DISASTER MANAGEMENT PLAN.
[DoWR]
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1. Introduction

The state Odisha is ranked as the 5th most flood prone state of the country after UP, Bihar, Assam and West Bengal with a flood prone area of 33400 km^2. The south-west monsoon brings rains to the state from June to September every year. The state receives an average annual rainfall of 1500 mm and more than 80% of it occurs during monsoon period only. The coastal districts of the state are more vulnerable to frequent low pressure, cyclonic storms, depression and deep depression. The state has five major river basins namely Mahanadi, Brahmani, Baitarani, Subarnarekha and Rushikulya which cause high floods in their respective deltas. The rivers like Vamshadhara and Burhabalang also cause flash floods due to instant runoff from their hilly catchment.

It is a fact that the three major river system Mahanadi, Brahmani and Baitarani forms a single delta during high flood and in most of the cases the flood water of these three systems blend together causing considerable flood havoc.

Besides the state has 476.40 kms of coastline on the west of Bay of Bengal. The flood problem becomes more severe when the flood synchronies with high tides causing slow recede of flood. The silt deposited constantly by the waves in the delta area raises the flood level and the rivers often overflow their banks.

The flood problem in the state generally aggravated due to some or all of the reasons as below:

- Erratic monsoon, heavy monsoon rainfall accompanied by low pressures, depressions, deep depressions and cyclones.
- Dam releases due to heavy inflows, thus causing massive outflows in the river.
- Inadequate channel carrying capacity.
- Low rate of discharge of floodwater into the sea due to congestion of river mouths.
- Tidal surge during the flood thereby heading up of floodwater. This may occur during monsoon or non-monsoon.

- Changing land use conditions leading to the erosion of soils, thus reducing the channel carrying and reservoir capacity.
- Due to continuous deposit of sand in river beds which ultimately reduces the carrying capacity of river.
- Thick clay layer mostly over deltaic area (paddy grown area) which form an impervious bed.
- Free flow flood plains are gradually being closed due to public utility/demand causing excess floodwater in the rivers, which ultimately threats to the capital embankments.

Some of the major floods that occurred in recent past are shown in Table 1.

Table1. Few major floods of Odisha basins

Sl. No.	Year	River	Month of occurrence	Area affected in Lakh hectare
1	1980	Mahanadi, Brahmani, Baitarani & Vamsadhara	September	3.19
2	1982	Mahanadi, Rushikulya	August-September	12.00
3	2001	Mahanadi, Brahmani,Baitarani, Subarnarekha, Burhabalang, Vamsadhara, Rushikulya & Indravati	July - August	7.99
4	2003	Mahanadi, Brahmani, Baitarani Subarnarekha, Burhabalang, Vamsadhara, Rushikulya & Indravati	July-October	5.03
5	2006	Baitarani, Mahanadi, Rushikulya, Vamsadhara, Burhabalang & Indravati	July - August	3.04
6	2008	Mahanadi, Brahmani, Baitarani	September	
7	2011	Mahanadi	September	

Source: Flood Management Manual (2008) DOWR up to Sl. No. 5

Considering the annual flood havocs, the basin wise vulnerable points have been identified and necessary precautionary measures have been taken. A list of vulnerable points as assessed during 2013 has given along with the map of the basin (Table 2).

Table 2: List of vulnerable locations of all the basins

Sl. No	Location	Irrigation Division	Name of The River
1	Rathapurusottampur	Puri Irr.Divn	Bhargavi right
2	Sunapada	Puri Irr.Divn	Bhargavi right
3	Kantisal	Prachi Irr.Divn	Devi right
4	Tainsal	Prachi Irr.Divn	Kandal left
5	Bauriakana	Nimapara Irr.Divn.	Devi right
6	Asan	Nimapara Irr.Divn.	Devi right
7	Dighala Kudhasahi	Nimapara Irr.Divn.	Kushabhadra left
8	Gauligaon	Aul Embankment Divn.	Baitarani right near Gualigaon
9	Maharakul	Aul Embankment Divn.	Gobindpur,Hadua,Madhuban TRE on Kharasuan right
10	Jharamal	Aul Embankment Divn.	Garadpur Iswarpur OAE on 'Brahmani Left'
11	Bhatapada	Aul Embankment Divn.	Keradagada Alatanga S/E on Hansua right
12	Gopalpur	Aul Embankment Divn.	Keradagada Alatanga S/E on Hansua right
13	Jagannathpur	Aul Embankment Divn.	Keradagada Alatanga S/E on Hansua right
14	Barkot	Aul Embankment Divn.	Keradagada Alatanga S/E on Hansua right
15	Koilipur	Aul Embankment Divn.	Keradagada Alatanga S/E on Hansua right
16	Pentha	Aul Embankment Divn.	Rajnagar Gopalpur S/E on Sea facing
17	Banaghat	Mahanadi North Divn.	Birupa left
18	Ganeshghat	Mahanadi North Divn.	Birupa left
19	Mula Basanta	Mahanadi North Divn.	Birupa left
20	Balipadia	Mahanadi North Divn.	Birupa left
21	Mandia Gherry	Mahanadi North Divn.	Chitrotpalla left
22	Orisha	Mahanadi North Divn.	Chitrotpalla left
23	Narasinghpur	Mahanadi North Divn.	Chitrotpalla left
24	Akhua	Mahanadi North Divn.	Chitrotpalla left
25	Khurusia	Kendrapara Irr. Divn.	Mahanadi left (Kodakana gherry at RD1.40Km)
26	Danpur to Kalapada	Kendrapara Irr. Divn.	Luna left
27	Musadiha	Mahanadi South Divn.	Mahanadi right
28	Itatikiri	Mahanadi South Divn.	C.E.No.62 B on Mahanadi right
29	Kula Samantrapur	Mahanadi South Divn.	Paika left (Sherapur OAE)
30	Sherapur	Jarka Irr. Divn.	Brahmani left (Sherapur OAE)
31	Saranga Sahi	Jarka Irr. Divn.	Tantighai right (Bhanra TRE)
32	Radhadharpur	Jarka Irr. Divn.	Kelua (Rahapada Mohanpur TRE)
33	Kochila mouth near Daspur	Jajpur Irr. Divn.	Kochila mouth on Baitarani left embankment
34	Mohammadpur	Jajpur Irr. Divn.	Kharsuan right
35	Tala Astar	Jajpur Irr. Divn.	Baitarani left
36	Balarampur	Jajpur Irr. Divn.	Baitarani right

37	Dasandhikula	Jajpur Irr. Divn.	Baitarani left
38	Mugupur	Baitarani Divn.	Baitarani left embankment
39	Govindpur	Baitarani Divn.	Baitarani left embankment
40	Mankidia	Balasore Irr. Divn.	Subarnarekha right
41	At RD 2.85 to 2.93Km near village Kuli	Salandi Canal Divn.	Baitarani left
42	Hindula to Munisipentha	Berhampur Irr. Divn.	Rushikulya right
43	Allipur	Bhanjanagar Irr. Divn.	Badanadi left
44	Kinigaon	Chikiti Irr.Divn.	Vamsadhara left
45	Gudari Near PWD rest Shed	Chikiti Irr.Divn.	Vamsadhara left

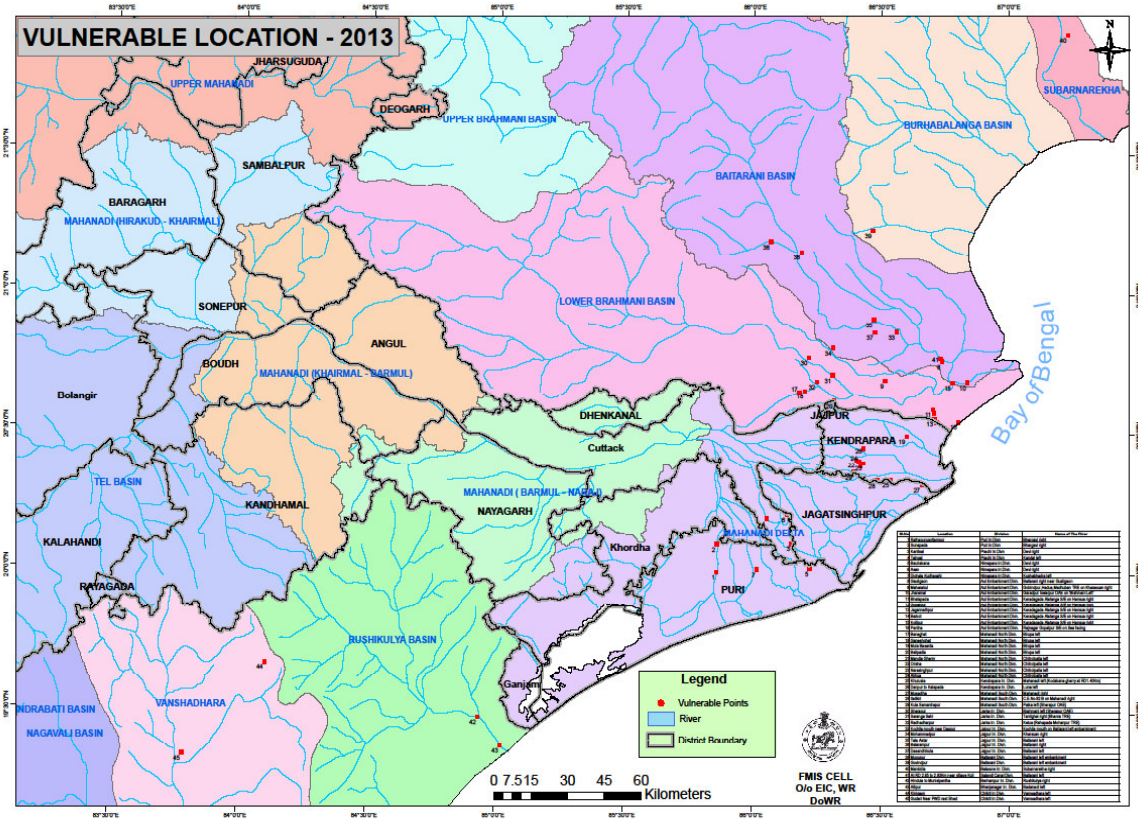


Fig 1. Map of identified vulnerable location for 2013

After commissioning of Hirakud dam during 1958 flood miseries in Mahanadi system have been reduced considerably. However still it continues either due to dam releases from Hirakud reservoir or due to flow contributions from intercepted catchments of over 50,000 sq. km. Down below Hirakud dam project and upto delta. In Mahanadi system, mostly the rivers Kathjori, Devi, Kuakhai, Kushabhadra, Daya, Bhargabi, Birupa, Chitroptala, Paika drains most of the floodwater in to the sea. Due to excess of water than carrying capacity,

major breaches occurred on these rivers and almost inundate the deltaic area. The flood damage statistics of past five major floods are as given in the Table 3.

Table 3 Flood damage statistics

Flood damage due to	1982	2001	2006	2008	2011
Peak flood at Mundali (Lakh cusecs)	15.84	14.09	12.83	15.81	13.67
Breaches (Nos.)		379	120	78	
Damages (Rs. Crores)		559	429	745	

The most recent floods in the state occurred during Sept.' 2008 and 2011. While, the flood 2008 in Mahanadi basin was due to lower catchment contribution, the flood of 2011 was due to that from the heavy rainfall in the upstream. The inundation map of 14 Sept. 2011 (Fig. 2) is as shown below. All the coastal districts are affected during these floods. Agricultural fields, roads and railway networks are completely disrupted along with lives of human and domestic animals are jeopardized.

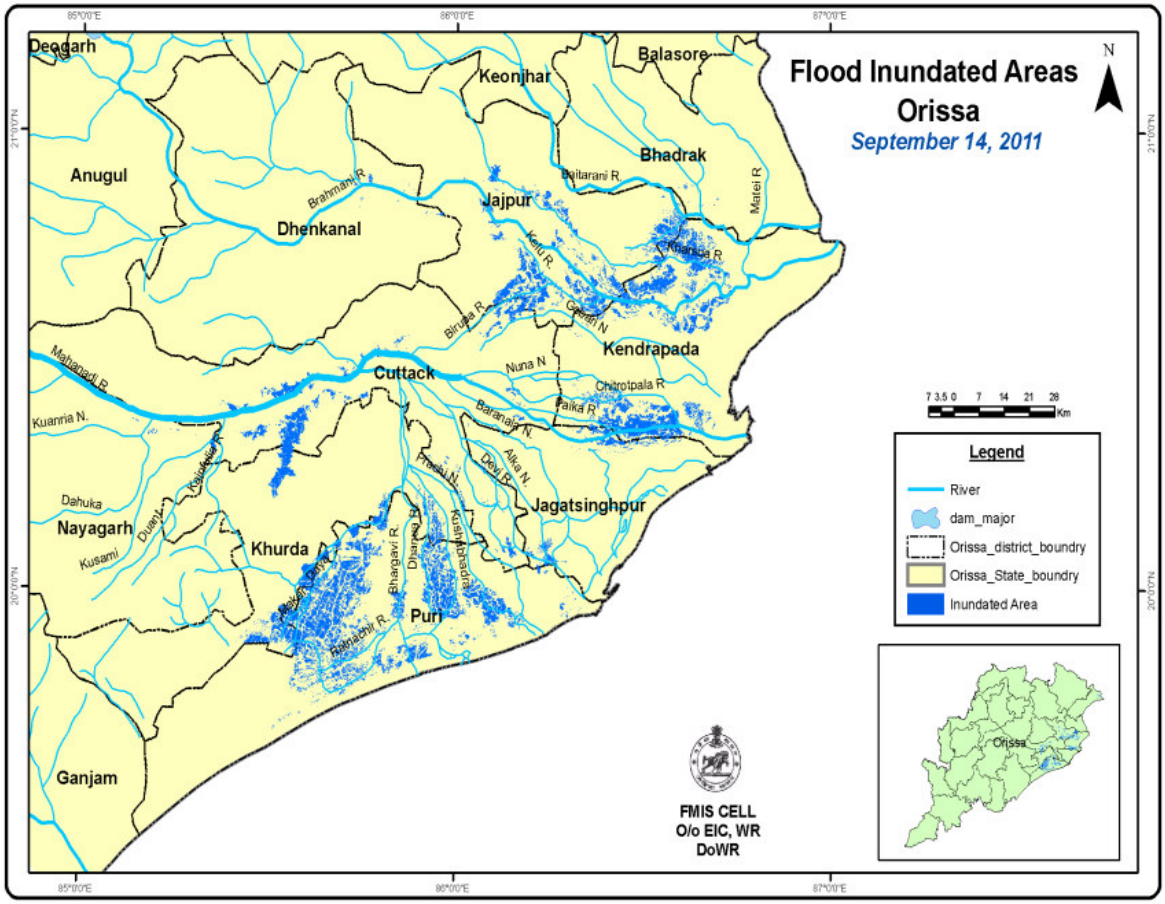
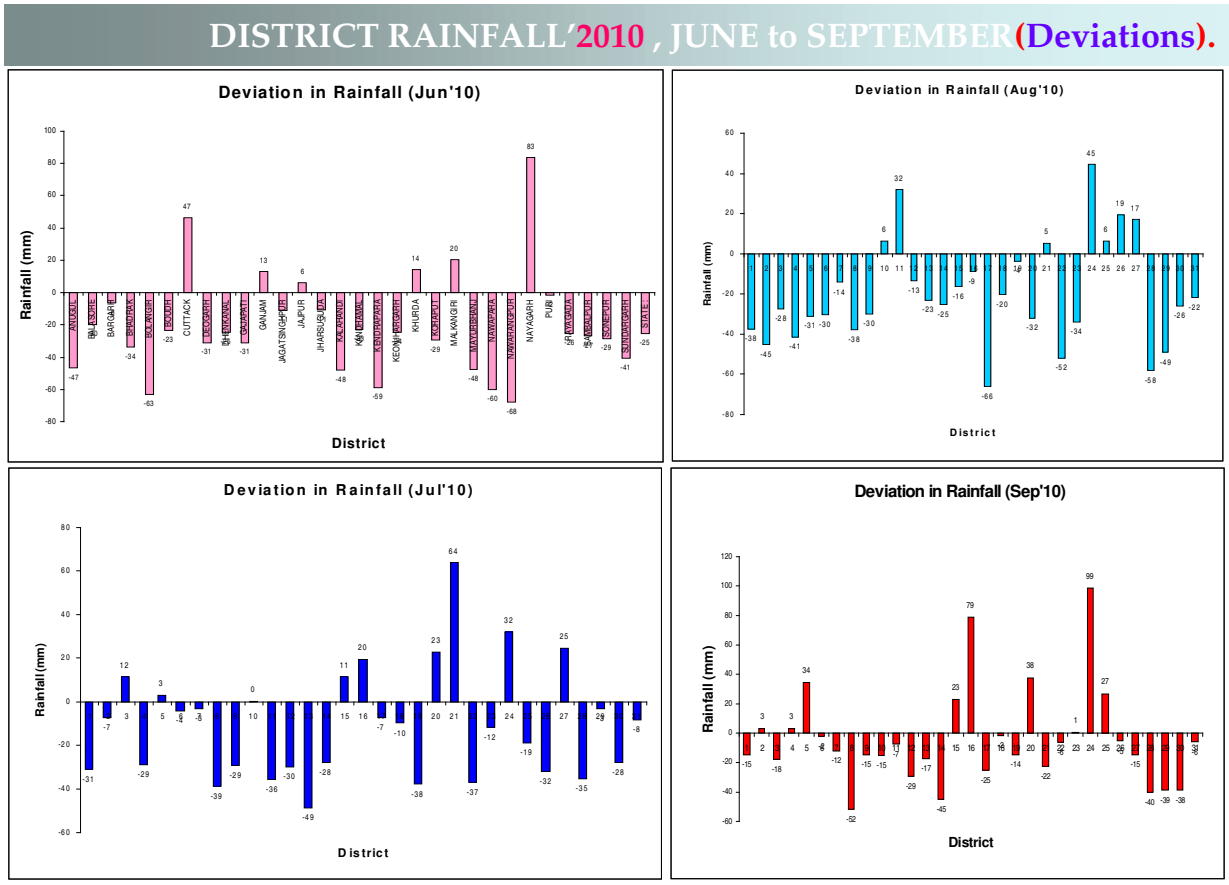


Fig 2 **Flood inundation map of 14 Sep. 2011**

It has been observed over the years, that the rainfall pattern as well as the rainfall distribution in the state has been changed resulting more deviations from the normal rainfall (Fig.3 for 2010). The usual 120 days monsoon rain has gradually has shrunk to 60-70 days, with the annual average still over 1400mm resulting unusual spikes in short term rainfall. The torrential rainfall spells of over 200-250mm in a day are more frequent during monsoon.



Data Source : IMD, Bhubaneswar.

Fig. 3 Deviation of the rainfall from the normal

The variation in monsoon rainfall resulting short term high intensity in various catchments results in frequent floods in different river systems. As a measure of flood management, the various Major and Medium storage schemes in the states already exists have been evaluated for their live storage capacities to conserve water (Table.T1 and T2). But still it is felt; the storage quantum is inadequate against the flow volumes of the floods.

2. Flood Management in Odisha.

The seven multipurpose reservoir projects have been constructed with basic objectives of irrigation, flood control and power. The conservation of the reservoirs are regulated by a standard rule curve in operation. These are sometimes known as Rule Curve. The rule curve in operation for Hirakud multipurpose project is given in Fig.4.

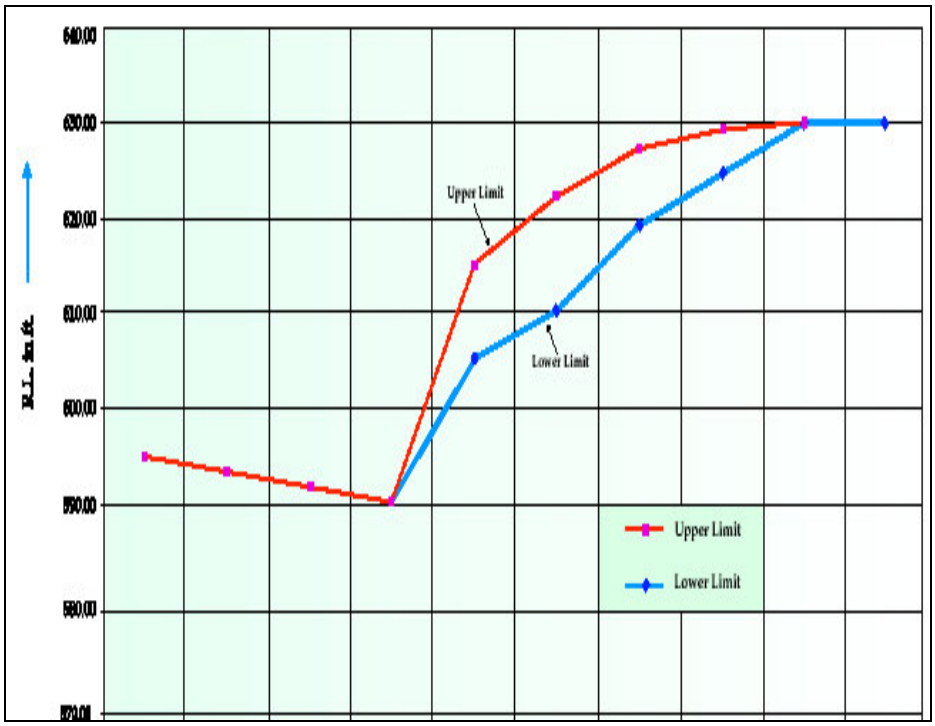


Fig. 4 Rule curve of Hirakud

The average annual flow from the upstream catchment of Hirakud is of the order of 20-25 M.Ac.ft. with volume during the flood events ranging from 1.0 to 4.0 M.Ac.ft per day. Low storage capacity (Live storage capacity 3.91 M.Ac.ft) of Hirakud dam is a major concern for moderating the flow from its upstream catchment. For Mahandi system, different major schemes have been evaluated for their feasibility without detailed survey and investigation downstream of existing Hirakud dam over time with an objective of better flood management. One of the suitable sites for the construction of a storage scheme in the form of a barrage is at Manibhadra.

The standard travel time of flood, those have been observed between different points of the Mahanadi system basin is given in Table 4.

Table 4 Travel times of flood water in Mahanadi basin

Station to Station	Travel time (hr.)	Distance (km)
Ghorari to Seorinarayan	14	102
Nandaghat to Seorinarayan	8	104
Seorinarayan to Saradihi	8	56
Hasdeo to Saradihi	10	80
Saradihi to Hirakud dam	12	97
Tarapur to Hirakud dam	14	103
Deogaon to Hirakud dam	9	90
Hirakud dam to Khairmal	12-18	115
Khairmal to Barmul	12-16	109
Barmul to Mundali	12-16	125
Mundali to Naraj	0.45(Avg.)	3

Source: Flood management Plan 2008, DOWR

In case of Baitarani system, the frequency of formation of the depressions/cyclonic storms formed in the North Bay of Bengal during the Southwest monsoon months June to September increases as the monsoon progresses. On an average one/two depressions forms in the months of June and July and two/three in the month of August and September. These systems may take 2 to 3 days to form over the Bay of Bengal and intensify into a depression or cyclonic storm and then move inland in a north-westerly direction across the coast of Odisha. Once the system crosses the coast, it starts weakening and dissipates in a 2 to 3 days of time. These systems cause widespread rains all along the track with the central region receiving very heavy rainfall. The catchments of river Brahmani and Baitarani generally remain under the influence of these moving depressions/cyclonic storms for 1 to 2 days depending upon their speed and direction of movement. A widespread system generally covers an area of 50,000 sq.km. or more and may yield 150 to 200 mm rainfall in one day over this extensive area. Initially the river Baitarani flows in a northern direction for about 80 km and then takes an abrupt right turn near Champua and flows in a south easterly direction and finally discharges into Bay of Bengal through the deltaic area of river Brahmani. The river travels a total distance of 360 km and drains an area of over 14,000 sq.km. The annual normal rainfall varies from 1250 mm to 1500 mm over the Baitarani basin.

In the context of Baitarani river system, some of the major causes can be summarized as follows.

1. The drainage pattern of Baitarani river basin (central plateau) is dendrite type and flash flood is a natural character of such type of drainage pattern. Again since the upper catchment of Baitarani is full of hillocks and occurrence of a large number of drainage lines allow the run off generating over there to gush into the main river with greater force in very short span of time. The lower part of Baitarani is a part of greater Mahanadi & Brahmani delta.
2. Baitarani is a highly meandering river. In meandering channels the flow is highly turbulent and forms eddy currents, which very often leads to sudden overflow of the embankments causing inundation of surrounding areas.
3. Due to heavy mining activities and practices of shifting cultivation in the upper catchment a large quantity of sediments are added to the river during monsoon seasons. This lowers the carrying capacity of the river and thus even a medium size rainfall can cause high flood in Baitarani.
4. The shallow aquifer conditions, water table nearer to the ground level, spread of water logging areas, swamps, and estuarine etc. do not allow precipitation & thus compound the impact of flood.
5. There is no major diversion channel to control flood in Baitarani river Basin
6. The upper catchment i.e. the central plateau comprises of meta-sediment & controlled by severe fault & shear zones, which contributes more sediment into the basin.
7. Encroachment of flood plains due to growth of population is also causing heavy damage though the flood is not so high. Sufficient area should be left in order to allow the floodwater flow into the sea safely. This particular cause is an important human factor. Such that there is no flood zone planning for the coastal area of eastern ghat region.
8. The flow of Brahmani River is also adding to the flood in Baitarani River in the downstream.

The most flood affected blocks in Baitarani system are Anandapur, Dasarathpur, Korei, Bari , Jajpur, Binjharpur , Rajkanika.

All the severe storms that have occurred since 1901 over the catchment areas of Brahmani and Baitarani and other neighboring basins have been studied by IMD. Enveloping curves for

1-day and 2-day rainfall amounts have been drawn. The rainfall depths corresponding to different standard areas were picked up as given in Table 5.

Table 5: 1 and 2-day rainfall maxima as a function of area

Area (km2.)	Rainfall Depths (mm)	
	1 – day	2 – day
1000	521	737
5000	434	653
10000	366	574
20000	292	465
50000	198	366
100000	142	279

(Period 1901-1950) *(Source: Hydrology Project Report)*

Another flood causing basin in the state is the Brahmani system. The annual normal rainfall in this system varies from 1250 mm to 1750 mm. From different hydrological studies, it has been revealed that the floods in the Brahmani delta are governed by:

1. Inflow from Brahmani river system as well as flow from Rengali dam. The total intercepted catchment at Brahmani delta at Jenapur is 35,700 sq.km, of which 25,100 sq.km.is controlled by Rengali dam, leaving 10,600 sq.km. fully uncontrolled.
2. Baitarani river system which drains a catchment 14,200 sq.km joins to Brahmani and thus they combine to form a delta.
3. Mahanadi river through Birupa branch sometimes substantially contribute to Brahmani flow. (the Sept'2011 flood in Brahmani)
4. Rainfall in the total deltaic catchment over 2000 Sq.km. of the combined Mahanadi, Brahmani and Baitarani.
5. Tidal water level in the river mouths at the Bay of Bengal.

It is imperative that the total control of flood is not practicable from economic considerations and therefore flood management is essential. Flood management rationally refers provision of reasonable degree of protection against floods by structural / non-structural measures to mitigate the recurring havoc caused by floods. During the last five decades, a number of structural and non-structural measures have been taken to minimize flood.

- As a part of structural measures, reservoirs namely Hirakud on the Mahanadi river, Rengali on the Brahmani river, Upper Kolab in Kolab river and Upper Indravati in Indravati river have been constructed. Similarly, Kanupur Dam is under construction in Keonjhar will also moderate flood to some extent in Baitarani delta. Chanduli and Icha dam (under construction) in Jharkhand will control flood to some extent in Subernarekha system.

- Rivers namely Rushikulya, Vamsadhara, Nagabali, Bahuda and Budhabalanga do not have flood control reservoirs.

- Besides, in the deltaic area, floods are being controlled by flood protection embankments constructed on both sides of the rivers. A total 7138 kms of protective embankments, 1952 spurs and 253 kms of stone packing have been constructed in different basins particularly in the deltaic areas to control the flood and saline ingress.

3. Proposed Flood Management Plan:

At the current scenario, with the existing flood management directives following measures below may be proposed.

Structural measure

Managing flood through structural measure is one of the effective ways, but it requires large investment, huge manpower and long time. Structural measure like construction of storage reservoir, detention tank, raising leaves, digging of silted channels and dredging of sea mouth, slope protection etc. are generally are executed for flood protection. So far seven numbers of major dams, forty medium projects and 2196 minor dams have been constructed and rest 22 major and medium projects are in the ongoing stage. These structures, especially major projects are minimizing the flood havocs to a greater extent as well as serving the multipurpose activities. River systems namely Baitarani, Rushikulya, Vamsadhara, Nagabali, Bahuda and Burhabalanga do not have major flood control reservoirs.

The raising of the embankments, slope protection, channels excavation, mouth clearance to sea etc. works are also being carried out every year and before starting of the monsoon season these factors are well checked and appropriate safety measures also been carried out at indentified vulnerable locations. Further the river falling to lake Chilika are also being treated

periodically for release of flood water during high tides while protecting the existing saline flora and fauna of the lake. Organisation like World Bank, Asian Development Bank, JICA and other infrastructural funding agency are supporting these developmental activities.

Non-structural measures

It has been realized that, there are difficulties to go in for structural measures in the form of major dams, barrages, raising and strengthening of embankments due to various constraint like time, money, as well as resettlement, rehabilitation and environmental factors. Non-structural measures like flood forecasting. Early warning, flood plain zoning and flood risk mapping and others needs to be adopted as tools for a better flood management.

For flood forecasting, a well distributed hydrological information system network is highly essential. So far the department has established 56 standard rain gauge stations under Hydrology Project and 34 non-HP stations. There are 12 Automated Rain Gauges, 44 Gauge Discharge sites, 12 water level recorder and 9 full climate stations also have been established at ten river basins of Odisha. Beside that 20 sedimentations laboratories 11 water quality and sedimentation laboratories are also established on the basins. Due to effective operation of full climate station, these will be established at Subarnarekha, Brahmani, Nagavali and Kolab basin very soon. It is also planned to develop the ARG & SRRG network over all the basins. Presently rainfall and gauging information are being received from IMD, CWC and Revenue Department and satellite imageries being received from NRSC for interpretation analyses.

Flood formulation also taken up with prime support of CWC. For modeling now physical based model like HEC-HMS, MIKE Model and IFAS model are also being exercised for better flood forecasting.

Round the clock (24x7) running flood cell is disseminating the flood information to all the recipient bodies. The Revenue Department, Agriculture Department, Water Resource Department, Health Department and Police Department co-operate each other and run side by side in order to avert the unprecedented flood havoc if arise. The flood information is updated in the site *http://www.dowrorissa.gov.in* every day during a period from 1st June to 31st October.

The Department of Water Resources is now planning to prepare the following works in order to properly model and manage total flood related scenarios.

- Digital terrain models for catchment delineation.
- Digital terrain models of floodplains.
- Catchment land use and soil data (derived from satellite imagery).
- Hydrological rainfall-runoff modeling to produce flood hydrograph at a range of return periods.
- River cross sections for the length of river that creates significant flood, and survey of bridge/culvert opening and other feature that may resist flow.
- Computational hydrologic modeling to produce flood inundation or flood hazard maps at a range of return periods.
- Detailed flood plain land use mapping using satellite imagery (road, embankments, commercial and industrial properties, public utility, (eg. water treatment, electricity sub-station etc) residential properties and properties classifications)
- Survey of levels of roads and typical floor level of properties in the flood plain.
- Flood risk mapping (combination of flood hazard map with land-use).

Institution and Community

- Development of coordination with IMD and CWC.
- Development of coordination for data sharing and dam release information among states in case of interstate basin.
- Developing awareness among community on flood preparedness.
- Awareness with school and college students regarding hydro-meteorological information and flood related activities.

Duties and responsibilities of officers in flood management

Pre-flood maintenance of flood infrastructure and flood preparedness before the onset of monsoon plays a vital role in the smooth management of high flood situations. The adage"A stitch in time saves nine" has to be kept in mind. When the river is in spate, the embankment requires close and constant watch and unremitting day and night supervision by adequate

trained staff and officers. Efficient and constant patrolling with timely warning and timely action alone can avert a situation leading to disaster. During this period inspection by the senior officials will have to be carried out systematically and all the officers concerned and staff will have to remain alert to meet any emergent situation. The establishment required for this purpose will vary depending upon importance of the embankment and behavior of the river. The temporary headquarters of the Junior Engineer, Assistant Engineer and Executive Engineer are to be located near the vulnerable and important reaches of the embankment under this charge.

The duties and responsibilities of the officers for smooth management of the flood are as under.

Junior Engineer

A Junior Engineer is responsible for efficient flood management within his jurisdiction. A high level of alertness and resourcefulness are expected from the Junior Engineer for the above purpose. He should essentially be faithful to the Government and get thoroughly involved in all activities and discharge his duties sincerely.

He is entrusted with the following responsibilities.

Pre-flood measures

- Identification of vulnerable points, weak embankments and other problematic areas.
- Survey, investigation and preparation of estimates for raising and strengthening of embankments to design section, treatment of all piping points noticed during previous floods as per records maintained in the register, all flood protection works, procurement of flood fighting materials required for the embankments in his charge by 20th April.
- He will see that all departmental vehicles, boats, lunches are in working condition. He will also arrange all tools and equipment like torch, hurricane lamps, spades, etc. by 15th May.
- His duty comprises timely and efficient execution and completion of temporary / permanent flood protection works, repair of embankments to design section, breach closing works, treatment of gauge posts by painting, greasing etc. and collection of flood fighting materials at site by 1st week of June.
- The gates of all major, medium and minor dams, drainage sluice and canals are be checked, repaired if necessary by 1st week of June.

- The Junior Engineer has to certify in the log book of gates maintained by his section office that the maintenance and repair have already been done and all the gates are operational.

- Measurement of all the permanent / temporary flood protection works must be recorded before the monsoon flow starts in the river or by 15th June whichever is earlier with due acceptance of the executing agency.

- A Junior Engineer has to carefully record the level and slope of all the front and loop embankments after the year's maintenance raising is completed and keep the record in his custody.

- He is responsible for the proper custody of the monsoon period materials stacked at strategic locations. Accordingly he is to arrange necessary watch & ward for the purpose till their utilization during flood watching.

- He has to display the notice boards containing the nature of vulnerability at all the strategic locations like previous breach points, piping points, scouring points etc. for public awareness.

Measures during flood

- Junior Engineer concerned with his field staff will keep a sharp watch on the embankments during flood.

- He will prepare a duty chart for each embankment under his jurisdiction.

- He is required to see that all leaks, wave-wash action and wetting of embankments are properly attended to and that the entire establishment is doing the work allotted to them.

- He will observe the gauge readings, velocity of river flow by current meter or floats at critical and important points along the embankment and will also note the direction of flow during flood.

- He always remain in touch with the Assistant Engineer during flood watching and apprise him of the situation.

- In case of any emergent situation like piping, overtopping, scour of embankment or any other threat, he has to take appropriate steps to attend to the need in the absence of higher authorities with intimation to the Assistant Engineer.

- The J.E is to keep contact with the local bodies and NGOs for flood management in their respective jurisdictions.

- He has to keep his mobile phone in operative mode during high flood for instant communication.

- He has to record all the piping points in the register for permanent repair before the monsoon of the next year.

- He has to mark the high flood level of the year and keep record of its for reference.

Post-flood measures

- As soon as the flood record, the Junior Engineer concerned has to open the sluice gates for release of drain water.

- He has to assess the damages due to flood immediately through personnel verification, prepare the flood damage report and submit the same to the Assistant Engineer as promptly as possible, not later than one week in any case.

General

The Junior Engineer concerned has to take the levels of river bed at 3 year intervals or if any change is noticed in order to find out any change in river bed or in its course, measure the scour lines of the river bank and incorporate the same in the scour line map maintained at his section and report to his next higher authority.

Assistant Engineer

An Assistant Engineer will remain in charge of the embankments and will be responsible for everything that occurs in his jurisdiction. The duties and responsibilities of the Assistant Engineer in flood management are as follows:

Pre-flood measures

- The Assistant Engineer concerned will inspect the embankments in his jurisdiction to suggest to the Junior Engineer, the nature and type of flood protection or flood fighting works to be taken up before monsoon and check at least 50% levels or measurements taken by the Junior Engineer for preparation of all the flood preparatory estimates. He shall ensure that the above estimates are prepared and submitted to the Executive Engineer by 30th April.

- His responsibility is to see that all the river embankments are repaired to designed section, breaches are closed, gauge posts are painted before 1st week of June.

- He will see that all the ongoing temporary / permanent flood protection works are completed by 1st week of June.

- He will check measure all the ongoing or completed flood protection works positively before arrival of monsoon flow in the river or latest by 15th June.

- He will ensure that the required flood fighting mat3erials are collected and stacked at strategic locations by 15th June and check at least 50% of materials. He will make arrangement for procurement of more materials in case of exigency.

- He will ensure that all the gates are made functional and the drains are cleared of silt and vegetation by 1st week of June.

- The Assistant Engineer will certify in the log book of gates maintained by the Section Officer that the maintenance and repair have already been done all the gates are operational and submit the copy to the Executive Engineer.

- He will check at least 50% of the free board statement prepared by the Junior Engineer and give a certificate that he has satisfied himself with regard to the correctness of the level of the top and of all flood embankments and submit the copy to the Executive Engineer.

Measures during Flood

- The Assistant Engineer concerned will remain in touch with the local bodies, N.G.Os for community participation during flood fighting.

- His establishment during flood watching consists of Junior Engineers, Work Mistries, Work Sarkars, Mates and Khalais.

- He will arrange proper distribution of patrol establishment for due discharge of duties keeping in view to various needs at different points.

- He will remain in contact with his Junior Engineers and keep himself in touch with up-to-date conditions of the embankments and river in his charge.

- During high floods the Assistant Engineer will visit the embankments continuously so that he can keep watch on the patrolling staff and find out the problems for taking immediate measures.

- Apart from engaging of patrols, he will keep one or two teams reserved at convenient place for employment when emergency arises.

- It is the duty of the Assistant Engineer to inform about the situation to the Executive Engineer everyday and to make suggestions for the efficient management of flood.

- The Assistant Engineer will encourage the participation of N.G.Os and local bodies for watch & ward and flood fighting during flood.

- In case of occurrence of any breach or overtopping, the Assistant Engineer will at once inform the Executive Engineer, Superintending Engineer, Chief Engineer and local/district administration for taking immediate precautionary measure for the safety of the lives and property of the local people.

- During the entire flood period, the Assistant Engineer will have to keep his mobile phone in operative mode for direct communication.

Post-Flood Measures

- The Asst. Engineer has to verify and consolidates the flood damage reports submitted by the JEs and submit the same to the Executive Engineer immediately.

General

The Assistant Engineer will check the levels and measurement of river bed and the scour lines of the river bank after the flood situation is over and incorporate the same in the scour line map and report to the Executive Engineer.

Executive Engineer

An Executive Engineer is the officer, fully responsible for smooth flood management of his jurisdiction. The duties and responsibilities of the Executive Engineer during flood are as follows.

Pre-Flood Measures

- The Executive Engineer concerned will inspect all embankments, sluices, gauge stations, flood protection works and cross check the flood fighting materials kept in readiness by

the end of 15th June. He will satisfy himself about the arrangement and report to the Superintending Engineer.

- He will check some of the gates randomly and countersign on the certificate of the log book and submit copies of the same to the S.E. before 1st week of June.

- He will countersign the certificate of free board statement of all embankments with a minimum check of 10% and submit the copy of the Superintending Engineer for record.

- He should be vigilant and keep track of flood situation at all the vulnerable points under his jurisdiction.

- During high floods the Executive Engineer has to make contact with S.E./C.E. & District Administration and inform them about the flood situation at different locations at regular intervals. The interval is to be reduced depending on the seriousness of the situation.

- The Executive Engineer concerned will have to take immediate steps for flood fighting measures, when he suspects that an abnormal condition may occur and intimate the District Administration and Superintending Engineer.

- For anticipated inundation of the low lying area, the Executive Engineer has to inform the local/district administration for immediate evacuation of the people to safe places in advance.

Measures during Floods

- In case of occurrence of any breach or overtopping, the Executive Engineer will immediately inform the district Collector to provide immediate relief and undertake rescue operation for the affected population with intimation to the Superintending Engineer and Chief Engineer. If possible, the Executive Engineer will take steps for temporary closing of the breach.

- He will always be available for ready communication through his mobile phone.

- Post-Flood Measures

- Damage reports will be consolidated and communicated to S.E. and Collector concerned for necessary action.

General

After the flood season, the Executive Engineer will submit a detailed report to the Superintending Engineer about the change of river course, if any, and the village map marked with scour line with his counter signature for record.

Superintending Engineer

The Superintending Engineer concerned is the controlling officer for repair and maintenance of the flood embankments. He will monitor the watch and ward of the entire length of embankments of his circle and will remain responsible for all occurrences.

- He will inspect some of the flood protection works, all vulnerable points, all breach closing works and repair works of embankments at random positively by end of 15th June and will issue instructions to the field staff for any remedial measures and furnish a report to the Chief Engineer mentioning the overall flood preparedness relating to his circle.

- He will keep record of free board statement of all embankments under his control. A graph would be drawn to compare the actual top level and the ground level with the highest flood level of the previous year and the other flood years as the interval of one kilometer.

- He will make additional arrangement for flood watching wherever needed by deputing technical staff from other places within his circle.

- He may place requisition for additional technical staff to the Chief Engineer for smooth flood management if he feels serious shortage of staff.

- He will not leave the head quarters during high flood. In such a situation if he wants to leave the head quarters due to any unavoidable reason, he will take prior permission of the Chief Engineer before leaving the head quarters.

- The Superintending Engineer concerned will be in touch with the Chief Engineer at hourly intervals and apprise him of the latest developments after receiving message from the Executive Engineers.

- After receiving message of any abnormal incident, which has occurred or about to occur from the Executive Engineer, he has to rush to the site and suggest appropriate measures to manage it efficiently with intimation to the Chief Engineer.

- He will always make himself available during the high flood through his mobile phone.

- Immediately after recession of each flood, the Superintending Engineer will submit a detailed report to the Chief Engineer about the extent of damage and the approximate cost of their restoration after consultation with the Executive Engineers concerned.

Chief Engineer / CE & BM

The Chief Engineer & Basin Manager, LMB is the reporting officer in the flood situation for the entire state and is directly responsible to the Government. The field Chief Engineers / CE & BMs are the reporting officers for the area under their jurisdiction.

- The Chief Engineer will make random visit to vulnerable points in order of importance basing on the report of the Superintending Engineers and furnish a brief report on flood preparedness to the D.O.W.R/S.R.C/CE&BM, LMB.

- He may depute some Executive Engineers, Assistant Engineers of Junior Engineers working in the unaffected areas with no flood duty to the divisions having important and dangerous vulnerable points to serve as additional hand during high flood after getting requisition from the Superintending Engineers.

- The Chief Engineer will always be in touch with Government during flood watching and intimate the developments to the Government.

- During flood in any river, the Chief Engineer will be in constant touch with the CWC & IMD and directly monitor the situation.

- He will keep in constant touch with the field officers on flood duty and control the system from the control room.

- He will collect information on the status of reservoirs within the State and those of other States for interstate rivers.

- In case of any abnormal incident which has either occurred or is about to occur, the Chief Engineer will jointly inspect the site with the concerned S.E. and suggest immediate measures to manage it efficiently.

- Immediately after receipt of message about occurrence of any breach or submergence of the embankment, the Chief Engineer will intimate to the D.O.W.R./S.R.C with details of the location, the time of occurrence, nature of damage for starting relief and rescue operation.

- After each flood, the Chief Engineer will submit a detailed report to the Govt. mentioning the cause of the flood, the extent of damage and the approximate cost of their restoration as early as possible.

4.Risk Analysis

An integrated risk analysis looks into both the probabilities and impacts of flooding. Modeling of river floods and/or storm surges forms an important part of the risk analysis. Flood Management Information System cell is functioning in the Water Resources Department, the cell is engaging in the data management, information sharing, research, flood modeling. The risk assessments are:

Assessing flood probabilities

The challenge is to extrapolate from a limited set of observations to determine the probability of an extreme rainfall or discharge event. Various statistical techniques are available to perform such extrapolations. MIKE and HEC software along with GIS provides easy use of all the main distribution functions, expertise to provide advice on sound extrapolations to assess flood probabilities.

Flood modeling of rivers

To translate an extreme event into a hydraulic load (a high water level) at the flood defense requires modeling of the runoff and of the river flow. For major rivers need simulates the hydrodynamics of both the one-dimensional river/channel network and the two-dimensional overland flow. The model is suited to simulate the dynamic behavior of overland flow over an initially dry land. It deals with every kind of geometry, including flat land or hilly terrain.

The 1D channel network and the 2D rectangular grid hydrodynamics are solved simultaneously using the HEC which is able to tackle steep fronts as well as sub critical and supercritical flow.

Storm-surge modeling for hurricanes and cyclones

The IMD is computing surface winds and pressure around the specified location of the moving eye of a cyclone taking into account the path or track of the storm. The information provided by Meteorological Department used for the Strom surge modeling which required trained manpower and investment.

There is always a risk of flooding from rivers or the sea, no matter how high and strong we make our embankments. What happens if a dike does fail? Simulations MIKE/HEC model assist in determining the extent and impacts of possible flood scenarios. The impacts include casualties as well as economic and environmental damage. MIKE/HEC with GIS performs casualty risk assessments using methods that combine the flood characteristics, such as water depth and flow velocity, with evacuation efficiency and vulnerability of inhabitants. A similar approach is adopted for economic damage, making use of damage functions for different types of land use.

5. Response

Field officers of Water Resources Department will remain alert for watch and ward of the embankments constantly at vulnerable locations and patrolling will be done at other places once the danger level is touched. Special attention is required to be given to new embankments and also to old embankments where breaches occurred in the past. The flood contingent materials like sand, empty cement bags, bamboos, bullahs etc. should be kept ready at all strategic locations for meeting eventuality like breach / overtopping of embankments. The details of activities to be under taken for flood watching, before and during floods are listed below.

- Repair of rain cuts are to be made.
- Scoured points are to be covered with sand bags with bullah piling, if necessary, before flood situation arises to avoid further damage. Geotextile or simple polythene sheets may be spread below sandbags if the soil is of less rigidity in order to arrest further scour.

- Round the clock watch and ward arrangement at vulnerable points will be made once

flood water touches the embankment and the water level shows a rising trend. Patrolling for this purpose will continue till water finally recedes from the embankment.

- The rivers are to be carefully watched for scouring and erosion of banks for taking necessary precautionary measures.
- Special vigilance is necessary in the countryside to detect any formation of boils due to seepage. This is to be immediately attended to by providing loading berm to counter balance exit gradient. A suitable filter material may be placed around boiling point below the loading berm to arrest fines in seepage water.
- Seepage under embankment through the sand stratum may be seen emerging on the countryside in the form of bubbling springs. As a protective measure embankment of earth filled sacks may be built around them for ponding the water and thus a head on the countryside is created sufficient to stop the flow of silt by minimizing the effective head of water.
- Overtopping and washing out of a portion of embankment will have to be prevented by providing dowels at the riverside top of the embankment with sand / earth filled bags. The bags are to be filled to half only so that they remain closely against each other.
- In case of emergency, earth may be taken from the back slope of levee much above the hydraulic gradient line with respect to maximum flood level.
- If scouring is noticed, the point of scour would be immediately attended to reduce the rate of scouring during flood. Bamboo grids may be lowered at the scouring point attached with mats and tightened rigidly to remain undisturbed. The place in between bamboo grid and the eroded embankment surface may be filled up with brushwood. This point would be immediately restored before next flood in the same season.
- The Breaches, if occurred, will also be temporarily closed keeping in view possible further flood attack.
- Community participation will be encouraged for flood watching and flood fighting activities/ measures.
- Co-operation of NGOs will be sought.
- The canals running parallel to the river embankments should be charged with full supply during high flood situation in order to counter the river side water pressure on the embankment.

FORMAT FOR FLOOD DAMAGE REPORT

Sl. No.	Period of Occurrence	Name of the River	Name of the District	Name of the Block	Name of the Constituency	Name of the Asset and Location	Length of Breach/ Damage in mtr.	Brief Description of work required for immediate restoration	Amount required (Rs. In lakh)	Remarks
1	2	3	4	5	6	7	8	9	10	11

6.Action Plan

Table: Physical action to be taken by officials

Sl. No.	Designated Officer	Responsibility	Stipulated date
1	**Junior Engineer**		
	Responsible for efficient flood management, alert, resourceful, faithful to Govt, and needs to thoroughly involve in all activities.		
	Pre- flood measure	Identification of vulnerable points	10th April
		Survey, Investigation, Estimates of all raising of embankments	20th April
		Checking working condition of vehicles, boats, launches. Arranging torch light, petromax, lanterns, candles, spades.	15th May
		Completion of execution of all temporary/ Permanent flood protection works, Repair of embankments, breach closing, Treatment of gauging sites, Collection of flood fighting materials at site.	1st week of June
		Repair of gates of all major, medium, minor dams, drainage sluices, canals. JE to certify the log books of all gates as operational.	1st week of June
		Measurement of all flood protection works temporary or permanent with acceptance of executants.	15th June
		Certifying all level books Proper custody of monsoon materials Displaying and maintaining notice boards at strategic locations.	Before monsoon
	During flood	JE and his field staff watch embankment	
		JE to prepare duty chart	
		Check leakage , wave wash, embankment related, keep record of all piping points	
		Apprise to the Asst Engineer about the situation Keep coordination with local bodies.	
		Mobile phone on operative mode	
		Record FRL	
	Post flood	Opening sluices for draining flood water	
		Prepare Flood Damage Report and submit to AE	1 week after flood.
	General duty	River bed level measurement	Every 3 year
		Mark scour line	

2	**Assistant Engineer**		
	In-charge of embankments and responsible for happenings under his jurisdiction.		
	Pre- flood measure	Inspect the embankment and suggest JE about the type of flood protection needed	30th April
		Verify all breaching closed, gauge posts painted Ensure functioning of all gates and certify the log books to next higher authority (EE)	1st week of June
		Check measurement complete of all flood protection works Ensure collection of all flood fighting materials	15th June
		Check measure 50% of all flood embankments	
	During flood	Remain in touch with local bodies, NGOs and other bodies.	
		Arrange and distribute patrol establishments and reserve team for any exigencies.	
		Contact with JE and other staffs.	
		Updating higher officer	
		Mobile phone on alert mode	
	Post flood	Verify FDR and submit to EE	
	General duty	Check levels of river bed, scour line, top bank	
3	**Executive Engineer**		
	Fully responsible for smooth management of flood		
	Pre- flood measure	Inspect embankments, breaches, all flood protection works , gauges and report to SE.1	15th June
		Randomly checking gates and signing log book	1st week of June
		Countersign all free board statements of embankments (check measure 10%) and report to SE	
		Remain vigilant and report to next higher authority.	
		Capable of taking immediate steps	
		For anticipating inundated area inform to local or district administration	
	During flood	In case of breaching inform district administration for relief Can take step for breach clsing im mediately.	
		In relation with all top and bottom officers and mobile on active mode.	
	Post flood	FDR to be sent to SE and Collector	
	General duty	Submit a detailed report after flood to SE	

4	**Superintending Engineer**		
	Controlling officer for repair and maintenance of flood embankments.		
	Pre- flood measure	Inspect embankments and vulnerable points Instructing to field and reporting to CE	15th June
		Keep record of free board statement Keep additional arrangement of flood watching May arrange additional technical staff..	
	During flood	Not to leave HQ without permission of CE.	
		Inform CE hourly latest updates after receiving the same from EE,	
		Available on mobile phone	
	Post flood	Submit a detailed flood report to CE.	
5	**Chief Engineer**		
	Reporting officer on flood situation, responsible to state.		
	Pre- flood measure	Inspect random vulnerable points and report to DOWR/SRC/CEBM,LMB. May depute Engineers of other to flooding areas.	
	During flood	Updating flood situation to Govt. Constant touch with CWC, IMD., field officer, control room Collect information on status of reservoir and that of other states, For any abnormal happenings joint verification with SE and suggest for immediate measure. Immediately informing breach details DOWR/ SRC during a breach.	
	Post flood	Submit a detailed flood report to Govt. mentioning cause, damage, breaching .	

Table: Long term actions and responsibility

Sl. No	Infrastructure	Risk Expected	Proposed Strategic Outlay	Responsibility
1	Dam	• Dam Break; • Excess Inflow; • Reduction in Storage Space.	• Mathematical dam break model will be prepared; • Corresponding risk map for dam break along with evacuation route and Safe shelter location will be finalized; • Pre-depletion of the reservoir in conformity to rule curve and downstream conditions; • Dredging of the reservoir, silt clearance through excluder; • Raising dam and embankment heights; • Catchment treatment.	EIC Water Resources in co-ordination with CWC
2	Embankment	• Over Topping; • Seepage; • Breach & Cutting; • Erosion.	• Dredging the river bed; • Raising embankment heights; • Consolidation of the embankment; • Identification of weaker location and necessary measure (slope protection, toe wall, spur, stone pitching and vegetative coverage; • Awareness among people for protection of embankment.	EIC Water Resources along with Concern division along with Local community
3	Canal	• Breach & Cutting; • Blockage of canal passage.	• Awareness among farmers and Water User Association for the protection and maintenance of Canal.	EIC Water Resources along with Water User Association.

Points for open discussions

1) **Embankment free flood plain**:

From the period prior to construction of dams/reservoirs when uncontrolled flow was available at delta, there was no embankment to confine the flood within a channel. Again it is seen due to continuous siltation river beds are getting up day by day (aggradations of bed levels) and the country sides remains at comparatively down level. At this condition any occurrence of breaches may cause a huge loss in the country side. So in order to maintain the regime condition (balanced channel bed and flood plain) the embankments should be made open at strategic locations allowing unobstructed free flow thereby reducing the flood furry.

Encroachment in the flood plain has become a regular phenomenon over the year. It needs to implement the law to make the flood plain free for safe disposal of flood water.

2) **De-commissioning of older dams:**

The management of flood in the major flood causing basins like Mahanadi and Brahmani still relies on the dams of over **56years (Hirakud)** and **38 years (Rengali)**. After a decade or so, debate may come towards the decommissioning of such dams. The next alternative may to go in for such storage projects or to live with flood.

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Drawings and Tables:

D1. River Basins of Odisha
D2. Rainfall Tracks
D3. Inundation'2011

T1. Salient Features of Major and Medium Dams
T2. Salient Features of Major and Medium Dams (Contd...)
T3. Minor Dams