and Genguti.The Mahanadi ,Devi and Kushabhadra have got direct mouth to sea .The Bhargavi and Daya rivers falls into the Chilika lake while the branch river Birupa joins Brahmani .

The details of flow of the rivers and its branches are shown in **fig1**.

Mahanadi[2] in whole of its length of 858 km has 437 nos. of tributaries up to delta area of Naraj . Kathajuri which has branched off from Mahanadi was widening alarmingly by 1855 and drawing more water than Mahanadi . The Kuakhai takes off from the Kathajuri just down stream of Naraj , has become a river with poor carrying capacity and its bed at the off take is about 2.5 m higher than its parent river .The river Kuakhai bifurcates into three rivers , 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 . The water levels of Chilika is about 1.5 m higher than mean sea level so 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 river flowing in the command area are almost flat in character . The average ground profile and bed slope of river[1-3] varies from 1 in 5000 to 1 in 6000 . The doabs in the delta area are intersected by several drainage channels and are draining either to main stream or to the sea . The doabs tend to slope down from the river to the interior and from top near the delta apex to bottom at the coast . Flatness of the ground helps the low level flood escapes to function at different stages of Mahanadi flood .The bed of river are full of sand at u/s reaches followed by clayey deposit at d/s reaches nearer to sea shore . The side slope of river are very much steep and almost 1V:1/2H.. Rivers are more straight in u/s than nearer to shores . They throw up their branches to their sides again branches combine to form loops and process continues with the branches almost flowing at a radial pattern creating the acute delta in Mahanadi .

ISOLATED MEASURES

The coastal Orissa on the East Coast along with West Bengal and Andhrapradesh has the locational disadvantage of being in the path of depression of severe cyclonic storms that occur before the onset of south-west monsoon or after it recedes . Eleven coastal districts lying in five major river basins of Mahanadi , Brahmani , Baitarani , Budhabalanga and Subarnarekha receive heavy rainfall during this time . It is a pity that coastal orissa is frequently exposed to high flood damage

The highest flood of 1982 and the Super Cyclone and severe Cyclone of Oct.1999 of the Coastal Orissa is unforgettable* Coastal Orissa which was full of greenery virtually turned barren with over 9 crores of trees getting uprooted .The Cyclone not only flattened out paddy crops but totally destroyed cash crops . The tidal surge of 6 to 7 m arising out of wind speed of 300 km/hr, on the morning of 29th October rapidly swept across a 100 Km of coastal stretch in Jagatsinghpur and Kendrapara districts, submerging the entire area and destroying all the houses and infrastructures .Saline inundation of 2,00,000 ha. of extremely fertile agricultural land struck a death blow to standing crops of the entire coastal area .As the rivers were overful and strong unprecedented Cyclonic gale of 200 to 300 kmph was blowing so large stretch of protective embankments and saline embankments received the massive scouring ,sloughing and overtopping .Therefore breaches in the dams, collapses of spillway structures occured in all medium and minor projects of the state .The loss in Super cyclone is estimated to be around 20,000 crores of rupees.The largest concenetration of urban population of 1.5 million in Cuttack and Bhubaneswar suffered unprecedented damage from intense rainfall of 500 to 600 mm and cyclonic gale of 200-250 Km/hr. The major cause of such damage was due to

a) Extremely intense rainfall from 400 to 960 mm in two to three days which occurred in the coastal districtsaccompanied by strong gale upto 300 km at Paradeep .In Ganjam the most intense rainfall of 452 mm at Berhampur in 36 hours, accompanied by cyclonic wind of 180 km/hr .The Isohytes of both cyclonic precipitations are shown in **fig-1 & 2[1] .**

b)The deltaic area from Mahanadi to Subarnarekha got submerged up to 3m depth by stagnation and impeded drainage ,extremely high flood occurred in all the catchments in all the basins that resulted highest ever flood of 5,00000cusecs in Baitarani at Akhupada .

c)Grossly obstructed and poorly maintained drainage channels over 30,000 sq.Km. of deltaic area caused high afflux and created submergence of Agricultural land up to 10 days

.d)Cyclonic gale caused a tidal wave of 5 to 6 m height to travel in land , submerging and severely scouring /breaching all the saline embankments .Saline inundation over 2,00,000 ha. is seriously affecting the fertility

CYCLONE

.A Super Cyclone is one whose wind speed encountered in core-area of a tropical Cyclone equals or exceeds 226 kmph .The super cyclone that originated in the Bay of Bengal near Andaman-Nicobar Islands on 25th Oct. concentered into a severe cyclonic storm and had finally landfall at Paradeep on 29th Oct. morning . It penetrated up to 150 km inland and caused torrential precipitation over 45000 sqkm from the 29th october to 1st november lashing practically the entire coastal stretch of Orissa with a cyclonic gale of 300 kmph .Incessant rain under the influence of depression over the Bay of bengal , heavy down pour added to the miseries of the homeless people .

RAINFALL AND FLOOD

Eleven coastal districts lying in 4 major river basins of Mahanadi, Brahmani,Baitarani and Budhabalanga received massive rainfall of 500 mm to 900 mm .The depth-area-duration curve of these basins have been shown in **fig-5**[1] .The drainage basins of six dams ,Ramiala,Remal,Kanjhari,Salandi,Sunei and Kalo have received 500 to 900 mm of rainfall in 36 to 48 hours that has resulted in generation of peak flood much in excess of of their design spillway capacity .Damages to head works ,canal systems have occured ,rendering the irrigation projects incapable of providing any irrigation although the reservoirs are absolutely full on Nov. 10 ,1999. Due to supercyclone and flood the headworks and distribution systems of 422 Minor Irrigation projects have been seriously affected/damaged . It can be seen that the observed floods (**table 4)**[1] ,in some cases are as high as 150% of the design flood of the projects .31 nos.of dams have partially breached/slipped ,with significant damage to head regulators and protective stone peaching .Heavy concentration of flood and wave action has caused subsidence and serious surface erosion .On the spillway side embankments have been damaged ,the gradewalls have collapsed with deep scours and protective aprons have largely subsided and removed away. Diversion weirs have mostly been out flanked and body wall damaged .The distribution systems over a command area of 86,824 ha.out of total of 1,56,178 ha. has been totally /partially damaged . Almost 1090 Km. of distribution channels have suffered erosion through 1052 breaches and 306 canal structures had received massive damage . Due to super cyclone ,5636 lift Irrigation Projects have been seriously affected .This include disruptions of power supply and damage of head works and distribution system .Due to high flood ,most of the pumps and other machinaries were submerged which require rewinding .

The deltaic track that received the most intense rainfall partcularly in Mahanadi , Brahmani, and Baitarani basin is extremely flat with slope of the order of 1 in 5000 to 10,000 . The two smaller river basins ,Baitarani and Burhabalanga received the most severe rainfall and consequently generated extremely high floods .River Baitarani bifurcates into a branch Budha at Akhupada , which joins Kharsuan , another deltaic branch of river Brahmani . Due to most intense rainfall between 29th Oct. to 1st Nov. the peak flood discharge is assessed as 4,98,000 cusecs at Akhupada against safe carrying capacity of 10,000 cusecs in the main channel and 50, 000 cusecs in Budha . The flood hydrograph of river Baitarani is shown in **fig-6**. The flood in Baitarani and its branches caused serious damages to all embankments and channels of Keonjhar , Jajpur , Bhadrak and Kendrapara districts .Both Anandapur and district town of Jajpur on the bank has been seriously affected by flood spill .

DEPTH-AREA-DURATION CURVE

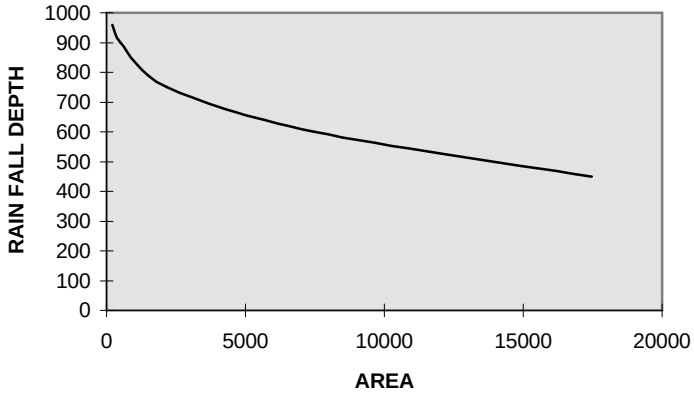

fig-5

FLOOD HYDRO GRAPH OF RIVER BAITARANI(At Akhupada)
28thoct.-6 AM to 1st nov.99-6 PM

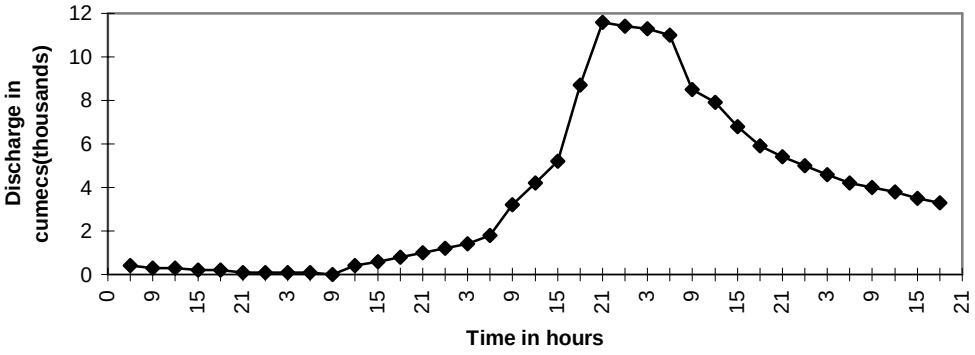

Fig-6

Major contribution to catastrophic flood was from river Kusei (basin area 870 sq. kms) on the right and from several smaller rivers. The river Kusei before its confluence with Baitarani carried almost 200,000 cusecs , resulted in abnormal increase of flow to 498,000 cusecs at the delta head (Akhupada) . The river carried close to 500,000 cusecs crossing the the previous ever highest of 375,000cusecs in 1975 . As the river's carrying capacity at the head of delta is less than 200,000 cusecs, massive breaches occurred in the left and right embankments of the river and all its branches . Baitarani basin had not experienced a flood of this magnitude earlier . A major state highway bridge on this river was outflanked , and due to heavy concentration of flow , has collapsed by scour .The major flow from left to right was contributed by 26 nos of minor irrigation projects by breaches in the dam, collapse of spillway control structure and scour of protective grade walls .All minor projects in this basin irrigating 23,000 ha. have been totally devastated .The river Baitarani through its deltaic branch Budha spilled almost 250,000cusecs into Brahmani basin causing flooding of practically the entire delta of both the rivers and even 30 to 40 km upstream in the sub mountaining

region . The NH-5 crosses the river just above the head of the delta where discharge through the bridge was observed as 408,000 cusecs . The two largest rivers basins Mahanadi and Brahmani received intense rainfall only in tail and consequently didnot generate high flood at the head of their delta . It is however more interesting to note that all deltaic branches of these rivers were flowing above danger levels, at locations as far as 20 kms inland from their sea mouth . The high flood occured here because of severe rainfall of 500 to 700 mm on the delta resulting in peak flood in the drainage channels ,which disgorged into the rivers at lower reaches . One million ha. arable land in coastal area were affected primarily by stagnation . The drainage was impeded because of flatness of the terrain being 1 feet/ mile . As the river Mahanadi and its branches Devi, Daya ,Bhargavi were overfull and 200 to 300 km/hr gale was blowing , the protective embankments of 2000 to 2500 kms length including the saline gherries along the coast lines of 350 kms received the massive scour , sloughing , overtopping . Strong cyclonic gale of 300 Kmph at Paradeep which caused a tidal wave 5 to 6 mtrs high traveled inland and spill laterally through all the coastal rivers and creeks upto 20 to 30 km parallel to coast .The length of coastal stretch affected is 250 kms and due to earlier cyclone 100 km length of Ganjam , Khurda , Puri districts has been affected .The saline inundation that occured over 20 to 30 km. wide coastal stretch was also caused by overtopping , breaching , and severe scouring of saline embankments along the coast of almost 1400 km length . The cyclone not only flattened out paddy crops but totally destroy the cash crops .The agricultural land area that has been affected by salinity is 2 lakhs ha. , which was covered with paddy and plantation crops , coconuts in particular . The district of Jagatsinghpur and Kendrapara has suffered massive loss due to wind and submergence in the lower reach .The basin area affected in main 4 rivers are shown in **Table-3[1] .**

Table-3[1] **BASIN AREA AFFECTED**

Name of the basin	Agricultural land in M Ha	Irrigated land in M Ha	Area affected in M Ha
Mahanadi	1.85	0.6	1.20
Brahmani-Baitarani	0.65	0.16	0.45
Burhabalanga	0.3	0.04	0.2

Table4 [1] **DANGER LEVEL OF THE RIVERS**

Name of river	**Gauging Station**	**Peak Gauge Recorded**	**Danger Level**
Baitarani	**Anandapur**	**40.05m**	**38.36m**
Baitarani	**Akhupada**	**20.77m**	**17.83m**
Brahmani	**Alva**	**5.36m**	**4.87m**
Brahmani	**Indupur**	**2.64m**	**2.50m**
Salandi	**Rajghat**	**16.72m**	**15.13m**
Kharsuan	**Binjharpur**	**6.40m**	**5.95m**
Kharsuan	**Aul Rajbati**	**4.70m**	**4.42m**
Mahanadi	**Bhutamundei**	**4.3m**	**2.8m**
Devi	**Sribantapur**	**4.5m**	**3.1m**
Daya	**Kanas**	**4.63m**	**3.99m**
Bhargavi	**Khujuria**	**3.07m**	**2.74m**

6.Rushikulya: The river originates from Deghi of Phulbani district at an altitude of 1000m .It has catchments area of 7800sq.kms having length of 150kms.

The Coastal part of the state Orissa is frequented by natural disasters like flood and cyclone year after year . Out of the total geographic area of 156 lakh hectare , the available Irrigation potential in the State is 24 lakh hectare during Kharif and 11 lakh hectare during Rabi. Agriculture is the main stay of the states economy .About 86% of total population of the State dependant on Agriculture. The natural calamities adversely affects the Agricultural production of the State.

The coastal Orissa on the East Coast along with West Bengal and Andhrapradesh has the locational disadvantage of being in the path of depression of severe cyclonic storms that occur before the onset of south-west monsoon or after it recedes . Eleven coastal districts lying in five major river basins of Mahanadi , Brahmani , Baitarani , Budhabalanga and Subarnarekha receive heavy rainfall during this time .

It is a pity that coastal orissa is frequently exposed to high flood damage .Flattnessof the terrains, Existance of Low level escapes ,Improper drainage works accelerates the flood and drainage problems there. Only two major rivers Mahanadi and Brahmani have been dammed at Hirakud and Rengali respectively . Though Hirakud dam is controlling the flood situation in the delta area but for complete flood and drainage control Sir M.Visweswaray's phase wise Mahanadi river valley project should be implemented . General flood control measures like afforestation and adopting soil conservation measures , construction of check dams , adoption of contour farming , small dams in the tributaries , flood forecasting and warning , should be adopted . Raising the existing embankments , dredging of river channels , constructions of escapes in the delta should be provided to control flood and avoid drainage problems in the delta . Short term measures like closing critical breaches , strengthening of embankments by pitching and revetments by spurs and groynes and long term measures as envisaged above will save the people from fury of flood and cyclone . Be it High flood ,Supercyclone or severe cyclone the suffering of people of Orissa is due to absence of proper disaster management plans . A task force should be set up disaster management .Cyclones and floods are annual scourages and they may return next year . But with adequate will , with support of people , NGO's , different departments of governments , these calamities can be faced and scale of human suffering reduced to minimum .

The highest flood of 1982 and the Super Cyclone and severe Cyclone of Oct.1999 of the Coastal Orissa is unforgettable

.Cautionary measures like installation of radars , providing with Iridium hand sets and pagers (which are reputed to be extremely durable , handy in bad weather and rough terrains and provides reliable two-way communications during disaster) will caution the people in face of ensuing danger to shift to safer places. Forewarning of the disaster is desired and where prevention is not possible , it is the duty of the government to organise and manage short term and long term relief measures that reduce human miseries to the maximum extent . Andhrapradesh and Tamilnadu have thousands of cyclone shelters along the coastal belt , stocked with basic amenities of life . Orissa is not having any such cyclone shelters . It is high time to go for construction of a chain of Precast / R.C.C cyclone shelters on safe and high ground .The shelters can be used as schools or community centers in normal times . The affected peoples should be encouraged to go for cyclone resistant R.C.C.construction . Subsidy by government will help the people in the regard . Proposal of Cyclone shelters, Coastal High way , Iridium-phones ,Conservation of declining mangrove and other forests , Afforestation and drainage improvements are the main need in the area. Improvements of saline and other embankments ,de-silting(dredging) of the mouths of channels and rivers and Additional ventage to the roads and cross drainage structures have been advocated. Proper Forecasting and other curative measures with proper disaster Management programme can mitigate the flood and Cyclone to a great extent

Embankments:

In Mahanadi delta command area i.e. both stage I & stage II river embankments[3] exist on both sides of rivers to protect the irrigated land from river floods . In stageI only it is continuos and are under sized . Material used which are available at adjacent lands are sandy or entirely silty .

The existing embankments are of five types **1**. Capital embankments(1038.10kms) **2**. Other agricultural embankments(403.19kms) **3**. Saline embankments(261.01kms) **4** . Test relief embankments (48.73kms) **5**. Protective gherry bundh or Ring 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 in stageI .Top level 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 in stage II 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 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 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. In stageII these escapes have no continuos embankments on both sides and create inundation

Drainage channels :

The rain fall and flood water are carried through the drainage channels and disposal is made either to sea , lake or to major rivers . The carrying capacity is 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 agraded , silted up , cross bunded , full of weeds and some times considerably encroached upon .Therefore their carrying capacity is deteriorated to a great extent . Very inadequate provision of water ways in the construction of bridges and other cross - drainage structures have 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]:

In u/s of Mahanadi Hirakud reservoir exists , 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 will protect the area in monsoon against the flood arising from 16990 cumecs to 28300 cumecs .This barrage will also divert a discharge less than 17,370 cumecs to Mahanadi and Birupa arm which is their design discharge to provide irrigation in delta stage I command area . In case undivided flood in Mahanadi becomes more than the safe limit all the gates of the barrages (Naraj , Mahanadi , Birupa) will be fully opened and the normal distribution shall pass in the respective rivers . If the flood exceeds the safe limits , then there is possibilities of breaches causing severe damage . In that case the damage will be distributed in both stage I and stage II area as per its natural distribution .

SPECIAL WORK OF FLOOD CONTROL.

1.Cuttack city protection work: The largest and important city of Orissa which lies at the head of the Mahanadi delta is protected by reveted 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 flood water into sea and into rivers and consequently remains full . So it has been attempted[3] 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 and extra length increased due to meandering . The discharge 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 45kms 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** .

New embankments are advocated on consideration of socio-economic and technical aspect of locality but priority must be given to 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 continuos revetments and apron for river bank stabilisation

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 wirenets .

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 as per standard , no minimum H.G.line for the berm of the embankments and Lacey's width is not available . Even after raising & 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

CONCLUSIONS

Effective enforcement of non-structural measures is essential for absolute functioning of structural measures and reducing flood damages and loss of all kinds of properties and lives . Beside this structural measures and its improvements , afforestations 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 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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8. Non structural aspects of flood Management in India , INCID .**Table1**