BEFORE THE NATIONAL GREEN TRIBUNAL
EASTERN ZONE BENCH, KOLKATA
O.A. No. 68 of 2020 (EZ)

IN THE MATTER OF:
Pradip Kumar Pattnaik

.....Applicant(s)

Vs.

Union of India & Ors.

.....Respondent(s)

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Place: Kolkata
Date- 01/09/2022

(Mrinal Kanti Biswas)
Scientist E & Regional Director
CPCB, RD, Kolkata

Filed through Counsel

Annexure-A

REPORT OF THE JOINT COMMITTEE

CONSTITUTED BY

HON'BLE NATIONAL GREEN TRIBUNAL

(ORDER DATED 07.02.2022)

IN THE MATTER OF

PRADIP KUMAR PATTNAIK VS UNION OF INDIA & ORS.

[O.A. NO. 68/2020(EZ)]

CENTRAL POLLUTION CONTROL BOARD

August 2022

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Report of the Joint Committee constituted as per **the Hon'ble** NGT order dated 07.02.2022 in the matter of Pradip Kumar Pattnaik vrs. Union of India & Ors. in OA No. 68/2020(EZ)

1.0 Background

1.1 **Hon'ble NGT Order dated 07.02.2022**:

Hon'ble National Green Tribunal in order dated 07.02.2022 in the matter of Pradip Kumar Pattnaik vrs. Union of India and others in OA No. 68/2020 EZ directed constitution of a Joint Committee of seven Experts, with five members of earlier Committee namely, Mr. M. K. Biswas, Dr. A. K. Lohani, Shri Amrish Pal Singh, Shri M.R Prasad and Dr Sohan Giri and additionally two more members, Prof. C.R. Babu from Delhi and Prof P. C. Mishra from Bhubaneswar to undertake a study so as to include ecological and hydrological aspects and vulnerability components to the existing report of the earlier five member committee and to make detailed recommendation within three months identifying the steps required for protecting the flood plain zone and the environment.

Relevant portions of the Hon'ble NGT order are reproduced below;

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7. We have heard learned Counsels for the parties. Learned Counsel for the applicant submitted that while the report considers engineering aspects in light of guidelines issued by National Disaster Management Authority, it does not consider ecological and hydrological aspects in terms of order of this Tribunal dated 15.12.2020 in O.A. No. 22/2020(EZ), Dilip Kumar Samantaray (Supra). Such consideration is essential for protection of flood plain zone and associated issues relating to the ecology, environment and biodiversity. Ecological vulnerability and combined hazard vulnerability are required to be studied in light of observation of this Tribunal in order dated 15.12.2020 and safeguards need to be identified for protection of the flood plains. It requires constitution of joint Committee comprising Experts in the field of Hydrology, remote sensing and Ecology.

8. We do not see any reason not to accept the suggestion for such further study to consider appropriate directions in the interest of environment. Accordingly, we

direct a joint Committee of seven Experts, with five members in the earlier Committee and two other Experts viz. Prof. C.R. Babu, eminent ecologist and environmentalist and Prof. P.C. Mishra, former Expert Member of NGT to undertake the study in light of above observations so as to include ecological and hydrological aspects and vulnerability, adding these components in the report and to make detailed recommendations identifying the steps required for protecting the flood plain zone and the environment within three months. It will be open to the applicant as well as State of Odisha to place their respective view point before the Committee. CPCB will be the nodal agency to carry out the entire exercise. Report may be filed before the Tribunal on or before 30.04.2022 by e-mail at judicial-ngt@gov.in preferably in the form 10 of searchable PDF/ OCR Support PDF and not in the form of Image PDF on or before 30.04.2022. Report may also be placed on the website of CPCB for response by any stakeholder before the next date of hearing.

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In the matter of OA 22 of 2020 the NGT Judgment at para 16 reads as under,

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Accordingly, we constitute a joint Committee comprising representative of Central water Commission (CWC), nominee of MoEF&CC, CPCB, National Institute of Hydrology, Roorkee and the State PCB to consider the issue and lay down norms so as to ensure that the proposal of the state for construction of the medical college and river front development takes place in accordance with law, without damage to the flood plains of the river. Flood plain zones need to be identified and demarcated in the light of such norms. The Committee may identify the extent of flood plain zone/active flood plain zone from the edge of the river.

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1.2 First Meeting of the Joint Committee:

CPCB, Regional Directorate, Kolkata being the nodal agency of the committee, convened the first meeting of the seven member joint committee on 31.3.2022 at 3.30 pm through video conferencing. The minutes of the meeting is provided in Annexure 1 and the decisions made in the meeting are reproduced below.

"Based on the deliberations made, the following were decided;

i. A fundamental study based on analyzing and scrutinizing the basic nature and conditions of the concerned flood plain is to be executed.

ii. A preliminary site visit to the concerned area is to be undertaken at the earliest.

iii. Considering the health issues of Prof. C.R. Babu, Professor Emeritus & Former Pro-Vice-Chancellor, University of Delhi and the limited time available to conduct the study and submit the report, the committee agreed to the proposal that Dr. M. Shah Hussain, Scientist (Ecologist), Biodiversity Park Programme, CEMDE, University of Delhi, a representative of Prof Babu to visit the site along with Prof. P. C. Mishra, Former Expert Member, NGT; Dr.Sohan Giri, Regional Officer, SPCB, Odisha & Prof. K. C. Patra, Professor, Civil Engg. Dept., NIT Rourkela. After recovery of Prof. Babu, another field visit by all the committee members may be conducted.

iv. Following the preliminary visit, an extension of 3 months after 30.04.2022 for submission of the Joint Committee report will be requested before NGT.

5. Accommodation and logistics of the visit may be arranged by OSPCB and may be coordinated by Dr.Sohan Giri, Regional Officer, OSPCB.

6. Travel and other expenses of Dr. Shah Hussain may also be reimbursed as a member of the committee under NGT(EC) funds of CPCB as per the prevailing orders."

1.3 Preliminary field visit:

As per the decision made in the first meeting, field visit of Prof P. C. Mishra, Prof K. C. Patra, Dr Shah Hussain and Dr. Sohan Giri was conducted on 17.4.2022.

Before the field visit, following documents were consulted by the members.

i. The Judgment of the Hon'ble Odisha High Court, Cuttack in W.P (C) NO. 20283 of 2011 in the matter of The Nationalist Lawyers Forum Vrs State of Odisha and Ors.
ii. Judgment of Hon'ble NGT EZ in original application No.47/2016/EZ in the matter of Biswajit Mohanty Vrs State of Odisha and Ors.

iii. Report on Flood Plain Zoning Study for identified stretches of Mahanadi river basin prepared by Prof K. C. Patra, NIT Rourkela and accepted by the five members committee, and

iv. Report of the five member Joint Committee constituted by Hon'ble NGT dated 15.12.2020 in the matter of OA No. 22/2020 (EZ).

v. CDA Concept Note on Mahanadi Water Front Development.

The team of four members visited the site, commencing from the sand filling area of extended Balijatra ground up to the view point through the IOCL intake well before the Jobra barrage where the river water has touched the concrete bank separating the river bed from ring road, to get first-hand knowledge on extent of sand filling /deposits, hydrological and biodiversity features of the existing site and vulnerability of the specific areas from extended Balijatra ground to View point.

After completing the field visit, the members met and discussed the outcome of the visit based on the following records available.

i. Order of the Honourable Odisha High Court Cuttack in WP(C) No.20283 of 2011

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"*Keeping in view the aforesaid fact and after going through the report of the Technical Expert Committee, we accept the Report and direct the followings:*

(1) We direct the State Government as well as the IOCL to strictly adhere to the suggestion made by the Technical Expert Committee in Point No.5 of their report, as quoted above.

(2) As it is stated that the IOCL has already applied for permission before the CDA for the construction made, they shall be permitted for the construction, which has been indicated in the suggestions given by the Technical Committee in Point No.5, which should have been approved by the chief Engineer & Basin Manager, Lower Mahanadi Division.

(3) With regard to removal of Shoal, as stated by the Secretary Water Resources Department as well as the Engineer-in-Chief, the bathometric survey is to be done

through IIT Chennai, as the State Government had already taken the expertise of IIT Chennai in some other projects. Cost of which shall be borne by the IOCL.

(4) So far as removal of old Anicut is concerned, it shall be done at the cost of the IOCL under the supervision and technical guidance of the Water Resource Department.

Since, it is stated that previously a part of the Anicut was removed by the Orissa Construction Corporation (OCC) and eventually the present Secretary, Water Resource Department is the Chairman of the said Corporation and the Corporation had got the men and machinery and expertise for the aforesaid work, let the IOCL keep in touch with the Chairman, OCC and if the Government desires, it can be done through OCC, but at the cost of the IOCL.

(5) So far as dredging is concerned, it is also stated that the dredging can also be done by the OCC with the help and expertise of Water Resources Department at the cost of IOCL and modalities of the same shall be decided by the officials of the Water Resources Department and IOCL and the Executing Agency. Hence such dredging shall be done as suggested above, at the cost of the IOCL.

(6) Regarding the strengthening of the existing City Protective embankment, since it is stated in the affidavit of the Chief Engineer that usable earth from the dredging activities will have to be utilized for strengthening of the existing City Protective embankment and the unusable earth will be utilized for filling up the low lying areas nearby, let the Revenue Department and Department of Water Resources demarcate the land and areas where the unusable earths can be dumped of if any portion of the same shall be used for widening of the embankment (Ring) Road.

(7) It is directed that, during lean period there shall be no water supply to IOCL and the IOCL will have its own reservoir near the plant area fur utilization of water during those period.

(8) So far as, Survey, dredging and removal of old Anicut are concerned, the work should be taken up at the earliest and it should be completed before the actual drawal of water from the reservoir is made by the IOCL. So, the Water Resources

Department shall give proposals to the IOCL, who shall place funds with the respective executing agency as per the decision taken between the Water Resources Department and the IOCL. It shall be done within a period of two months from today.

In order to expedite the matter, we form a committee comprising Shri Suresh Ch. Mohapatra, Secretary, Water Resources Department, Revenue Divisional Commissioner (CD), Cuttack, Collector, Cuttack, Er. Baidhar Panda, Chief Engineer & Basin Manager, Lower Mahanadi Basin, Bhubaneswar and one of the citizens of the Cuttack City, namely Akshaya Kumar Das, President Jala Surakhya Janamanch. Er. Baidhar Panda will be the Nodal Officer of the Committee Now with regard to the Corporate Social Responsibility of the IOCL, which it has to discharge so far as Cuttack City is concerned, we have already indicated this fact in our order dated 29.9.2011 and also discussed in the hearing of the case. Adding to this, it may be indicated that Cuttack is a very old city, which includes its narrow lanes and bye-lanes. The health system is at its primitive stage. The traffic signal system is not up to the mark.

One of the major difficulties the city people are facing is due to lack of well equipped ambulances.

In view of such, we direct the IOCL to provide a Water Treatment Plant for drinking water to be utilized for Public Health Department, Cuttack for the purpose of supplying drinking water in Cuttack City. The plan and estimate is to be made by the P.H.D. and the land for the said plant is be identified and provided by the Collector and permission be granted for establishment of said plant. After the said plant is commissioned, the same be handed over to PHD With regard to Health Care, we direct the IOCL to provide Rs.10.00 crores to Sardar Vallabbhai Patel P.G. Institute of Paediatrics (Shishu Bhawan) to be used for its developmental works including drinking water facility, sanitation, modernization of wards and a modernized outdoor for providing treatment to the emergency patents.

Apart from that, Rs.3.00 crores be provided to the Commissioner of Police, Cuttack-Bhubaneswar towards the improvement and management of traffic system and traffic signal lights at various junctions in the city of Cuttack.

The IOCL shall also provide five hi-tech Ambulances to the Committee so formed above, which shall provide the same to different Government Hospitals or Philanthropic Organizations of their own choice. The running and recurring cost for three years shall be assessed by the Committee, which shall be deposited by the IOCL with the Committee, thereafter the Government/ Philanthropic Organization shall bear the same."

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ii. **Judgment of Hon'ble NGT in O.A.** No. 47/2016/EZ in the matter of Biswajit Mohanty Vrs State of Odisha and Ors.

The Hon'ble NGT issued the following directions for timely compliance by the respective Government respondents;

1. *"The District Administration of Cuttack shall ensure that no construction debris/waste, municipal wastes etc. are illegally dumped on the river beds. In case of violation of this direction the local authority shall impose appropriate penalty to be decided by them, confiscate the vehicles and machinery and initiate criminal proceedings against the violators.*

2. All illegal encroachments of the river banks/ beds of Mahanadi and Kathjodi at Cuttack shall be evicted by the District Administration and all illegal constructions on the river bank/bed shall be removed following the provisions of law and an action taken report shall be filed by the respondent no.3 every six months in the Registry.

3. We allow the Balijatra festival to be held in the Balijatra field (Kila Maidan) between Barabati Stadium & Gadagadia temple as well as in the silted-up alluvium space on north side of river embankment (extended Balijatra field), the areas where the festival was held during 2016 on the following conditions:

(i) The distance of the river flow from the boarder of the extended site shall be a minimum of 50 m. (ii) The festival site shall be declared as Plastic Free Zone by the authorities.

(iii)The solid waste generated during the festival shall be regularly collected on daily basis by the municipal corporation for appropriate disposal. Throwing of such wastes on river bed and burning of such wastes shall be strictly prohibited.

(iv)Appropriate arrangement shall be made for proper drainage of waste water from festival site to the nearest municipal drain.

(v) The public and vendors shall be informed through announcement and distribution of leaflets about their role for making the area clean and pollution free. The organizer shall prepare a guideline for an eco-friendly Balijatra festival.

(vi)The Balijatra site shall be completely restored by 9th day of the commencement of the festival.

(vii) A compliance report shall be filed by the District Collector in the Registry of the NGT within a month of completion of Balijatra every year."

Thus, Balijatra festival has been allowed to be held in the original Balijatra field as well as in the silted up alluvium space on north side of the river embankment (extended Balijatra Field). It was observed during the field visit that all illegal encroachments have been removed from the area.

iii. Report on Flood Plain Zoning Study by Prof K. C. Patra and Team as accepted by the five members Committee

The study on Flood Plain Zoning (Annexure 2) was undertaken for the stretch from Mundali Barrage to Jobra barrage using the statistical parameters from the CWC as well as WRD, Odisha data. The study found that during passage of flood of Q25 and Q100, the difference in flood depths over the study area is not significant. This may be the due to the river at this stretch is quite wide and it is in a position to pass the flood of various return periods without appreciable change in the flood plain submergence geometry.

The depth of water over the Balijatra Ground during propagation of Q25 Flood just exceeds its average formation level of 24.5 meter, but below the RL of ring road which is 25.6 m. Therefore, it is recommended for suitable planning of any development activities keeping in mind the possible submergence of the rehabilitated area.

iv. Vision Document of Cuttack Municipal Corporation

As claimed by CMC, the vision document on Mahanadi Waterfront Development (Annexure 3) suggesting development on 426 acres of reclaimed land in the northern side of the river is guided by a 3 E Principles, Environment, Economy and Equity. However, the five member committee have recommended prohibition of construction of structure of permanent nature and only non-permanent structure may be allowed following the NDMA guidelines.

1.4 Second Joint Committee meeting:

The second meeting of the seven-member joint committee was convened on 27.05.2022 through video conferencing the decisions of which are reproduced below.

"Based on the deliberation made, the following were decided;

1. CPCB would request the concerned state department to provide the following information;

a. Salient Features of the Jobra Barrage

b. Designed pondage area of the reservoir and area submerged as a result of construction of barrage in the concerned site.

c. Relevant maps and documents to justify the purpose or need of construction of the Jobra barrage.

d. Drone pictures of the barrage and its reservoir along with the 426 acres filled
structure

e. Relevant information justifying the dredging and removal of the sand from the storage area

2. A field visit of the Joint Committee Members to the concerned area is to be undertaken during July, 2022 following the acquisition of the required documents and information from the State Govt.

3. The Applicant and concerned state department as well as respondents in the matter will be informed about the field visit and a meeting may be convened at Cuttack to hear the viewpoints/ representation by the Committee during the field visit.

4. As kindly agreed by Prof. Patra, a draft point wise reply would be prepared and shared with members before the meeting at Cuttack.

5. OSPCB may be requested to coordinate with the state departments to arrange to provide the requisite information/documents at the earliest and also to organize the meeting with concerned agencies and applicants during the field visit of the committee.

6. OSPCB may also be requested to arrange the logistic for the members and for Prof. Patra."

The Minutes of the second meeting of the Joint Committee is provided at Annexure 4.

2.0 Field Visit of the Joint committee to the concerned area

During the second Joint Committee meeting, the Extended Technical Committee of 7 members decided to make another site visit with the presence of all the members and also to listen to the submission of the Applicants as well as the opposite Govt. parties of the State Government in terms of the order of Hon'ble National Green Tribunal. Accordingly, the Regional Director, Central Pollution Control Board, Kolkata, Mr. M. K. Biswas facilitated the site visit with the help of State Pollution Control Board, Bhubaneshwar on 12th and 13th July 2022.

2.1 Meeting on 12th July 2022:

On 12th July 2022, the Committee met the Applicants with their Counsel and Govt. officials in the conference room of the State Pollution Control Board, Odisha at 12.00 noon where the parties made the following oral as well as written submissions to communicate their view points on the afore-stated issues.

List of the participants:

Sl. No.	Name	Designation
1	Prof. (Dr) P. C. Mishra	Member, Technical Committee
2.	Prof. (Dr) C. R. Babu	Member, Technical Committee
3.	Dr. A. K. Lohani	Scientist 'G', NIH, Roorkee
	Dr. Amrish Pal Singh	Supt. Engg(C), UGBO, CWC, Lucknow
4	Dr. T. H. Mahato	Scientist D, MOEF&CC, Bhubaneswar
5.	Dr. Sohan Giri	RO, SPCB, Bhubaneswar
	Shri Mrinal Kanti Biswas	Regional Director, CPCB, Kolkata
6	Prof. (Dr) K. C. Patra	Professor, Civil Engg. Dept., NIT Rourkela
8.	Dr. K. Murugusen	Member Secretary, SPCB, Bhubaneswar
10	Shri Bhakta Ranjan Mohanty	Chief Engineer and Basin Manager, Mahanadi Kathajodi Basin, WRD, Govt. of Odisha
11	Shri Purna Chandra Rath	Addl Chief Engineer, Eastern Circle, Cuttack, WRD, Govt. of Odisha
12	Shri Pradip Kumar Pattnaik	Petitioner
13	Dr. Biswajit Mohanty	Petitioner
14	Shri Sisir Das	Advocate, Odisha High Court
15	Shri Shankar Prasad Pani	Advocate
16	Shri Nirod Chandra Panda	Advocate, Odisha High Court

2.1.1 Submission by applicant and their counsel:

i. Submissions by Adv Sisir Das, Counsel of Shri *Pradip Kumar Pattnaik in OA No.68/2020/EZ*
ii. Submissions by Advocate Shankar Kumar Pani, Counsel of *Dilip Kumar Samantaray in OA No.22/2020(EZ)*
iii. Submissions by Dr Biswajit Mohanty, applicant in *OA No.47/2016(EZ) (disposed) and MA No.8/2020*

Salient features of their submission are as follows;

i. While undertaking dredging work, instead of removing the sands and shoals excavated from the pondage area to other places, the state Govt. authorities

deposited the excavated materials within the pond area encroaching 5 km long and 1.5 km width i.e from Jobra barrage to Gadagadia Ghat creating a dump area of about 426 acres of land resulting in substantial reduction in water retaining area of Jobra Barrage.

ii. The order of the Honourable Orissa High Court has been defied and defaced and the purpose of enhancing the water retaining capacity of Jobra barrage has been sabotaged. This has resulted in providing no/less water to some 50 lakhs farmers of nearby districts for irrigation during lean season.

iii. Dumping of sands and shoals in the river bed has damaged the riverine ecosystem and reduced the ground water level in Cuttack town and it is likely that the embankment of Mahanadi river may break at the upper level any time during heavy flood thereby putting Cuttack town in danger.

iv. The encroachment into river Mahanadi is still continuing with dumping of debris and solid wastes thereby elevating the river bed from its original level and using it for vehicle parking area, Parks, Temples, OTDC River Cruise Project.

v. The extended Balijatra ground is the illegally reclaimed land in river bed where the height of the bed has been raised substantially by dumping of debris, building wastes and silt excavated from Barabati moat.

vi. The Topo Sheet No. F45 T 15 of Survey of India clearly depicts the area as river bed within the embankment. A small stream shown in the topo sheet adjoining the ring road has now been forcibly closed by dumping such wastes.

vii. The Classification of extended Balijatra Grounds as "Recreational Use Zone" in 2012 was with an intent to use it round the year by the Housing and Urban Development Department under ODA Act,1982.

viii. Due to river training work with construction of two spurs, the flow path of the river has been progressively diverted away from the right flood embankment towards central portion.

ix. Such tampering of flow channel will have enormous and permanent impact on the ecology and flooding patterns

x. The reclaimed land of 426 acres has been inside the right bank of river Mahanadi which has historically served as a buffer to absorb the flood water should be treated as Riverbed for which the reclaim area is to be restored to its original status by removing the shoals and sand deposited by the authority.

xi. While referring to some research papers published in standard journals, Mr Biswajit Mohanty emphasized the necessity of protecting a threatened riverine bird population, *Rynchop salbicollis* Swainson, the Indian Skimmer which has a status of "Vulnerable" in the IUCN Red List of Threatened species, has been reported first in 2009 around Mundali site towards Jobra barrage. Rise and fall of water level of rivers has direct impact on nesting success of the birds and fall in their population.

2.1.2 Submission by Officials from Govt. of Odisha

i. The officers of the State Government apprised the members about the objection filed by the Respondent No.6, the State Government, to the report prepared by the joint Committee on flood plain zoning Study and the respective part of the affidavit filed by the Central Pollution Control Board on 4th October 2021.
ii. They handed over a copy of the objection filed before the Honourable NGT and also made oral submission on the points mentioned in the affidavit (Annexure 5) with a request to consider it as their submission before the Committee.

After detailed deliberation on the representation submitted by the Odisha State Government on the flood plain zoning study, the seven member joint committee also accepted the recommendation of the five membered joint committee report. However, going through the findings of the State Technical Committee report vis-à-vis the recommendation of the joint committee some suggestions are made for consideration which is provided in Annexure 6.

2.2 Site visit on 13th July 2022

The members of the Committee made the site visit on 13th July 2022 from 9.0 am starting from the point near Dear Park in the ring road, the right embankment of the river through Gadagadia Ghat (the extended Balijatra ground), IOCL intake well area, the view point in front of Maritime Museum and also went to the left bank side crossing the Jobra barage where Birupa river originates as a distributaries of river Mahanadi. The District Administration, Applicants with their Counsel were also present. After a thorough survey, the team also visited the Mundali barrage alongside the river and got the first-hand knowledge on the flood plain status in the upstream of Jobra Barrage as well as downstream of Mundali

barrage. After completing the site visit, members met and discussed the features to be reflected in the report and thus a guideline was discussed.

3.0 Flood plain zoning study including aspects of Ecological, hydrological and vulnerability checks

The five member joint committee carried out the Flood Plain Zoning Study for identified stretches of Mahanadi River through NIT Rourkela. The present committee accepts the findings of the study and carried out further study to include Ecological, hydrological aspects and vulnerability of flood plain of the identified stretches.

3.1 Brief about Mahanadi River and Jobra Barrage

River Mahanadi, a perennial river with high inflows during monsoon period, originates from Dhamtari district hills in Chhattisgarh. It drains about 1410000 sq. km. over a distance of 851 km before it joins Bay of Bengal. It forms extensive floodplains in coastal districts of Odisha and branches extensively (multiple channels) leading to formation of islands known as shoals locally. It forms delta head at Cuttack before its outfall into Bay of Bengal. In fact, the Cuttack city itself is an island between Mahandi and its one of the major channels called Kathajodi river (distributary) and there is another channel (distributary) before Jobra barrage on the left bank. In order to ensure protection for the city from the floods of main channel of Mahandi and its branch, a ring road (bund road) was constructed encircling Cuttack. In other words, the city of Cuttack is confined between two rivers.

An anicut (check dam/ weir of stones) was constructed by the then British Government (sometime in 1864) over main channel of Mahanadi River at Jobra, Cuttack to retain water for feeding irrigation canals. The Odisha Government constructed a Barrage just 60 m downstream of anicut during 1985-92 to retain more water not only for irrigation but also to meet the needs of industries like Indian Oil Corporation Limited (IOCL) and also for domestic use in the city. The barrage is known as Jobra or Mahanadi barrage.

As per the data provided by the Department of Water Resource, Government of Odisha (Annexure 7), the features of Jobra barrage located in Cuttack (120°28′30″ N, 85°54′0″ E) are as follows:

I. The pond level is 21.20 m; waterway has 95 bays of 18 m (79 bays of spillway + 8 bays of under sluices right + 8 bays under sluice left); the crest level under sluices is RL (reduced level with respect to MSL) 16.00 m and spillways is RL 18.50 m; the cistern level both under sluices and spillway is RL 13.50 m; the cistern length under sluices is RL 28:30 m and spillway is RL 22.10 m; the left head regulator: 107 cumecs and right head regulator is 94 cumecs; the catchment at Naraj is 1,32,085 sq. km. and maximum flood discharge at Naraj is 42,475 cumecs and the design discharge is 15300 m^3/sec and High Flood Level (HFL) (including afflux of 0.3 m) is RL 23.05 m +0.3 m (Figure 1).

II. It has two canals just close to barrage - one is on the right and other is on the left banks of the river. For Taladanda Canal – the Full Supply Level (FSL) in the canal is 20.80 m and for Kendrapara Canal – the FSL is 20.75m.

Figure 1: Jobra barrage with its pondage showing stagnant water with marshy vegetation on the shoreline and islands

The site visit to the Jobra barrage was made essentially to find out whether the disputed landscape of 426 acres (including the extended 34 acres of Baliyatra ground) is located in the submerged portion of the river due to Jobra barrage (pondage of the barrage) or located on the floodplain of the river at the end of

upper pondage, and the possible ecological and hydrological implications and vulnerability of the 426 acre landscape under dispute.

The Committee members, in presence of Government Officials (concerned Department), the applicants and their Advocates and the city District Magistrate, criss-crossed the area lengthwise and breadthwise, and critically evaluated the morphological and ecological features of the landscape and riverscape at the site.

3.2 Observations:

The following are major observations made by the Committee:

I. The river takes very deep meandering just in the upstream of barrage on the northern side (right bank) and vast open area on the southern side (left bank) and vegetated island in the middle of the riverscape opposite to barrage in the upstream (about 4 to 5 km upstream) (Figure 2).

Figure 2: Upper end of barrage showing stagnant water, submerged vegetation, marshy vegetation, a vegetated large island located in centre of the pondage of barrage and vegetated floodplain on the left side of pondage.

II. From the right side of the barrage as well as from the left side close to barrage two irrigation canals take their origin; on the left side there is a channel (distributary) which almost looks like river originating from pondage; the main channel has vast elevated vegetated floodplain which is being encroached on the left side (a religious structure was constructed); a ring road (bund road encircles the city of Cuttack along the river Mahanadi and its channel (Kathjodi) branched in the upstream of barrage; the ring

road almost takes the contour of meandering of river (Figure 3) at the pondage which is about 5 km long.

Photo Source: Report of Water Resource Department, Govt. of Odisha

Figure 3: River showing meandering in the Pondage area along the ring road and the bay of the pondage of barrage is filled with dump and water bearing pondage area at both ends of the dump indicating that the dump is located in the pondage area.

III. The bay formed by meandering of the river is perhaps submerged portion of pondage as evident by the following facts: (i) the water in the pondage is stagnant; (ii) rooted submerged vascular plants are found growing in abundance (Figure 4); (iii) the stagnant water is observed at both ends of the disputed structure of 426 acre, i.e. one end is at the view point and the other end is tip of extended Baliyatra ground in the upper end of pondage (Figures 3). The bay created by meandering of river serve as pondage to retain more water and also allowed free floodway.

IV. Before anicut/ barrage constructed, it was a floodplain submerged under water during flood. This is evident by time series of Google Earth Maps taken starting from 2007 to 2022 (Figures 5).

Figure 4: Stagnant water of the pondage area showing rooted submerged aquatic plants.

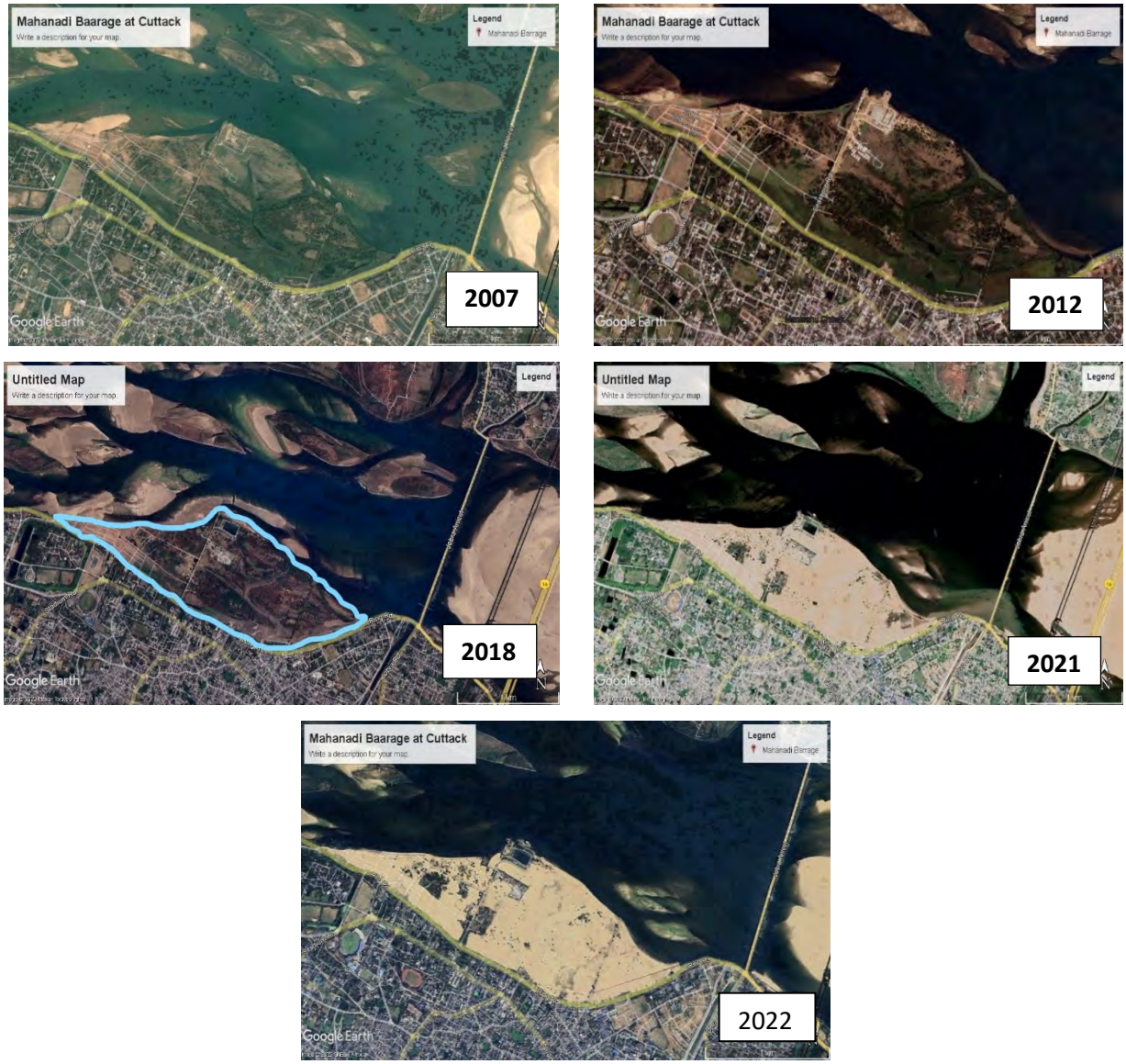

Figure 5: Google earth maps taken at different years (2007-2022) showing evolution of manmade dump in the pondage area of the barrage.

V. Continuous pumping coupled with sedimentation due to spurs led to enhanced deposition of sediment within the pond area; solid waste was and is being dumped.

Figure 6: Freshly dumped sand on the 426 acres dump to increase its height

VI. The sand dredged from small islands was also dumped (Figure 6). Further, to prevent erosion of the dumped material two levels of Iron sheets of 20 mm thick and 25 feet high were piled (Figure 7).

VII. The consequences of all these developments are a) the evolutions of a dump of 426 acres in the pondage of Jobra barrage. There is a low-lying area between two 5 to 6 m high sand dumps (Figure 8);

Figure 7: Dump (near Baliyatra ground) showing two levels of iron sheet piles - one pile at the higher level and other pile at lower level almost touching the shorelines.

Figure 8: Low-lying silted storm drain between two elevated dumps of sand.

b) compacting the ground with gravel on the Baliyatra area was done which prevents infiltration of rain water and flood water and a gate was created (Figure 9);

Figure 9: Bali yatra area of the dump showing the gate and compacted ground with gravel.

c) Presence of unauthorized occupation (encroachment) of the area is still found (Figure 10); and

Figure 10: Encroachment on the dump closed to the shoreline

d) A number of old trees, the trunks, of which were buried within the sand dumped was observed (Figure 11).

Figure 11: Dump showing the trees with their trunks almost buried under the dumped material

Some of the old trees found at the site are exotics and fast growing and include *Pithecellobium dulce* (Jungle Jalebi), *Cassia siamea* (Kassod tree) and one or two trees of *Anogeissus sericea* (Round leaf Axlewood), *Eucalyptus* (Southern blue gum), *Delonix regia* (Gulmohar), and *Alstonia scholaris* (Devil's tree) (Figure 12).

Figure 12: Fast growing exotic trees like Cassia siameaplanted on the dump

There are low lying marshy areas adjacent to the dump (close to shoreline) and these areas are colonized by alien weedy species such as *Croton bonplandianum* (Ban Tulsi), *Solanum* sp. (Wild eggplant), *Cassia occidentalis* (Septic weed),

C. tora (Sickle senna), *Datura innoxia* (Thorn apple), *Polygonum sp.* (Knotweed), *Cyanodon (Bermunda grass)* etc. (Figure 13).

Figure 13: Weedy community growing on the marshy area near the shoreline of the pondage area

At one side of the Viewpoint towards barrage there is a patch of Lotus plants. A number of private cars were also parked opposite to hospital. A dump was observed near the Pumping Station of IOCL in the pondage and the shoreline was planted with *Ipomea fistulosa* (Bush morning glory). All these facts indicate that dump is of anthropogenic origin and not natural.

Near the view point, there are a couple of Islands with grasses and these are submerged except the tops which are visible (Figure 14). These natural islands were supposed to have been dredged and used it for elevating the 426 acre area further. Figure 15 shows Water pipeline of IOCL standing on the dump as the supporting piles (short columns) are buried under sand.

Figure 14: Pondage area showing two small islands almost submerged in the water

Figure 15: Water pipeline of IOCL standing on the dump as the supporting piles are buried under sand.

It has been brought to the notice of the Committee that a vulnerable Indian Skimmer (Rynchopsalbicollis) – an aquatic bird was first sighted in 2009 around Mundali site towards Jobra barrage. This threatened bird needs undisturbed habitat. Dredging of islands and creation of massive dumps in the pondage area may adversely impact the threatened bird species. Consequently, undredged shoals (islands) in front of barrage should not be disturbed as these will be utilized by avifauna.

3.3 Conclusion

Based on the above mentioned field observations, the following conclusions are drawn:

1. The 426 acre area is a dump of anthropogenic origin within the pondage area along the ring road (bund road) and is filled with solid waste and sand dredged from the exposed floodplain (shoals/ islands) of the pond.
2. The size of pond is vast and perhaps 3 to 5 km^2 and the dump is about 5 km length wise and <0.5-1.2 km widthwise.
3. There are evidences that the area has been used for dumping for a long period and was encroached as evident by old trees and some of trees might have come up on their own from seeds brought by water. Heavy dumping of dredged sand took place resulting in the death of some trees and iron sheets of 8.5 mm thick and 12 m high were piled at two levels on the shoreline to prevent erosion of dumped material. Recent dumping was also done on water bearing portion of the pond. The 1000 mm pipeline was standing short columns at one time but now seems standing on sand (Figure 15).
4. Time series of maps starting from 2007 to 2022 Google Earth also show water channels passing through the area and flooding of the area but photographs of 2021/ 2022 showed only sand.
5. In simple way, the 426 acre dump is on the floodplain of river Mahanadi in the upstream of Mahanadi barrage which resulted in the submergence of the area under water due to barrage.

3.4 Consequences anticipated

What are the consequences of such dumps in the mouth of barrage?

(i) The impact of habitat vulnerability during once in 25 years flood and once 100 years flood events have been worked out by the Joint Committee based on the studies carried out by Prof. K. C. Patra and the Report was submitted to Hon'ble NGT: The objections to the studies carried by Prof K. C. Patra have been filed by the Odisha State

Government at Hon'ble NGT and a copy of which was submitted to the Members of the Joint Committee for responses. The responses of K. C. Patra to the objection have been accepted by the Committee and included in the Report (Annexure 6).

(ii) The hydrological impact and vulnerability of the dump are:

(A) possible reduction in the water quantity retained in the pond of the tune of 426 × 4046 × 6.50 m= 11203374 m^3 ×1000 L / m^3 = 11203374000 L = 2463 MG,

(B) enhanced resistance to floodway of waters which result in the following hydrological and ecological vulnerability;

(a) The floodwaters may breach embankments leading to flooding of the city and human habitations located along the embankments, particularly during the extreme events of flooding due to climate change, as it has happened in in the past not only in India but also outside India.

(b) The floodwaters may result in washing away of the barrage leading to flashfloods in the downstream that not only submerge crop fields and washing away of villages but also drastically alter the downstream of river ecosystems, particularly floodplain ecosystems.

3.5 Alternative options to protect the flood pain

1. The Committee further deliberated on the following options to address the issues arising out of the dump area within the pondage of Jobra barrage.

Option 1: Remove 426 acre dump from the pondage and utilize the sand for construction purpose.

Option 2: Bring the entire mound to the level of lower iron sheet pile so that the area receives flood water, like other islands in the river and mitigate the impacts of flood water and also retain more water during monsoon and greater recharging of ground water. The Channels that used to exist can be easily revived.

Option 3: The extended Baliyatra ground (34 acres) may be retained without further expanding it and rising its height and use it as per the Hon'ble High Court Order (Honourable Odisha High Court, Cuttack in W.P

(C) NO. 20283 of 2011 in the matter of The Nationalist Lawyers Forum Vrs State of Odisha and Ors.). The remaining part of the dump may be removed and no concretization nor compacting with gravel is permitted at Baliyatra ground.

Option 4: The whole area may be developed into greens with revival of channels buried under sand.

Option 5: Develop the area into a Biodiversity Park that includes revival of old channels, development of Recreational Parks and Bamboo huts that contain Natural History of the River Mahanadi and its people.

Option 6: Integration of *Option 2* with *Option 4*.

Option 7: Integration of *Option 2* with *Option 5*.

4.0 Recommendations

Considering the above mentioned facts and figures, the Committee makes the following recommendations:

1. The Hon'ble NGT may consider to immediately issue direction to Govt. of Odisha
   i. not to dump any solid material (sand and/or solid wastes etc.) nor undertake any activity in 426 acre area, including dredging of remaining islands in the pondage area.
   ii. To remove all encroachments including unauthorized religious structure on the floodplain.
2. Although the members are of the view that the flood plain has been illegally reclaimed in the river bed and there has been violation of Hon'ble High Court Order, any attempt to restore it to original situation may create further problem and may not be economically feasible. Therefore, Committee unanimously recommends that
   i. the extended Baliyatra ground (34 acres) may be retained without further expanding it or raising its height and shall be used as per the Hon'ble High Court/ NGT Order as stated above.
   ii. Neither concretization nor compacting with gravel be permitted at extended Baliyatra ground.
   iii. The whole reclaimed land (426-34 = 392 acres) except the 34 acre of Baliyatra ground may be used for plantation with appropriate Local

species and the area may be developed into a Biological park reviving the old channel buried under sand.

iv. The reclaimed land must not be used for any commercial use.

3. The Government of Odisha may also be directed to take necessary steps for floodplain zoning of major rivers in the State and secure them to prevent floods, particularly flash floods that cause community losses, loses of human lives and irreparable damage to river ecosystems.

Prof C.R. Babu	Prof P.C. Mishra	Dr. A.K.Lohani	Mr. M.K.Biswas
Dr. T. H. Mahato	Mr. Amrish Pal Singh	Dr. S. Giri	

Annexure-1

Minutes of the 1st Meeting of the seven membered Joint Committee constituted by Hon'ble NGT vide its order dated 07.02.2022 in the matter of Pradip Kumar Pattnaik Vs Union of India & Ors. in O.A. No. 68/2020(EZ) held on 31.03.2022 at 3.30 PM through video conferencing

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Hon'ble NGT in its order dated 07.02.2022 in the matter of Pradip Kumar Pattnaik Vs Union of India & Ors in OA No. 68/2020(EZ) directed *"a joint Committee of seven Experts, with five members in the earlier Committee and two other Experts viz. Prof. C.R. Babu, eminent ecologist and environmentalist and Prof. P.C. Mishra, former Expert Member of NGT to undertake the study in light of above observations so as to include ecological and hydrological aspects and vulnerability, adding these components in the report and to make detailed recommendations identifying the steps required for protecting the flood plain zone and the environment within three months."*

In compliance to the above-mentioned Hon'ble NGT order, a Joint Committee of seven Experts, with five members in the earlier Committee and two other Experts was constituted vide CPCB order dated 24.03.2022 comprising of the following members;

i. Prof. C.R. Babu, Professor Emeritus & Ex-Pro-Vice-Chancellor, University of Delhi
ii. Prof. P.C. Mishra, former Expert Member of NGT
iii. Dr. A. K. Lohani, Scientist 'G', National Institute of Hydrology, Roorkee Shri Amrish Pal Singh, Superintending Engineer (C), M&ERO, CWC, Bhubaneswar
iv. Dr. Sohan Giri, Regional Officer, Odisha State Pollution Control Board
v. Shri M. R. Prasad, Scientist 'C', MoEF&CC, Bhubaneswar
vi. Shri M. K. Biswas, Regional Director, CPCB RD, Kolkata (Nodal Agency)

The 1st meeting of the aforesaid seven membered Joint Committee was held on 31.03.2022 at 3:30 P.M through video conferencing.

All the committee members and Prof. K. C. Patra, Professor, Civil Engg. Dept., NIT Rourkela attended the meeting.

List of the participants attended the meeting is enclosed at Annexure I.

Based on the deliberations made, the following were decided;

1. A fundamental study based on analyzing and scrutinizing the basic nature and conditions of the concerned flood plain is to be executed.
2. A preliminary site visit to the concerned area is to be undertaken at the earliest.
3. Considering the health issues of Prof. C.R. Babu, Professor Emeritus & Ex-Pro-Vice-Chancellor, University of Delhi and the limited time available to conduct the study and submit the report, the committee agreed to the proposal that Dr. M. Shah Hussain, Scientist (Ecologist), Biodiversity Park Programme, CEMDE, University of Delhi, a representative of Prof Babu to visit the site along with Prof. P. C. Mishra, Former Expert Member, NGT; Shri. Sohan Giri, Regional Officer, SPCB, Odisha & Prof. K. C. Patra, Professor, Civil Engg. Dept., NIT Rourkela. After recovery of Prof. Babu, another field visit by all the committee members may be conducted.
4. Following the preliminary visit, an extension of 3 months after 30.04.2022 for submission of the Joint Committee report will be requested before NGT.
5. Accommodation and logistics of the visit may be arranged by OSPCB and may be coordinated by Dr. Sohan Giri, Regional Officer, OSPCB.
6. Travel and other expenses of Dr. Shah Hussain may also be reimbursed as a member of the committee under NGT(EC) funds of CPCB as per the prevailing orders.

The meeting ended with vote of thanks to and from the members.

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Annexure-I

List of participants attending the 1st meeting on 31.03.2022 at 3.30 PM through video conferencing

Sl. No	Name of the Participants	Organization	Designation	E-mail id
1	Prof. C.R. Babu	University of Delhi	Professor Emeritus & Ex-Pro-Vice-Chancellor	crb26@hotmail.com, crbabu26@gmail.com
2	Prof. P.C. Mishra,	Sambalpur University, NGT	Professor & former Expert Member of NGT	profpcmishra@gmail.com
3	Dr. A. K. Lohani	National Institute of Hydrology, Roorkee	Scientist 'G'	lohani.nihr@gov.in
4	Shri M. K. Biswas	CPCB, RD, Kolkata	Regional Director (Nodal Agency)	biswasmrinal@gmail.com
5	Dr. Sohan Giri	SPCB, Odisha	Regional Officer	giri.sohan@yahoo.com
6	Dr. M.R. Prasad	RO, Bhubaneswar	Scientist 'C'	secobhubaneshwarcwc@nic.in; cemero-cwc@nic.in
8	Dr. Amrish Pal Singh	CWC, Bhubaneswar	Superintending Engineer (C), M&ERO	prasad.mr@gov.in
9	Prof. K.C.Patra,	Civil Engg. Dept., NIT Rourkela	Professor	kcpatra@nitrkl.ac.in
10	Ms. Pallavi Mukherjee	CPCB, RD, Kolkata	Research Associate	pallavimukherjenv@gmail.com

Report

On

Floodplain Zoning Study for the Identified Stretches of Mahanadi River Basin

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For

By

Report Prepared by: Prof (Dr) K.C Patra

Assisted By

M Uma Maheswar Rao
Satya Narayana Bhuyana

Department of Civil Engineering
National Institute of Technology Rourkela-769008

September, 2021

Members of the Joint Committee

1. **Dr. M. K. Biswas**, Regional Director, ERD Kolkata and Nodal Agency of Joint Committee
2. **Dr. A. K. Lohani**, Scientist 'G', National Institute of Hydrology, Roorkee, Uttarakhand
3. **Shri Amrish Pal Singh**, Superintending Engineer (C), M&ERO, CWC, Bhubaneswar, Odisha
4. **Shri M. R. Prasad**, Scientist 'B', RO, Bhubaneswar, MoEF&CC
5. **Dr. Sohan Giri**, Regional Officer, Odisha State Pollution Control Board, Paribesh Bhawan, Bhubaneswar, Odisha

Floodplain Zoning Study for the Identified Stretches of Mahanadi River Basin

NGT order: Hon'ble NGT vide its order dated 15.12.2020 in O.A. No. 22/2020(EZ) has directed in point 16 **"***to consider the issue and laid down norms to ensure that the proposal of the State for construction of the medical college and riverfront development takes place following the law, without damage to the flood plains of the Rivers. Flood plain zones need to be identified and demarcated in light of such norms. The Committee may identify the extent of floodplain zone/active floodplain zone from the edge of the river. CPCB will be the nodal agency for compliance".*

1. INTRODUCTION

Following the order of the Hon'ble National Green Tribunal (NGT), the Central Pollution Control Board (CPCB), and the nodal agency of the committee constituted by the NGT has approached the National Institute of Technology Rourkela for the "*Floodplain Zoning Study for the Identified Stretches of Mahanadi River Basin*" in a stipulated time of two months. The project has the following two specific objectives to be carried out by NIT Rourkela as referred by the Eastern Regional Directorate, Kolkata.

1. To carry out flood plain zoning based on the modeling results for the characteristic discharges calculated for the Mahanadi River (flood frequencies of 5 years, 10 years, 25 years, 50 years, 100 years, and above return periods, as decided by the CPCB) for the identified stretches.
2. To propose norms for demarcation of flood plain zones from the edge of the river and also to indicate allowable and restricted activities in the demarcated zones

1.1 Time Frame

Honouring the request of CPCB on the urgency of completion of the project work, a time frame of 2 (TWO) months is accepted.

It has been agreed during the 1st field visit of the committee on 7th – 8th April 2021 that the Superintending Engineer, Cuttack irrigation circle of the water resources department of Government of Odisha shall make availability of required data to NIT Rourkela for the project.

The timeline of the work order and other follow-ups are as follows:

(i) Date of issue of the work order by CPCB 18.06.2021

(ii) Date of transfer of 1st instalment of project money to NIT Rourkela 07.07.2021

(iii) Date of procurement of DEM and final data 22.07.2021

1.2 Scope of the Work

The scope of work as per the CPCB work order is as follows:

a. Preparation of Map of the Mahanadi river system from Hirakud to its outfall into the Bay of Bengal showing all the major cities, towns, semi-urban development using satellite imageries.
b. Preparation of Digital Elevation Map of the proposed study area.
c. Preparation of Land Use Land Cover Map showing habitation around the rivers.
d. Calculation of Characteristic flood discharges of the stream based on flood frequency analysis.
e. Preparation of digital/GIS map showing the defined flood plain boundary limit which shall be the guiding factor for any construction to the proposal near river banks.
f. Tabulation of flood plain boundary limit in various cities/towns, villages based on modeling (between Munduli to Jobra Barrage).
g. Propose norms for demarcation of flood plain zones from the edge of the river and also indicate allowable and restricted activities in the demarcated zones

1.3 Methodology

1. Carry out the flood frequency analysis of various return periods using the best fit flood frequency approach for various return periods.
2. Preparation of Shapefiles for the proposed study area by using the available latest version of ArcGis10.4 (Inputs for this preparation are proposed to be taken from the latest satellite/google map) as available in the institute.
3. Preparation of Digital Elevation Model by using the latest version of ArcGis10.4.
4. Preparation of LULC Map by using the latest version of ArcGis10.4 (Inputs for this preparation is proposed to be taken from the sentinel data with less than 10% cloud cover)
5. Flood Zone Mapping and Inundation Map by using the latest version of HEC-RAS V-6.0 (1-D Modelling).

6. Preparation of flood plain zoning map based on the modeling results (HEC-RAS V-6.0) for the characteristic discharges calculated for the Mahanadi River (flood frequencies of 5 years, 10 years, 25 years, 50 years, 100 years, and above return periods, as finally decided by the CPCB/Joint Committee) for the identified stretches.
7. Identify and demarcate the flood plain zones from the edge of the river and also indicate allowable and restricted activities in the demarcated zones.

1.4 Terms and Conditions as per the Work Order

1. The area of study, the scope of work, and timeframe for completion of the study areas mentioned above.
2. The total cost of complete work is Rs. 6, 28,940/- only inclusive of all taxes. No extra payment will be made on this account. 75% of the amount will be released after acceptance of the work and 25% will be released on completion of the work and submission of the complete final report. The payment will be released in favor of the Consultancy fund, NIT Rourkela.
3. Next to installation funds shall be released after furnishing of utilization certificate (UC) and expenditure statement of the previous instalment by NIT Rourkela as per the prescribed format in GFR 2017.
4. For monitoring of funds, payments are to be made by bank transfer and no cash payment is allowed.
5. Income tax shall be deducted at source as applicable.
6. The completed work along with the final report is to be submitted to CPCB within two (02) months from the date of issue of this order. Presentation(s) on the progress of the work is/are to be given before the joint commit during this course of time.
7. There should not be any overlapping of activities under the project with the activities of other projects or schemes.
8. The project may be terminated at any stage if the progress of the project is not found satisfactory. In such a case, the entire fund released shall be refunded with interest to CPCB.
9. The project sanctioned by CPCB shall be executed in totality with clear outputs/deliverables in case of partial completion or part procurement, the entire fund released shall be refunded with interest to CPCB.
10. The outcome of the study should be by the directives given in the order dated-15/12/2020 of the Honourable NGT matter of OA.No.22/2020 (EZ).
11. NIT Rourkela shall keep the funds in a separate interest-bearing bank account for the purpose and interest so earned shall be refunded to CPCB in terms of GFR 230(8). This account shall be open to audit.

12. This letter of award is being issued in duplicate. You are requested to return the duplicate copy duly signed on each page by your authorized signatory as a token of acknowledgment and unconditional acceptance of the offer.
13. Final UC, ten hard copies of the final report along with a softcopy have to be submitted to CPCB.
14. The invoice should be raised in favour of the Central Pollution Control Board, Delhi, and GST No. Of CPCB, Delhi is 07AAALC0228L2ZD.
15. A typographical and clerical error is subjected to correction.

2. STUDY AREA

Mahanadi is one of the major river systems in India, originating in the Dhamtari district of Chhattisgarh and draining into the Bay of Bengal. The total length of the river from its origin to its outfall is 851 km draining a total area of about 141,000 sq. Km. The basin can be divided into 3 sub-basins namely, the upper, middle, and lower Mahanadi. The demarked area comes under the lower Mahanadi sub-basin in the coastal plain of the Cuttack district. The study area is defined from the Munduli Barrage to Jobra Barrage which is taken as the modeling zone. A map of the Mahanadi River system from its origin to its outfall into the Bay of Bengal is given in Figure 1.

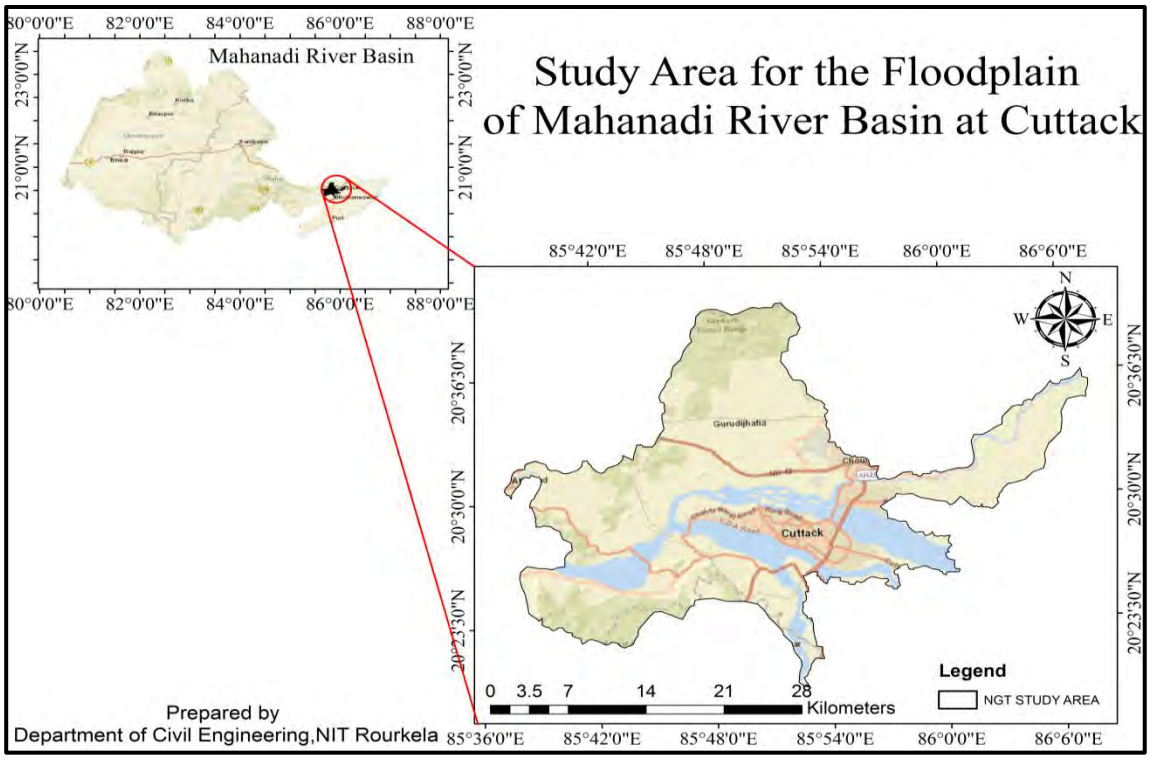


Figure 1: Map of Demarcated Study Area for the Flood Plain Study

The demarcated study area has a total catchment of 760.8 Sq.km which is nearly 0.55% of the total geographical area of the Mahanadi catchment. The study area extends over 18.67% of the Cuttack district and comparatively smaller portions 4.44% of Khordha and 0.18% of the Dhenkanal districts in Odisha. The river branches off to several sub-systems from its delta head at Cuttack before its outfall into the Bay of Bengal. The study area has the highest elevation of 378 m that gradually reduces to about 10 m near the river zones. The basin map of the Mahanadi River system showing all the major towns, semi-urban developments between Hirakud to its outfall into the Bay of Bengal is shown in Figure 2.

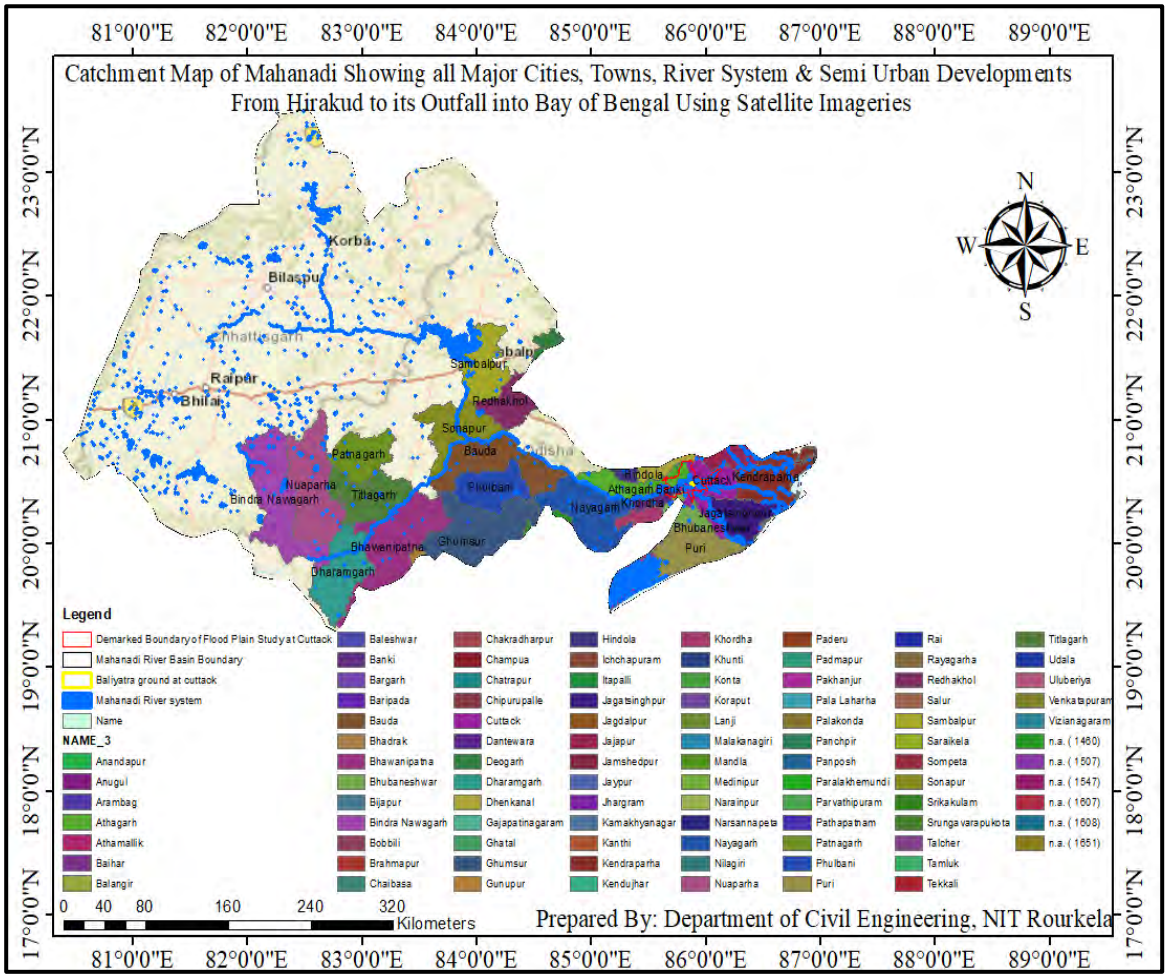


Figure 2: A map of Mahanadi River system showing all the major towns, and semi-urban developments between Hirakud to its outfall into the Bay of Bengal

3. Basic Definitions

3.1 River Basin

A drainage basin is a land area, where precipitation collects and drains off into a common outlet, such as into a river, or other water bodies. The drainage basin includes all the surface water from rainfall, snowmelt, hail, sleet, and nearby streams that run downslope towards the shared outlet, as well as the groundwater underneath the earth's surface. Drainage basins connect into other drainage basins at lower elevations in a hierarchical pattern, with smaller sub-drainage basins, which in turn drain into another common outlet.

3.2 Flood, Floodplains and its Zoning

A flood is an unusually high stage of water in a river that overflows the natural or manmade banks spreading water to its floodplains that are thickly populated due to the obvious advantages of water supply and irrigation.

A floodplain is a generally flat area of land adjacent to a river or stream. It stretches from the banks of the river to the outer edges of the valley. Floodplains are perhaps the most common of fluvial features in that they are usually found along every major river and tributary. Floodplains can be defined topographically as relatively flat surfaces that stand adjacent to river channels and occupy much of the flat areas. The floodplain is partially or inundated during periods of flooding. Thus, a floodplain is an integral part of the fluvial system.

Floodplain zoning involves placing restrictions on land usage in the areas surrounding a river at the given reach. Essentially, construction is restricted to the floodplain but for the construction of public outdoor facilities like playing fields and parks. This has several effects in reducing the risk and impact of flooding. If no one is allowed to build on a flood plain then the damage caused by the river flooding will be greatly reduced.

National Disaster Management Authority of India (NDMA) provides a simple guideline on the land uses of the floodplain. In the regulation of land use in flood plains, different types of buildings and utility services can be grouped under three priorities from the point of view of the damage likely to occur and the flood plain zone in which they are to be located.

Priority 1: Buildings (such as defence installations, industries, public utilities like hospitals, electricity installations, water supply, telephone exchanges, aerodromes, railway stations, commercial centres, etc.) under priority 1 should be located in such a fashion that they are above the levels corresponding to a 100- year frequency or the maximum observed flood

levels. Similarly, they should also be above the levels corresponding to a 50-year rainfall and the likely submersion due to drainage congestion.

Priority 2: The buildings under priority 2 (such as Public institutions, government offices, universities, public libraries, and residential areas, etc.) should be above a level corresponding to a 25-year flood or a 10-year rainfall with the stipulation that all buildings in vulnerable zones should be constructed on columns or stilts.

Priority 3: Parks and playgrounds infrastructure can be located in areas vulnerable to frequent floods. Since every city needs some open areas and gardens, by restricting building activity in a vulnerable area, it will be possible to develop parks and playgrounds, which would provide a proper environment for the growth of the city. In the same analogy, certain areas on either side of the existing and proposed drains (including rural drains) should be declared as green belts where no building or other activity can be allowed. This will not only facilitate improvement of these drains in the future for taking discharges on account of growing urbanization but will also help in minimizing the damage due to drainage congestion whenever rainfall of a higher frequency than designed These green belts, at suitable locations, can also be developed as parks and gardens. A tentative cross-section of floodplain zoning can be seen in Figure 3.

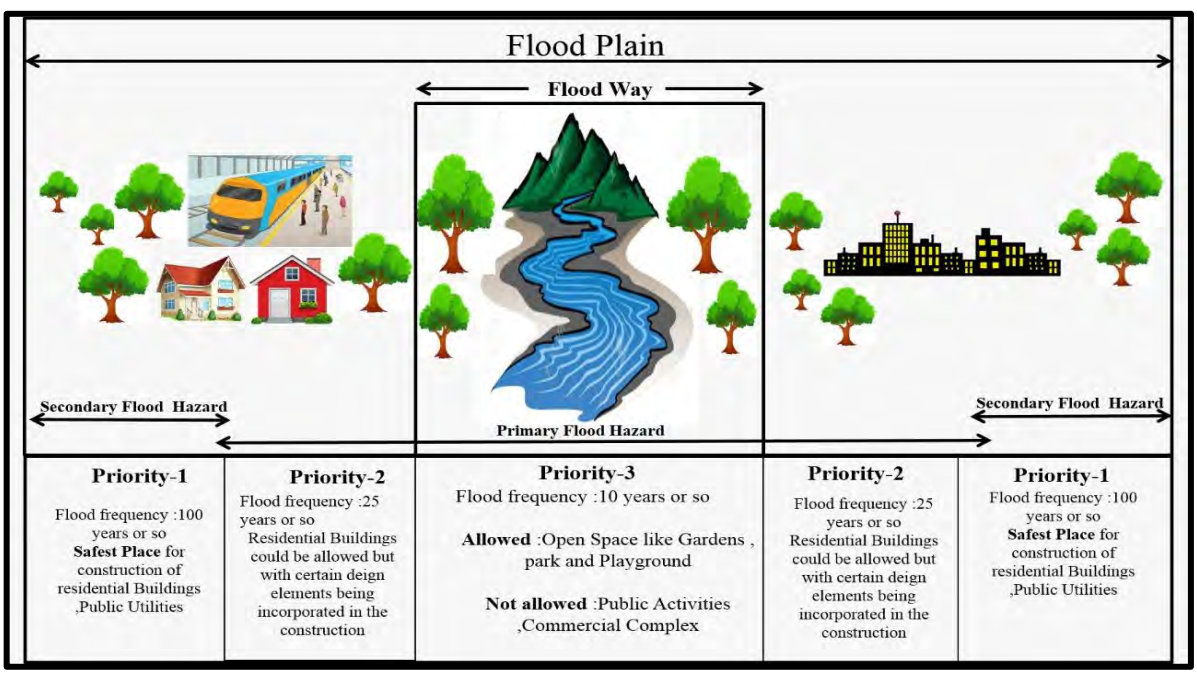


Figure 3: A tentative cross-section of floodplain zoning of a river

3.3 Return Periods of Floods

Return period is defined as the average interval of time T within which a flood or any other extreme event of a given magnitude will be equalled or exceeded at least once in that period. For example, if a probability of an event p is considered as 0.25, this means the probability of occurrence of the event is 25% every year. Thus out of 100year of life of project flood of this magnitude will exceed 25years giving rise to an average return period of the flood is 100/25 = 4 years.

Chow (1951) proposed a general equation for hydrological frequency analysis as

$$X_T = X_{avg} \pm \sigma K_T \quad (1)$$

where X_T is the event of return period T years, X_{avg} is the mean of data, σ the standard deviation, and K_T the frequency factor of T years. Depending on the statistical parameters of the data and the type of distribution adopted, K-T relations are usually established from the theoretical distributions, which are usually simplified in tabular forms given in standard textbooks.

4. Digital Elevation Models (DEMs)

The latest digital elevation model (DEM) for the study area has been procured from the National Remote Sensing Centre (NRSC), Hyderabad for the present study. The DEM uses information from the CARTOSAT-1 satellite sensor built by the ISRO (Indian Space

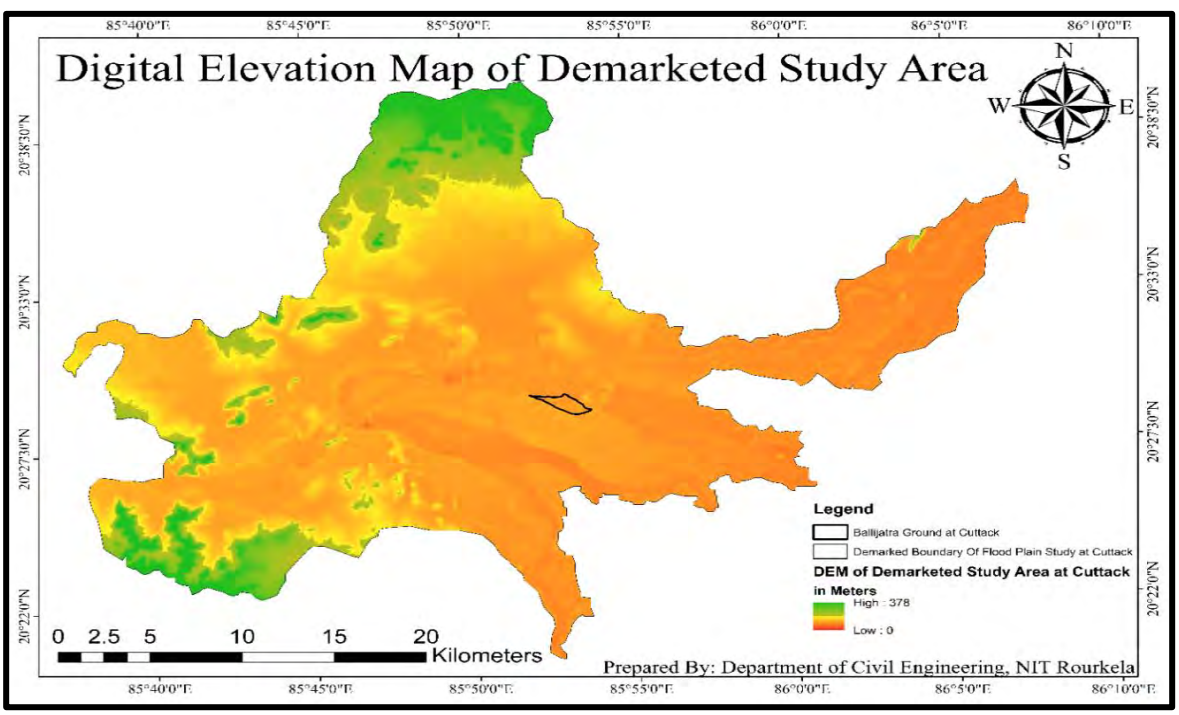


Figure 4: Generated DEM of the Demarcated Study Area

Research Organization). CARTOSAT-1 carries two panchromatic cameras that snap black-and-white stereoscopic pictures in the visible region of the electromagnetic spectrum. The satellite images have a spatial resolution of 2.5 meters and cover a swath of 30 km. The images taken by CARTOSAT-1 cameras enable us to generate the Digital Elevation Models (DEMs) of good resolution. The generated DEM of the study area obtained from the data provided by NRSC is shown in Figure 4. To prepare the digital elevation map for the demarcated study area of the flood plain, 15 tiles have been used, the ID of each tile is given in Table 1. Conversion of 15 tiles into a single frame is carried out by a mosaicking tool in ArcGIS Software. The predefined demarcated study area has been extracted by mask. The DEM of the demarcated study area showing different elevations is the most important input for the flood plain zoning. For better results, high-resolution DEM is used in the present study.

Table 1: Details of the Tiles Used To Frame the DEM for the Study Area

Sl.No.	Tile ID (ISRO)
1	P5_PAN_CD_N20_250_E085_625
2	P5_PAN_CD_N20_250 _E085_750
3	P5_PAN_CD_N20_250 _E085_875
4	P5_PAN_CD_N20_375 _E085_625
5	P5_PAN_CD_N20_375_E085_750
6	P5_PAN_CD_N20_375 _E085_875
7	P5_PAN_CD_N20_375 _E086_000
8	P5_PAN_CD_N20_500 _E085_500
9	P5_PAN_CD_N20_500 _E085_625
10	P5_PAN_CD_N20_500 _E085_750
11	P5_PAN_CD_N20_500_E085_875
12	P5_PAN_CD_N20_500_E086_000
13	P5_PAN_CD_N20_500_E086_125
14	P5_PAN_CD_N20_625_E085_750
15	P5_PAN_C D_N20_625_E085_875

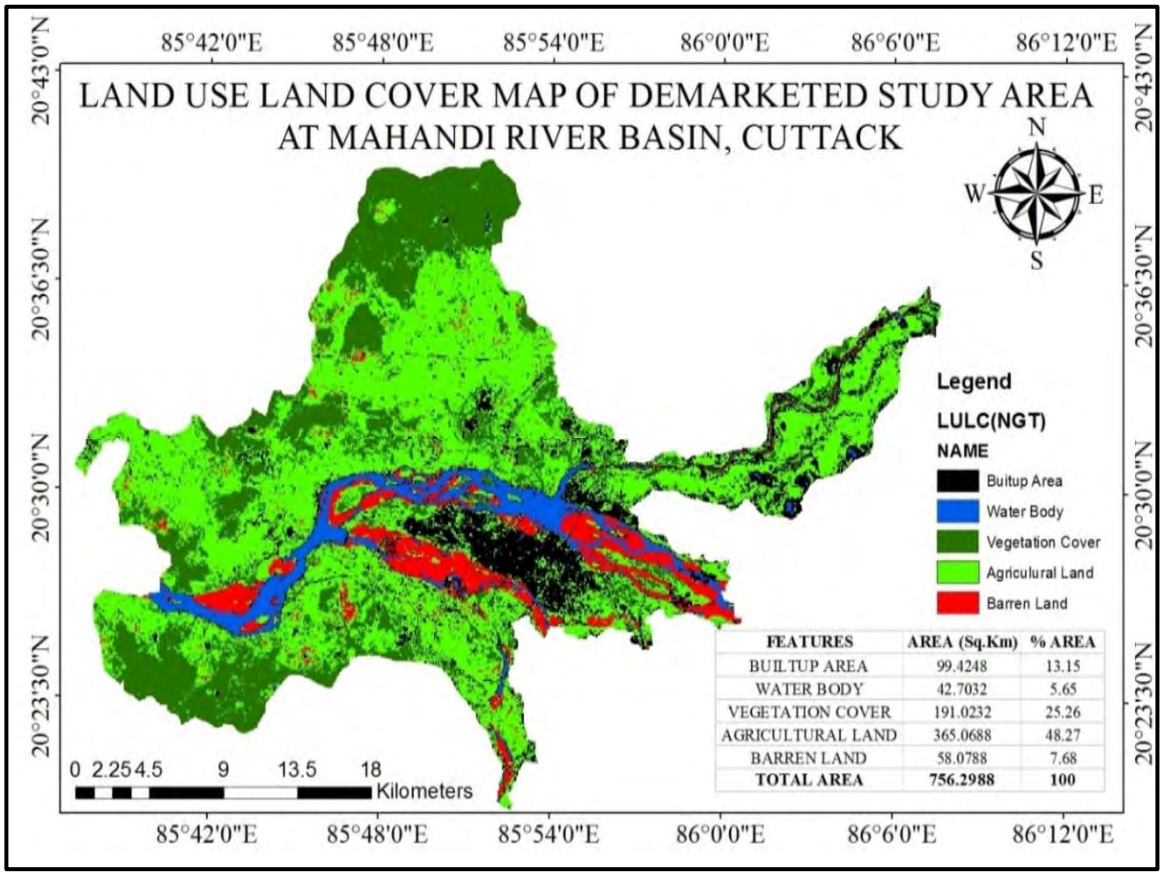
5. Land Use Land Cover Map

Image classification is the procedure of shorting pixels into the fixed number of individual classes from a multiband raster image with the help of a digital number (DN) value. The classification of remotely sensed data is cast-off to allocate respective levels concerning clusters with homogeneous characteristics, to difference multiple objects from each other

within the image. The subsequent raster obtained from image classification is used to fabricate thematic maps. Based on the collaboration between the computer and the analyst during classification, either the supervised classification or the unsupervised classification is adopted. In the present case, the supervised classification is carried out.

***Supervised Classification*:** In this study supervised classification with the maximum likelihood is chosen in which the tool considers both the covariance and variances of the class signatures while assigning individual cells to one of the classes signified in the signature file. With the supposition that the distribution of a class sample is normal, a class can be categorized by the covariance matrix and the mean vector. Given these two features for individual cell values, the statistical probability is calculated for each class to find out the membership of the cells to the class. When the default equal possibility for a priori probability weighting is specified, each cell is allocated to the class to which it has the uppermost probability of being a member. This is further used for showing the percentage of the different features like developed area, agricultural land, bare land, and waterbody affected due to flood .

Data used for the preparation of land use a land cover over the study area is collected from USGS (the United States Geological Survey) earth Explorer > Landsat > Landsat Collection 1 > Landsat collection 1 Level-1 > Landsat 8 OLI/TIRS C1 Level-1. The latest satellite images for the period of 1st Jan 2021 to 20th May, 2021 are used which has less than 10% cloud cover. The downloaded data comes in a raster format with different layered tiles. The downloaded data are merged into one tile and then the catchment boundary of the study area shapefile is added to getthe essential study area shape for the LULC map. Here the Arc-GIS 10.4 (Geographical Information System) is used to preparethe land use land cover map of the remarketed study are The latest Land Use Land Cover Map obtained for the year 2021 is shown in Figure 5 that depicts five LULC classes in the demarcated study area of Mahanadi at the study area**.** A major part of the basin is covered with agricultural land accounting for 48.27% of the total demarked area The basin has a fair area under vegetation covering 25.26 % and 5.65% of the basin area is covered by water bodies which include reservoirs, lakes, rivers, and others. Cuttack city in the eastern Indian state of Odisha is on a peninsula flanked by the Mahanadi River to the north and the Kathajodi River to the south. The major city and other built-up areas cover approximately 13.15%.



FEATURES	AREA (Sq.Km)	% AREA
BUILTUP AREA	99.4248	13.15
WATER BODY	42.7032	5.65
VEGETATION COVER	191.0232	25.26
AGRICULTURAL LAND	365.0688	48.27
BARREN LAND	58.0788	7.68
TOTAL AREA	**756.2988**	**100**

Figure 5: Generated Land Use and Land Cover Map of the Demarcated Study Area

6. Flood Frequency Analysis

6.1 Availability of Discharge Data

To study the flood-carrying capacity of Mahanadi River at the defined reach between (i) Munduli site which is just at the upstream of the river at Cuttack, before its bifurcation to Kathajodi and (ii) the branched Mahanadi at Jobra anicut (Figure 6), the first and the most important task is to find out the flood of various return periods at the delta head (Munduli). Towards this, the Central Water Commission Bhubaneswar volunteered and supplied the discharge data to NIT Rourkela. The Central Water Commission observes daily and hourly discharge records at the Tikarapara site since 1972, while the state water resources department of the Government of Odisha records daily discharge at two locations namely, at Munduli and Jobra barrage (Popularly known as Jobra Anicut) sites. Annual peaks observed at both sites are given in Table 2. The data at both the sites are arranged in descending order in the same table to find out the observed highest peaks and the mean flow. A map showing the Gauge-Discharge stations is shown in Figure 6.

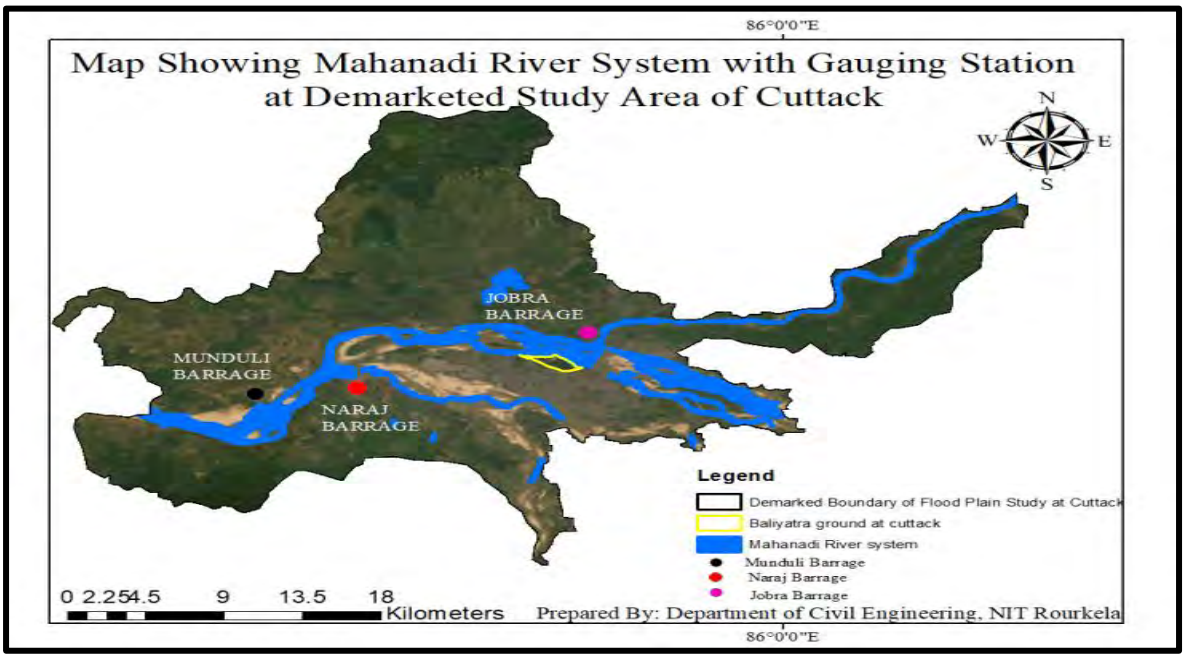


Figure 6: Map showing the Gauge-Discharge stations in the Study Area

Table 2: Discharge data of Mahanadi at Tikarapara observed by CWC and at Munduli Observed by the Odisha water resources department

	CWC DATA AT TIKERAPARA				ODISHA WRD DATA AT MUNDALI			
Sl. No	Year	Annual Peak Discharge (m^3/s)	Year	Sorted Annual Peak Flood Discharge (m^3/s)	Year	Annual Peak Discharge (m^3/s)	Year	Sorted Annual Peak Flood Discharge (m^3/s)
	(1)	(2)	(3)	(4)	(5)	(2)	(3)	(4)
1	13 SEP 1972-1973	16660	1981	4774				
2	27 SEP 1973-1974	23948	1995	31500				
3	19 AUG 1974-1975	17400	1983	31050				
4	23 AUG 1975-1976	22735	1979	30862				
5	14 AUG 1976-1977	26323	1992	30500				
6	14 SEP 1977-1978	28692	2012	30400				
7	29 AUG 1978-1979	30862	1984	30041				
8	9 AUG 1979-1980	14257	2015	29800				
9	21 SEP 1980-1981	33800	2007	29000				
10	10 AUG 1981-1982	15100	1978	28692				
11	30 AUG 1982-1983	31050	1993	28000				
12	8 SEP 1983-1984	30041	2002	26700				
13	17 AUG 1984-1985	24726	1987	26391				
14	7 AUG 1985-1986	23921	1977	26323				
15	21 AUG 1986-1987	26391	2004	25062				

16	23 JUL 1987-1988	10241	1999	25000				
17	9 AUG 1988-1989	9593	1985	24726				
18	18 AUG 1989-1990	6535	1974	23948				
19	5 SEP 1990-1991	20067	1986	23921				
20	14 AUG 1991-1992	30500	1996	23121				
21	21 AUG 1992-1993	28000	1998	23000				
22	20 AUG 1993-1994	20435	1976	22735				
23	13 JUL 1994-1995	31500	2020	21700				
24	24 JUL 1995-1996	23121	2009	20565				
25	22 AUG 1996-1997	11930	1994	20435				
26	5 AUG 1997-1998	23000	2019	20076	06-Aug-97	24295	2008	44768
27	13 SEP 1998-1999	25000	1991	20067	13-Sep-98	23248	2001	39898
28	10 AUG 1999-2000	13249	2006	19000	11-Aug-99	18066	2011	38709
29	01 SEP 2000-2001	4774	2014	18895	02-Sep-00	4728	2003	38227
30	19 JUL 2001-2002	26700	2010	17750	20-Jul-01	39898	2006	36330
31	13 SEP 2002-2003	12305	2005	17744	13-Sep-02	16225	2014	31516
32	29 AUG 2003-2004	25062	1975	17400	30-Aug-03	38227	2020	29053
33	12 AUG 2004-2005	17744	1973	16660	12-Aug-04	21690	2019	26447
34	31 JUL 2005-2006	19000	2008	15789	01-Aug-05	25570	2005	25570
35	31 AUG 2006-2007	29000	1982	15100	01-Aug-06	36330	1997	24295
36	24 SEP 2007-2008	15789	1980	14257	25-Sep-07	21039	2009	24267
37	19 SEP 2008-2009	33050	2011	13575	20-Sep-08	44768	1998	23248
38	21 JUL 2009-2010	17750	2000	13249	21-Jul-09	24267	2004	21690
39	20 SEP 2010-2011	13575	2017	12760	20-Sep-10	18538	2007	21039
40	10 SEP 2011-2012	30400	2003	12305	11-Sep-11	38709	2013	20869
41	7 AUG 2012-2013	11766	2016	12086	07-Aug-12	18536	2018	20699
42	1 AUG 2013-2014	18895	1997	11930	01-Aug-13	20869	2010	19538
43	6 AUG 2014-2015	29800	2013	11766	08-Aug-14	31516	2012	19142
44	18 SEP 2015-2016	12086	1988	10241	23-Sep-15	13931	1999	18066
45	11 AUG 2016-2017	12760	1989	9593	11-Aug-16	13725	2002	16225
46	21 JUL 2017-2018	8006	2018	8006	22-Jul-17	8381	2016	14668
47	23 JUL 2018-2019	20076	1990	6535	23-Jul-18	20699	2015	13931
48	14 AUG 2019-2020	21700	2001	4774	15-Aug-19	26447	2017	8381

The flow of the Mahanadi River gets divided into two parts just downstream of Munduli with river Kathajodi branching off from the main Mahanadi, thus forming a doab where the city of Cuttack is located. From the records maintained by the Odisha State Water Resources Department (Table 3), it can be seen that the flow distribution between the two branches in terms of percentage is highly uneven. The average flow ratio of between Mahanadi branch and Kathajodi after bifurcation is approximately 55% and 45% respectively.

Table 3: Flow in Main Mahanadi at Munduli and Kathajori

Year	Month	Flow in Main Mahanadi at Mundali (lakh cusecs)	Flow in Bifurcated Mahanadi (lakh cusecs)	Flow in Kathajadi Branch (Lakh cusecs)	Flow Percentage in Mahanadi after Bifurcation	Flow Percentage in Kathajadi after Bifurcation
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1997	Aug	8.57915	4.81248	3.76667	56.10	43.90
	Sep	5.54695	1.66954	3.87741	30.10	69.90
	Oct	0.56	0.28897	0.27103	51.60	48.40
1998	Aug	0.785	0.27201	0.51299	34.65	65.35
	Sep	8.20843	3.95823	4.2502	48.22	51.78
	Oct	1.27068	0.44878	0.8219	35.32	64.68
1999	Aug	6.37585	3.11848	3.25737	48.91	51.09
	Sep	4.74624	1.12778	3.61846	23.76	76.24
	Oct	1.75397	0.58855	1.16542	33.56	66.44
2000	Aug	1.082	0.39723	0.68477	36.71	63.29
	Sep	1.63818	0.52127	1.11691	31.82	68.18
	Oct	0.516	0.2313	0.2847	44.83	55.17
2001	Aug	6.02755	1.90582	4.12173	31.62	68.38
	Sep	2.32384	0.65404	1.6698	28.14	71.86
	Oct	0.739	0.34067	0.39833	46.10	53.90
2002	Aug	1.5806	0.51283	1.06777	32.45	67.55
	Sep	5.73475	1.56342	4.17133	27.26	72.74
	Oct	0.33	0.1565	0.1735	47.42	52.58
2003	Aug	13.49844	0.90981	12.58863	6.74	93.26
	Sep	12.33962	5.4785	6.86112	44.40	55.60
	Oct	5.04801	1.15581	3.8922	22.90	77.10
2004	Aug	7.66139	19.6	-11.93861	255.83	-155.83
	Sep	0.785	0.37277	0.41223	47.49	52.51
	Oct	1.81291	0.66976	1.14315	36.94	63.06
2005	Aug	9.03266	4.367	4.66566	48.35	51.65
	Sep	7.54385	3.99683	3.54702	52.98	47.02
	Oct	3.04895	0.89125	2.1577	29.23	70.77
2006	Aug	12.66784	4.98177	7.68607	39.33	60.67
	Sep	12.83338	6.97363	5.85975	54.34	45.66
	Oct	2.32384	1.4215	0.90234	61.17	38.83
2007	Aug	6.83	4.26004	2.56996	62.37	37.63
	Sep	7.42631	3.97071	3.4556	53.47	46.53
	Oct	3.47482	1.73707	1.73775	49.99	50.01
2008	Aug	6.37585	2.85821	3.51764	44.83	55.17
	Sep	15.81	8.47906	7.33094	53.63	46.37
	Oct	0.9	0.48761	0.41239	54.18	45.82
2009	Aug	4.20824	2.34074	1.8675	55.62	44.38
	Sep	2.744	1.00997	1.73403	36.81	63.19
	Oct	1.16	0.44984	0.71016	38.78	61.22
2010	Aug	6.9	3.5806	3.3194	51.89	48.11
	Sep	6.55	3.09345	3.45655	47.23	52.77
	Oct	1.03	0.59057	0.43943	57.34	42.66
2011	Aug	3.50016	1.95694	1.54322	55.91	44.09
	Sep	13.66688	7.34968	6.3172	53.78	46.22
	Oct	1.24301	0.64509	0.59792	51.90	48.10
2012	Aug	6.76	3.80928	2.95072	56.35	43.65
	Sep	5.64085	3.31673	2.32412	58.80	41.20
	Oct	1.5806	1.30479	0.27581	82.55	17.45
2013	Aug	7.36754	4.41276	2.95478	59.89	40.11
	Sep	4.53012	2.76368	1.76644	61.01	38.99
	Oct	6.55	4.11023	2.43977	62.75	37.25
2014	Aug	11.1296	6.33489	4.79471	56.92	43.08
	Sep	8.28257	4.37314	3.90943	52.80	47.20
	Oct	3.7852	2.39791	1.38729	63.35	36.65
2015	Aug	3.68174	2.92267	0.75907	79.38	20.62

	Sep	4.91887	2.96639	1.95248	60.31	39.69
	Oct	0.25	0.16687	0.08313	66.75	33.25
2016	Aug	5.17715	3.27969	1.89746	63.35	36.65
	Sep	4.36803	3.10159	1.26644	71.01	28.99
	Oct	3.7852	3.04601	0.73919	80.47	19.53
2017	Aug	1.66694	1.02886	0.63808	61.72	38.28
	Sep	1.49426	1.16003	0.33423	77.63	22.37
	Oct	1.03	0.85024	0.17976	82.55	17.45
2018	Aug	6.49195	3.2117	3.28025	49.47	50.53
	Sep	5.8756	2.97501	2.90059	50.63	49.37
	Oct	2.36192	1.80806	0.55386	76.55	23.45
2019	Aug	9.335	4.15682	5.17818	44.53	55.47
	Sep	7.48508	3.77786	3.70722	50.47	49.53
	Oct	5.7817	2.84516	2.93654	49.21	50.79
2020	Aug	10.26218	5.09939	5.16279	49.69	50.31
	Sep	10.26218	5.17555	5.08663	50.43	49.57
	Oct	2.17152	1.21009	0.96143	55.73	44.27
AVERAGE FLOW PERCENTAGE					**56.24**	**43.76**

While checking the data, it is found that there is good number of mismatches on the records of the daily data recorded between the two departments. Keeping aside the correctness of the data, the records by the CWC at Tikarapara located at the immediate upstream of Munduli is considered for the estimation of the flood of various frequencies required for the study.

6.2 Floods of Various Return Periods (Analysis by 48 Year Data)

The daily discharge data at the Tikarapara site recorded by the CWC on Mahanadi River since 1972 (48 years of continuous data) is used for predicting the flood peaks of various return periods. Using the data, floods of various return periods such as 5-year (Q_5), 10-year (Q_{10}), 25-year (Q_{25}), 50-year (Q_{50}), 100-year (Q_{100}), and 200-year (Q_{200}) are computed using (i) Extreme value type-I (Gumbel), (ii) Pearson type-III and (iii) Log-Pearson type-III distributions.

Catchment intercepted at Tikarapara gauging station is 1, 24, 450 Sq. Km, while at Munduli site is 1, 32, 085 Sq. Km. Since CWC does have a gauge-discharge measurement site at Munduli, the discharge observed is proportioned to Munduli site on catchment area ratio basis {(132085-124450)/124450 = 6.1%}, which is below 10% and therefore acceptable. For this, recorded daily peaks are scanned for every year and from the record, the monthly and therefore annual peaks are picked up year wise which are given in Table 2.

Similarly, the daily peaks of discharge data at the Munduli site from the records of Odisha WRD data are scanned for every year and from the record, the monthly and therefore annual peaks are picked up year wise which are given in the same table. The data are arranged in

descending order and the observed highest peak is found to have occurred on 20 September, 2008 with a value of 44768 m^3/s at Munduli.

6.2.1 Computation of Statistical Parameters for Flood Frequency Analysis using 48 Years CWC Data

To carry out the flood frequency analysis, the first information required is the estimation of values of various statistical parameters such as the mean, standard deviation, coefficient of variation, skewness, and others. From the data in Table 2, these parameters are computed as given below.

Mean $X_{avg} = \frac{x_i}{N} = \frac{986841.838}{48} = 20819$

Standard deviation $\sigma = \left\{\sqrt{\frac{\sum(X_i - X_{avg})^2}{N}}\right\} = \left\{\sqrt{\frac{2702431358.896}{48}}\right\} = 7713$

Coefficient of Variation $C_V = \frac{\sigma}{X_{avg}} = \frac{7503.376}{20559.205} = 0.3704$

Coefficient of Skewness $C_S = \frac{\propto}{\sigma^3} = \frac{-71857921068}{7503.376^3} = -0.16935$

And for the Log transferred series these values are computed as

Mean $X_{avg} = \frac{X_i}{N} = \frac{205.2767}{48} = 4.28088$

Standard deviation $\sigma = \left\{\sqrt{\frac{\sum(X_i - X_{avg})^2}{N}}\right\} = \left\{\sqrt{\frac{1.7554}{48}}\right\} = 0.194$

Coefficient of Variation $C_V = \frac{\sigma}{X_{avg}} = \frac{0.1912}{4.2766} = 0.04538$

Coefficient of Skewness $C_S = \frac{\propto}{\sigma^3} = \frac{-0.007028229}{0.1912^3} = -0.98425$

6.2.2 Floods of Various Return Periods Using Extreme Value Distribution Type I (Gumble's Distribution)

From the *K-T* relation available in the standard books (referred here from Table 2.7 of the book authored by K.C Patra, titled "*Hydrology and Water Resources Engineering*"), for a sample length of 48 years, the values of K_T are obtained as given in Table 4.

Table 4: Calculation of K-T parameters for Gumble's Extreme Value Analysis

Return periods	5 year	10 year	25 year	50 year	100 year	200 year
"K_T" Values	0.823	1.4708	2.29	2.8986	3.5026	3.725

Using the K_T values of Table 4, flood peaks of various return periods are obtained at the Tikarapara site and subsequently proportioned to Munduli is given in Table 5.

Table 5: Gumble's Distribution Discharge Output for different Return Period (Analysis by 48 Years CWC Data)

At Tikarapara in m^3/s	At Munduli = Tikarapara × (132085/124450) = 1.0613 in m^3/s
Q_5 = 26734	Q_5 = 28372
Q_{10} = 31595	Q_{10} = 33532
Q_{25} = 37749	Q_{25} = 40063
Q_{50} = 42308	Q_{50} = 44902
Q_{100} = 46840	Q_{100} = 49711
Q_{200} = 48509	Q_{200} = 51482

6.2.3 Floods of Various Return Periods Using Pearson Type-III Distribution

From the *K-T* relation for Pearson Type III distribution Table 2.8 of the book of K. C Patra, titled "*Hydrology and Water Resources Engineering*" is referred from where for sample length of 48 years, the values of K_T for a coefficient of skewness of (C_S) = **- 0.16935** are found out as given in Table 6.

Table 6: Calculation of K-T parameters for Pearson Type-III Distribution

Return periods	5 Year	10 Year	25 Year	50 Year	100 Year	200 Year
"K_T" Values	0.849	1.262	1.691	1.961	2.2	2.416

By using the information from Table 6, flood peaks of various return periods are obtained at the Tikarapara site and subsequently proportioned to Munduli is given in Table 7.

Table 7: Pearson Type-III Distribution Discharge Output for different Return Period (Analysis by 48 Years CWC Data)

At Tikarapara in m^3/s	At Munduli = Tikarapara × (132085/124450) = 1.0613 in m^3/s
Q_5 = 26929	Q_5 = 28580
Q_{10} = 30028	Q_{10} = 31869
Q_{25} = 33247	Q_{25} = 35285
Q_{50} = 35273	Q_{50} = 37435
Q_{100} = 37066	Q_{100} = 39338
Q_{200} = 38687	Q_{200} = 41059

6.2.4 Log Pearson Type-III Distribution

From the same book and Table 2.8, for a sample length of 48 years, the values of K_T are obtained for the Coefficient of skewness C_S = **-0.98425** as given in Table 8.

Table 8: Calculation of parameters for Log-Pearson Type-III Distribution

Return periods	5 years	10 years	25 years	50 years	100 years	200 years
"K_T" Values	0.8518	1.1203	1.3639	1.4891	1.5845	1.6598

By using the information in Table 8, flood peaks of various return periods are obtained at the Tikarapara site and subsequently proportioned to Munduli is given in Table 9. Results of flood peaks for the above distributions by using CWC data is given in Table 9.

Table 9: Log Pearson Type-III Distribution Discharge Output for different Return Period (Analysis by 48 Years CWC Data)

At Tikarapara in m^3/s	At Munduli = Tikarapara × (132085/124450) = 1.0613 in m^3/s
Q_5 = 27509	Q_5 = 29196
Q_{10} = 30962	Q_{10} = 32962
Q_{25} = 34468	Q_{25} = 36581
Q_{50} = 36421	Q_{50} = 38655
Q_{100} = 37984	Q_{100} = 40312
Q_{200} = 39265	Q_{200} = 41672

There are other types of distribution available in the literature out of which we have considered only three approaches. To check the best fit distribution for the present data a request was made to Dr A K Lohani, Scientist-G, NIH Roorkee, who as a joint committee member assisted us and carried out various L-moments for 7 types of frequency distributions (EV1, GEV, LOGISTIC, GEN LOGISTIC, GEN PARETO, NORMAL, and LOG NORMAL) and concluded that the log normal distribution has the best fit amongst all with respect to different performance indicators such as ADA, ADR, EFFICIENCY and DINDEX. The results of the log normal distribution for various return periods are given in Table 10 along with the others. It can be seen that the values of Q_{25} for LND is higher than the Pearson Type-III and the Log Pearson Type-III, while it is slightly less than the Gumble's Extreme Value distribution. Therefore, in the present study, Gumble's Extreme Value Analysis is selected against the others. Moreover, the difference between Log Normal value of Q_{25} of 38,291 m^3/s and Gumble's distribution value of Q_{25} 40,063 m^3/s may not have much difference in the submergence potential in the study area. The simulation output of testing of best fit distribution is given Appendix -1.

Table 10: Results of flood peaks (Analysis by 48 Years CWC Data)

At Munduli			
Gumble's Extreme Value Analysis in m^3/s	Pearson Type-III Distribution in m^3/s	Log Pearson Type-III Distribution in m^3/s	Log Normal Distribution in m^3/s
Q_5 = 28372	Q_5 = 28580	Q_5 = 29196	Q_5 = 29703
Q_{10} = 33532	Q_{10} = 31869	Q_{10} = 32962	Q_{10} = 33780
Q_{25} = 40063	Q_{25} = 35285	Q_{25} = 36581	Q_{25} = 38291
Q_{50} = 44902	Q_{50} = 37435	Q_{50} = 38655	Q_{50} = 41303
Q_{100} = 49711	Q_{100} = 39338	Q_{100} = 40312	Q_{100} = 44152
Q_{200} = 51482	Q_{200} = 41059	Q_{200} = *41672*	Q_{200} = *46682*

6.3 Computation of Statistical Parameters for Flood Frequency Analysis using 24 Years of Odisha WRD Data

6.3.1 Background of the Proposed Alternate Study

The study report was circulated to all the members of the joint committee on 9th August 2021 by the CPCB following which a meeting was convened online on 13th August at 4.15 pm for a thorough discussion and adoption. All the members deliberated on the initial draft report over 2 hours and the following decision followed.

The committee decided to redo the entire analysis using the available last 24 years of continuous data between 1997-2019 due to the following reasons

a) It is observed from the record that peak and average discharge from 1972-1973 to 1996-1997 are higher than the corresponding values for the data segment of the last 24 years from 1997 -1998 to 2019-2020.

- Peak discharge from 1972-1973 to 1996-1997 = 33800 m^3/s
- Peak discharge from 1997 -1998 to 2019-2020 = 33050 m^3/s
- Average discharge from 1972-1973 to 1996-1997 = 22313 m^3/s
- Average discharge from 1997 -1998 to 2019-2020 = 19195m^3/s

b) The estimated 25 year return period flood at the Munduli barrage site is 40063 m^3/s. This value looks higher as this flood has never been witnessed over the last 48 years of observed records at the site by CWC. This flood was supposed to have come at least once over the last 48 years of record.

c) Over the last 25 years, massive storage structures have been constructed in the upstream catchment of Mahanadi by the states of Odisha and Chhattisgarh because of which the flow over the years has reduced. The project details can be seen through the following link.
https://indiawris.gov.in/wiki/doku.php?id=major_medium_irrigation_projects_in_mahanadi_basin

d) Over the last two decades, appreciable changes in the climate are reported that have changed the rainfall pattern in the catchment and therefore it is pertinent to consider the last 24 years' data.

e) There has been a massive change in the Land use land cover (LULC) configurations that have changed the infiltration and runoff potentials over the catchment.

Considering the above, the committee has decided to redo the entire analysis by using the Odisha WRD data of the last 24 years.

6.4 Observations on Data

While on scrutiny it has found that CWC had missed the discharge observation for the highest peak flow on 19th to 21st September 2008. On the same day Odisha water resource department had recorded the highest peak discharge of 44,768 m^3/sec. Subsequently, CWC is requested to provide the missing data following which they provided the recast water level at Tikarapada as 74.52 m with a discharge of 33050 m^3/sec. This on prorated at Munduli comes out to be 35076 m^3/s, which has a difference of 9692 m^3/sec concerning Odisha, Water Resource Department data for the corresponding date.

6.5 Flood Frequency Study of Odisha WRD data at Munduli from 1997 to 2020

To carry out the flood frequency analysis, the first information required is the estimation of the values of various statistical parameters such as the mean, standard deviation, and coefficient of variation, skewness, and others. From the data in Table 2, these parameters are computed as given below.

Mean $X_{avg} = \frac{x_i}{N} = \frac{581315.58}{24} = 23900$

Standard deviation $\sigma = \left\{\sqrt{\frac{\sum(X_i - X_{avg})^2}{N}}\right\} = \left\{\sqrt{\frac{2322667335}{24}}\right\} = 10297$

Coefficient of Variation $C_V = \frac{\sigma}{X_{avg}} = \frac{10049.156}{46505.24} = 0.430848$

Coefficient of Skewness $C_S = \frac{\propto}{\sigma^3} = 0.313$

And for the Log transferred series these values are computed as

Mean $X_{avg} = \frac{X_i}{N} = 4.3$

Standard deviation $\sigma = \left\{\sqrt{\frac{\sum(X_i - X_{avg})^2}{N}}\right\} = = \left\{\sqrt{\frac{1.105}{24}}\right\} = 0.219$

Coefficient of Variation $C_V = \frac{\sigma}{X_{avg}} = 0.05$

Coefficient of Skewness $C_S = \frac{\propto}{\sigma^3} = -1.025$

Floods of Various Return Periods Using Extreme Value Distribution Type I (Gumble's Distribution)

From the *K-T* relation available in the standard books (referred here from Table 2.7 of the book authored by K.C Patra, titled "*Hydrology and Water Resources Engineering*"), for a sample length of 24 years, the values of K_T are obtained as given in Table 11.

Table 11: Calculation of K-T parameters for Gumble's extreme value analysis

Return periods	5 year	10 year	25 year	50 year	100 year	200 year
"K_T" Values	**0.8942**	**1.585**	**2.4586**	**3.1062**	**3.7504**	**3.9842**

Using the K_T values of Table 11, flood peaks of various return periods are obtained at the Tikerapara site and subsequently proportioned to Mundali is given in Table 12.

Table 12: Gumble's Distribution Discharge Output for different Return Period (Odisha WRD Data of 24 Years)

Return periods	5 years	10 years	25 years	50 years	100 years	200 years
Simulated Q	33207	40149	48928	55436	61910	64259

Floods of Various Return Periods Using Pearson Type-III Distribution

From the *K-T* relation for Pearson Type III distribution Table 2.8 of the book of K. C Patra, titled "*Hydrology and Water Resources Engineering*" is referred from where for sample length of 24 years, the values of K_T for a coefficient of skewness of (C_S) = **0.313** are found out as given in Table 13.

Table 13: Calculation of K-T parameters for Pearson Type-III Distribution

Return periods	5 Year	10 Year	25 Year	50 Year	100 Year	200 Year
"K_T" Values	**0.825**	**1.308**	**1.814**	**2.205**	**2.535**	**2.844**

By using the information from Table 13, flood peaks of various return periods are obtained at the Tikerapara site and subsequently proportioned to Mundali is given in Table 14.

Table 14: Pearson Type-III Distribution Discharge Output for different Return Period (Odisha WRD Data of 24 Years)

Return periods	5 years	10 years	25 years	50 years	100 years	200 years
Simulated Q	32512	37366	42451	46380	49696	52801

Log Pearson Type-III Distribution

From the same book and Table 2.8, for a sample length of 48 years, of the book of K. C Patra, titled "*Hydrology and Water Resources Engineering*" is referred from where for sample length of 24 years the values of K_T are obtained for the Coefficient of skewness C_S = **-1.025** as given in Table 15.

Table 15: Calculation of parameters for Log-Pearson Type-III Distribution

Return periods	5 years	10 years	25 years	50 years	100 years	200 years
"K_T" Values	0.839	1.066	1.244	1.329	1.389	1.431

By using the information in Table 15, flood peaks of various return periods are obtained at the Tikerapara site and subsequently proportioned to Mundali is given in Table 16.

Table 16: Log Pearson Type-III Distribution Discharge Output for different Return Period (Odisha WRD Data of 24 Years)

Return periods	5 years	10 years	25 years	50 years	100 years	200 years
Simulated Q	33397	37452	40973	42770	44085	45030

Flood peaks of various return periods and approaches can be seen in Table 17.

Table 157: Results of flood peaks (Analysis by 24 Years Odisha, WRD Data)

At Mundali in m^3/s		
Gumble's Extreme Value Analysis	Pearson Type-III Distribution	Log Pearson Type-III Distribution
Q_5=33207	Q_5=32512	Q_5=33397
Q_{10}=40149	Q_{10}=37366	Q_{10}=37452
Q_{25}=48928	Q_{25}=42451	Q_{25}=40973
Q_{50}=55436	Q_{50}=46380	Q_{50}=42770
Q_{100}=61910	Q_{100}=49696	Q_{100}=44085
Q_{200}=64259	Q_{200}=52801	Q_{200}=45030

6.6 Comparison of the Results

Results obtained from the two data sets of CWC as well as Odisha WRD are compared in Table 18 for Gumble's Extreme Value Analysis, Pearson Type-III Distribution and Log Pearson Type-III Distribution. It can be seen that the results of Gumble's Extreme Value Analysis using CWC data is 40063 m^3/s while for WRD data the value is 48928 m^3/s. CWC data has the Coefficient of Variation C_V = 0.3704 and skewness coefficient C_S = -0.169, while the data of Odisha WRD has a Coefficient of Variation C_V = 0.4308 with skewness coefficient Cs = 0.313. The corresponding values of the log transferred series for CWC data are Cv = 0.045 and Cs = - 0.984, while for WRD data are the values are C_V = 0.05 and skewness coefficient Cs = -1.025.

Looking at the statistical parameters of C_v and C_s of both the series, viz. the original and log transferred values, it can be noticed that the C_V and C_S for CWC data are less than WRD data. Since the interest is to choose the extreme value analysis, the values obtained from CWC data are taken for analysis.

Table 16: Results of Flood Peaks obtained from CWC and Odisha WRD Data

At Munduli (in m^3/s) Using CWC Data			At Mundali (in m^3/s) Using WRD Data		
Gumble's Extreme Value Analysis	Pearson Type-III Distribution	Log Pearson Type-III Distribution	Gumble's Extreme Value Analysis	Pearson Type-III Distribution	Log Pearson Type-III Distribution
Q_5 = 28372	Q_5 = 28580	Q_5 = 29196	Q_5=33207	Q_5=32512	Q_5=33397
Q_{10} = 33532	Q_{10} = 31869	Q_{10} = 32962	Q_{10}=40149	Q_{10}=37366	Q_{10}=37452
Q_{25} = 40063	Q_{25} = 35285	Q_{25} = 36581	Q_{25}=48928	Q_{25}=42451	Q_{25}=40973
Q_{50} = 44902	Q_{50} = 37435	Q_{50} = 38655	Q_{50}=55436	Q_{50}=46380	Q_{50}=42770
Q_{100} = 49711	Q_{100} = 39338	Q_{100} = 40312	Q_{100}=61910	Q_{100}=49696	Q_{100}=44085
Q_{200} = 51482	Q_{200} = 41059	Q_{200} = 41672	Q_{200}=64259	Q_{200}=52801	Q_{200}=45030

6.7 Generation of Flood Hydrographs

The hydrograph for the highest 48 years of record observed on 21st September, 1980-1981 has the base period from 7th September to 25th September. The hydrograph ordinates for the CWC data at Tikarapara are transferred to Munduli and are given in Table 19. To get the hydrograph of different return periods, a factor in the ratio of the peak of the Q_5, Q_{10}, Q_{25}, Q_{50}, Q_{100}, and Q_{200} to that of the observed peak discharge ordinates of the hydrograph for the highest observed values (Q_5/Q_p, Q_{10}/Q_p, Q_{25}/Q_p, Q_{50}/Q_p, Q_{100}/Q_p, and Q_{200}/Q_p) is multiplied and the hydrographs of the given return periods are given in Table 20.

Table 179: Hydrograph Ordinates (Analysis by 48 Years CWC Data)

Date	Discharges at Tikarapara (m^3/s)	Discharges at Munduli (m^3/s)
(1)	(2)	(3)
07-Sep (day -1)	2983.2	3126.3
08-Sep (day -2)	11149.8	11684.9
09-Sep (day -3)	17293.6	18123.7
10-Sep (day -4)	14438.8	15131.8
11-Sep (day -5)	16098.6	16871.3
12-Sep (day -6)	13258.9	13895.4
13-Sep (day -7)	20154.5	21121.9
14-Sep (day -8)	24767.9	25956.8
15-Sep (day -9)	20628.3	21618.5
16-Sep (day -10)	19364.7	20294.2
17-Sep(day -11)	11652.7	12212.0
18-Sep (day -12)	10225.3	10716.1
19-Sep (day -13)	16138.3	16913.0
20-Sep (day -14)	26268.1	27529.0
21-Sep (day -15)	33800.0	35422.4
22-Sep (day -16)	25066.0	26269.1
23-Sep (day -17)	14250.0	14934.0
24-Sep (day -18)	6046.0	6336.2
25-Sep (day -19)	2548.5	2670.8

Table 20: Ordinates of Hydrograph Generated for Various Return Periods in m^3/s

Time	*5-year Return Period Flood Hydrograph (Factor=0.791)*	*10-year Return Period Flood Hydrograph (Factor=0.935)*	*25-year Return Period Flood Hydrograph (Factor=1.117)*	*50-year Return Period Flood Hydrograph (Factor=1.252)*	*100-year Return Period Flood Hydrograph (Factor=1.386)*	*200-year Return Period Flood Hydrograph (Factor=1.435)*
Day-1	2504	2960	3536	3963	4388	4544
Day-2	9360	11062	13215	14812	16399	16983
Day-3	14518	17157	20498	22973	25435	26341
Day-4	12121	14325	17114	19181	21236	21993
Day-5	13515	15971	19081	21386	23677	24521
Day-6	11131	13154	15715	17614	19501	20196
Day-7	16920	19995	23888	26774	29642	30699
Day-8	20792	24572	29357	32903	36428	37726
Day-9	17317	20465	24450	27403	30339	31421

Day-10	16256	19212	22952	25725	28481	29496
Day-11	9782	11561	13811	15480	17138	17749
Day-12	8584	10145	12120	13584	15039	15575
Day-13	13548	16011	19128	21439	23735	24582
Day-14	22052	26061	31135	34895	38634	40011
Day-15	28375	33533	40062	44901	49711	51483
Day-16	21043	24868	29710	33298	36866	38180
Day-17	11963	14137	16890	18930	20958	21705
Day-18	5076	5998	7166	8032	8892	9209
Day-19	2139	2528	3021	3386	3748	3882

Finally, the hydrographs generated for various return periods are plotted and a typical Q_{25} graph is shown in Figure 7.

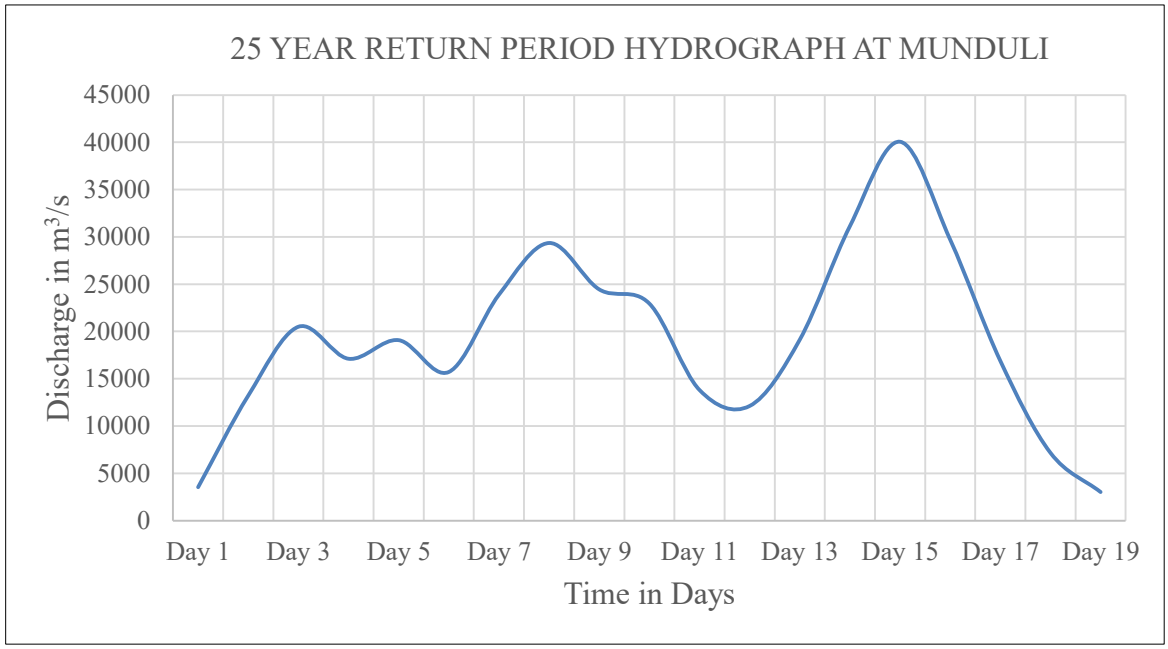


Figure 7: A 25 Year Return Period Hydrograph from CWC data at Munduli Site (Analysis by 48 Years CWC Data)

7. HEC-RAS Software and the RAS Mapper

The selection of a suitable modeling tool is very important to get the stability among modeling accuracies. The HEC-RAS software v5.0.7 model developed by the Hydrologic Engineering Centre of the U.S. Army Corps of Engineers is selected for the present study. HEC-RAS v5.0.7 is a unified system of software, developed for collaborating use in a multi-tasking environment. The system software includes a graphical user interface (GUI), separate hydraulic analysis mechanisms, organization abilities, and data storage, reporting facilities, and graphics. The HEC-RAS model comprises progressive features for the present simulation.

Floodplain analysis is one of the prime purposes of the U.S. Army Corps of Engineers Hydrologic Engineering Centre's HEC-RAS software package. RAS Mapper permits the user to quickly view floodplain ranges without using any other software like Arc-GIS, HEC-GeoRAS, and CADD program. The modeler can more effortlessly recognize problems with model results and know where to make improvements. Visualization of hydraulic outcomes is enormously valuable for model evaluation, reports, and presentation to clients. RAS Mapper permits for the presentation of inundation depth, water surface elevations (traditional floodplain mapping), floodplain depths, floodplain boundary, shear stress, ice thickness, stream power, flow velocities, and floodway encroachment data. This permits for a very special demonstration of hydraulic results for almost all types of hydraulic analysis. To use the RAS Mapper for analysis, a user should have a terrain model DEM in the form of a "Tagged Image Format File" (.TIFF). The resultant depth grid is stored in the (.TIFF) format while the boundary dataset is stored in the form of ESRI's Shapefile for use with geospatial software.

7.2 Preparation of Flood Inundation Maps

For the present work, flood peaks from 5 years to 200 year return periods, that is, (Q_5), (Q_{10}), (Q_{25}), (Q_{50}), (Q_{100}), and (Q_{200}) are obtained and their respective hydrographs are constituted as discussed in Table 20. These flood hydrographs are given as inputs to the HEC-RAS model with Munduli as the starting point of interest which is just the upstream of Cuttack and before the main Mahanadi branching off to Kathajodi. The primary interest is to prepare a flood inundation map on the branched main Mahanadi at the Baliyatra ground located near the Cuttack medical hospital.

The Baliyatra ground comes within the boundary of the reservoir area of the Jobra Anicut. The water resources department of the Government of Odisha has undertaken dredging activities in the reservoir. The activities involve excavating the dunes within the reservoir area and strengthening the Baliyatra ground by dumping the excavated sand materials on the area, thus increasing its elevation to some height while maintaining its level below the ring road level of the adjoining Cuttack city at the defined reach. This has changed the landscape of the area in the right banks of Mahanadi starting with the ring road from Cuttack. The length of this elevated area of Baliyatra ground is about 1.5 km along the ring road and off

shooting into the river for about 1 km at the maximum point in a triangular shape. This area can be seen in Figure 8. Thus the flow width at this point of Mahanadi River is reduced. People of the locality have apprehension about the subsequent flooding and submergence of the nearby areas due to the restriction imposed on the flow path (width) of the river

To understand the possible impact of this change in the landscape of the river at this stretch, routing of floods of various return periods is carried out using the HEC-RAS modeling tool. The flood water gets automatically divided into the Kathajori branch and the main Mahanadi following the elevation maps provided through the DEM. The simulated outputs are obtained. Propagation of flood waves in the river and the adjoining floodplains are captured in the inbuilt recording system in the software.

Figure 8: Map of Mahanadi River at Baliyatra Ground Showing Location of the Cross Sections

Water spread area during the passage of Q_{25} flood is captured and can be seen in Figure 9.

In a similar exercise flood inundation maps during the passages of Q_{25}, Q_{50}, and Q_{100} floods are shown in Figure 10. It can be seen that there is a small change in the flood water level between Q_{25}, Q_{50}, and Q_{100} even though the flood peaks for these events are significantly different. These peaks are 40063, 44902, and 49711 m^3/s respectively for the Q_{25}, Q_{50}, and Q_{100} floods.

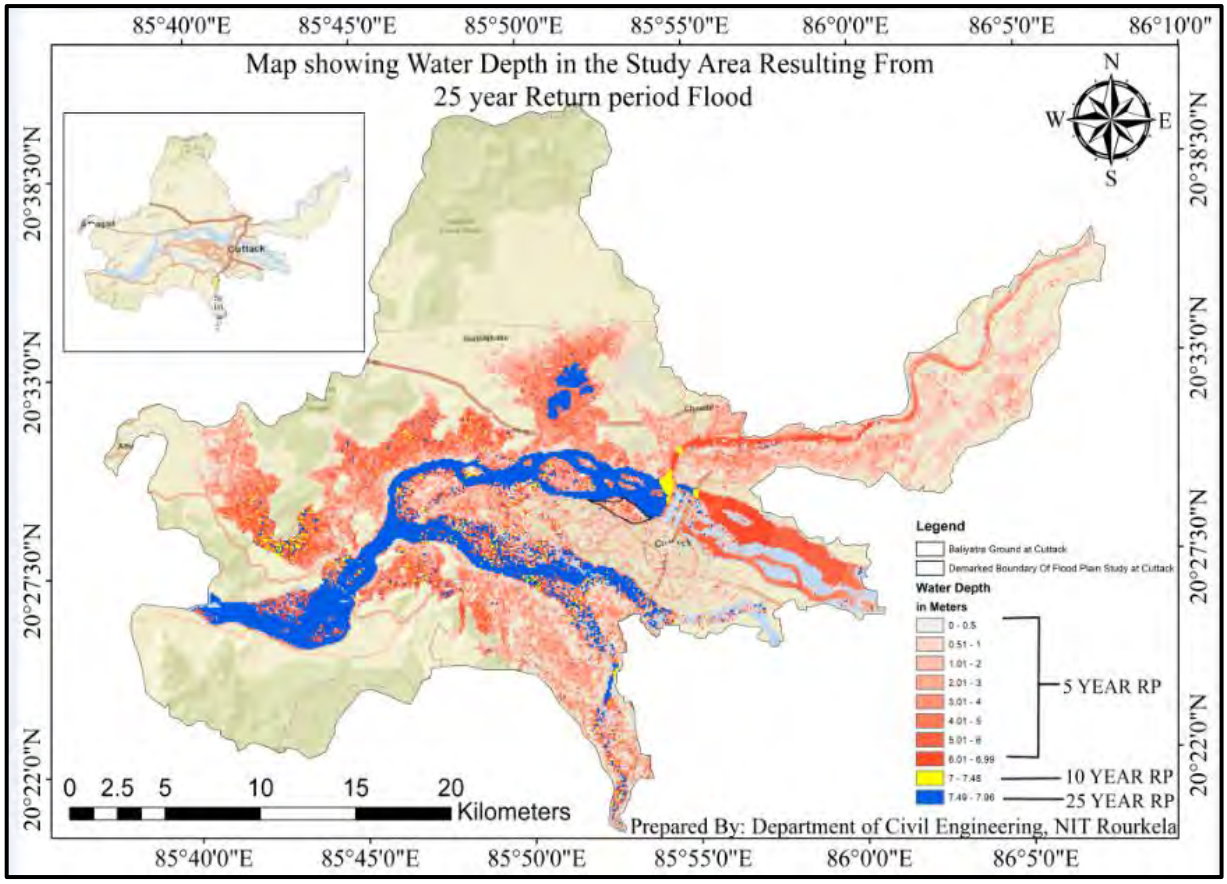


Figure 9: Flood Inundation Map of Mahanadi River at Baliyatra Ground during the passage of Q_{25} flood. (Analysis by 48 Year Data)

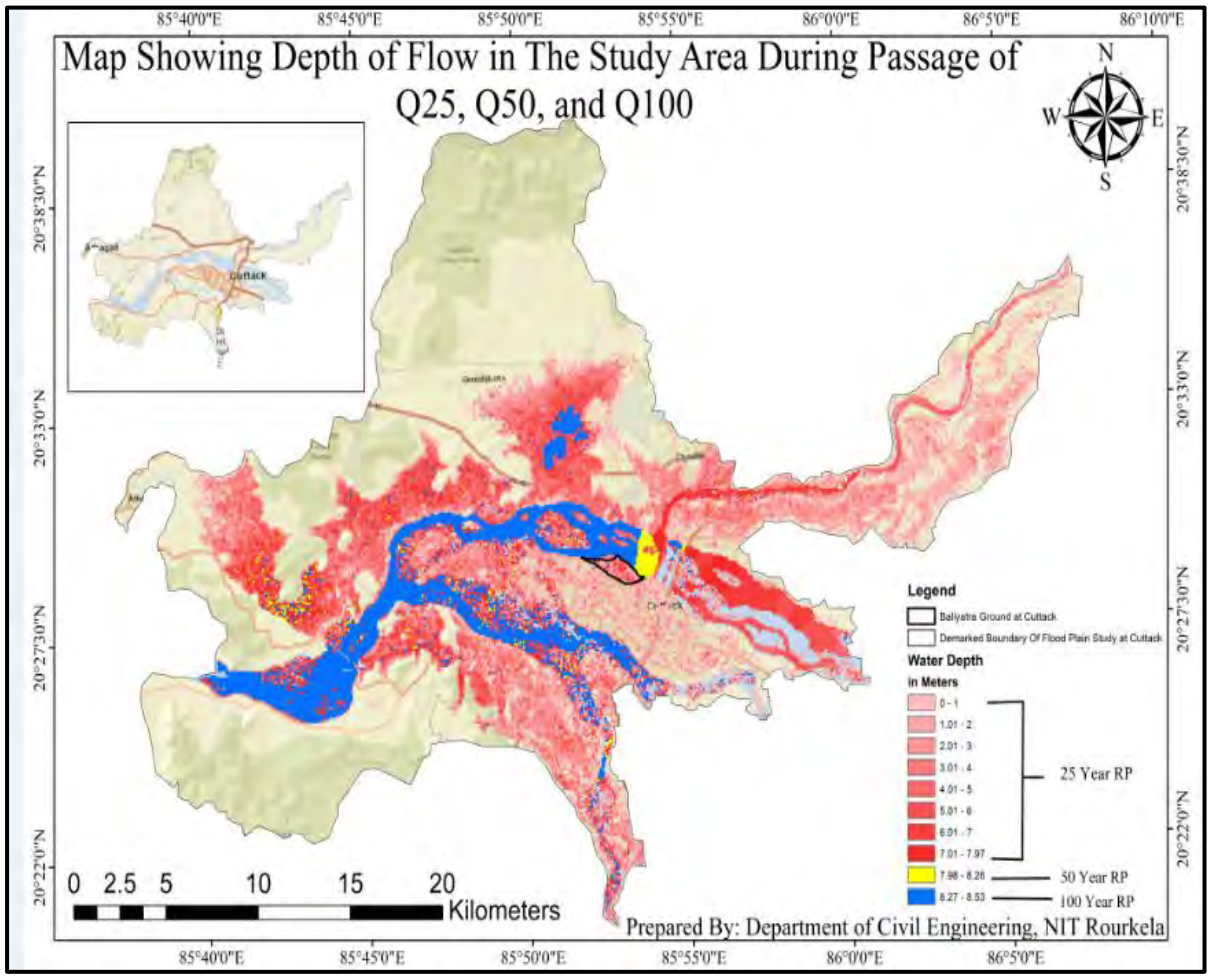


Figure 10: Water Spread Map of Mahanadi River at Baliyatra Ground during the passage of 25 year Return Period Flood along with 50 years and 100 year return period floods. (Analysis by 48 Year Data)

At the concerned stretch of Baliyatra ground, five cross-sections of the flood inundation area starting from inside the Cuttack city (right bank of the river) and extending beyond the left bank of the Mahanadi river into the adjoining floodplain area as marked in Figure 8 are selected. The five cross-sections extend into the floodplain to its full width to capture the inundated floodplain depths. These cross-sections are straight lines almost perpendicular to the flow line at these locations. This covers the full extent of the submergence area as mapped in the flood inundation map. Water level during the propagation of 25 year return period flood hydrographs across the river and the floodplain for the cross sections (CS 1.1, CS 3.1, and CS 5.1) are shown in Figures 11-13. The ground RLs across the cross sections are corrected uniformly with respect to the spot levels of the ring road, Baliyatra ground and river bed (provided by Odisha WRD) by applying a single correction factor.

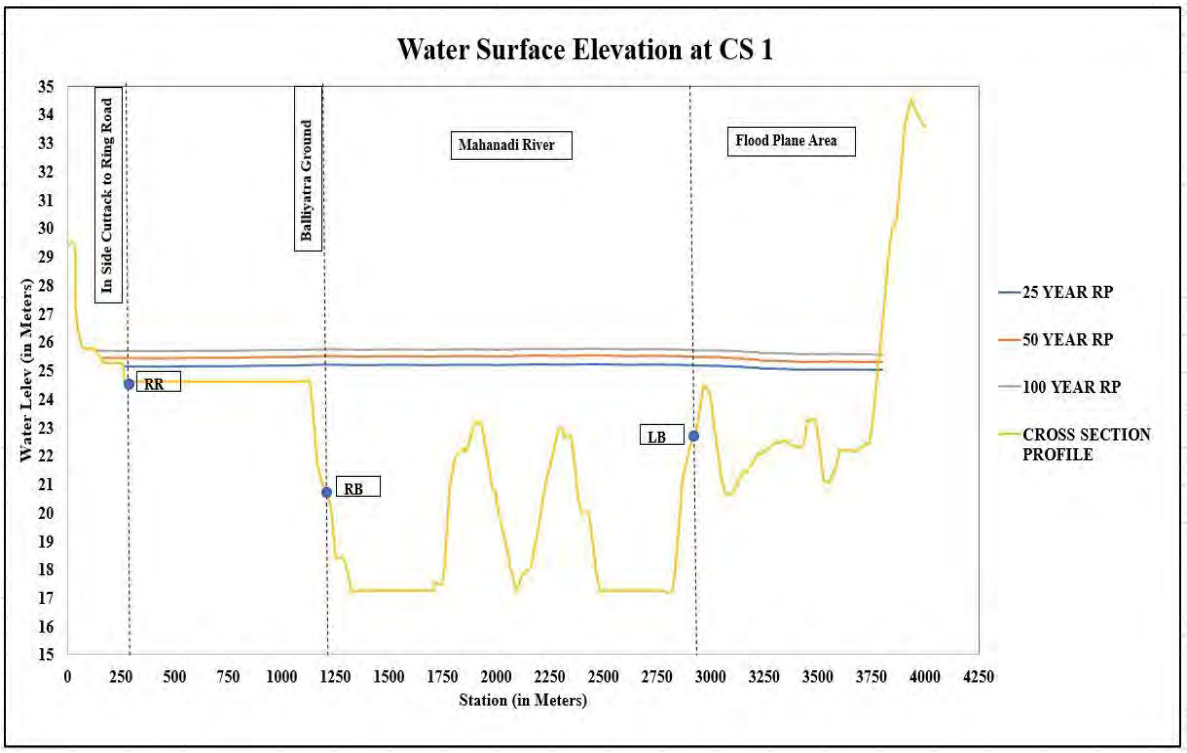


Figure 11: Water Surface Elevation Map at Cross Section 1 (48 Years CWC Data)

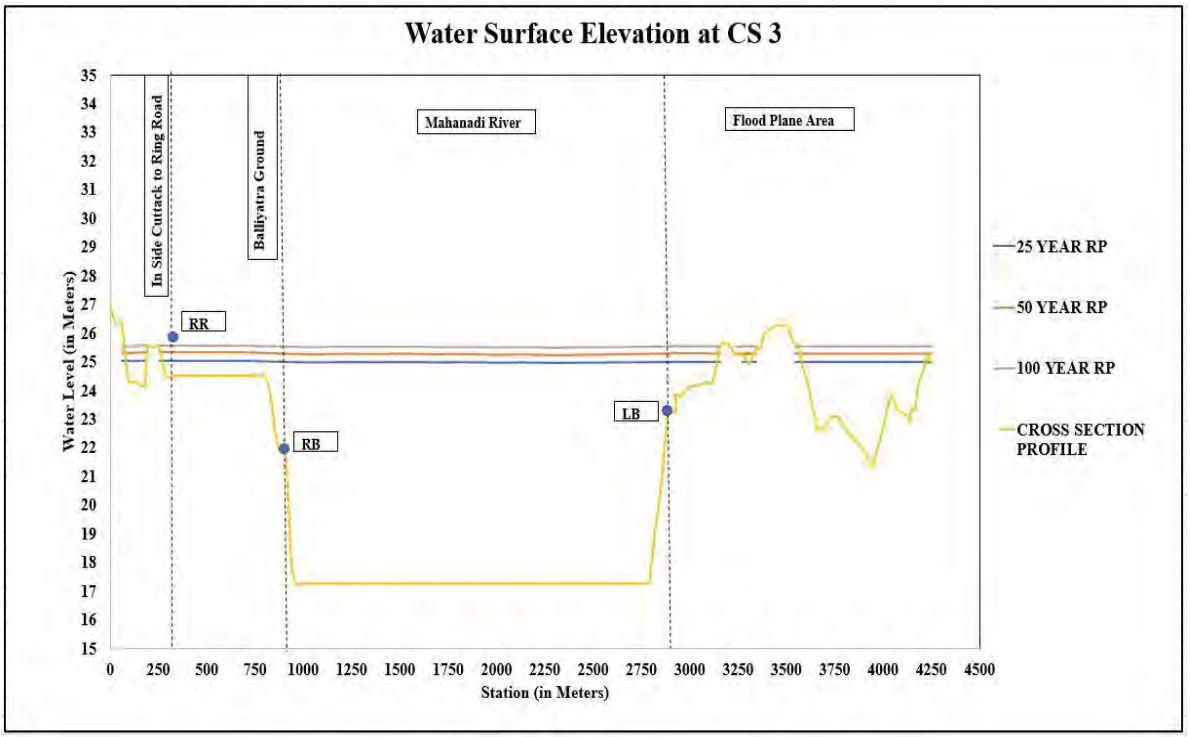


Figure 12: Water Surface Elevation Map at Cross Section 3 (48 Years CWC Data)

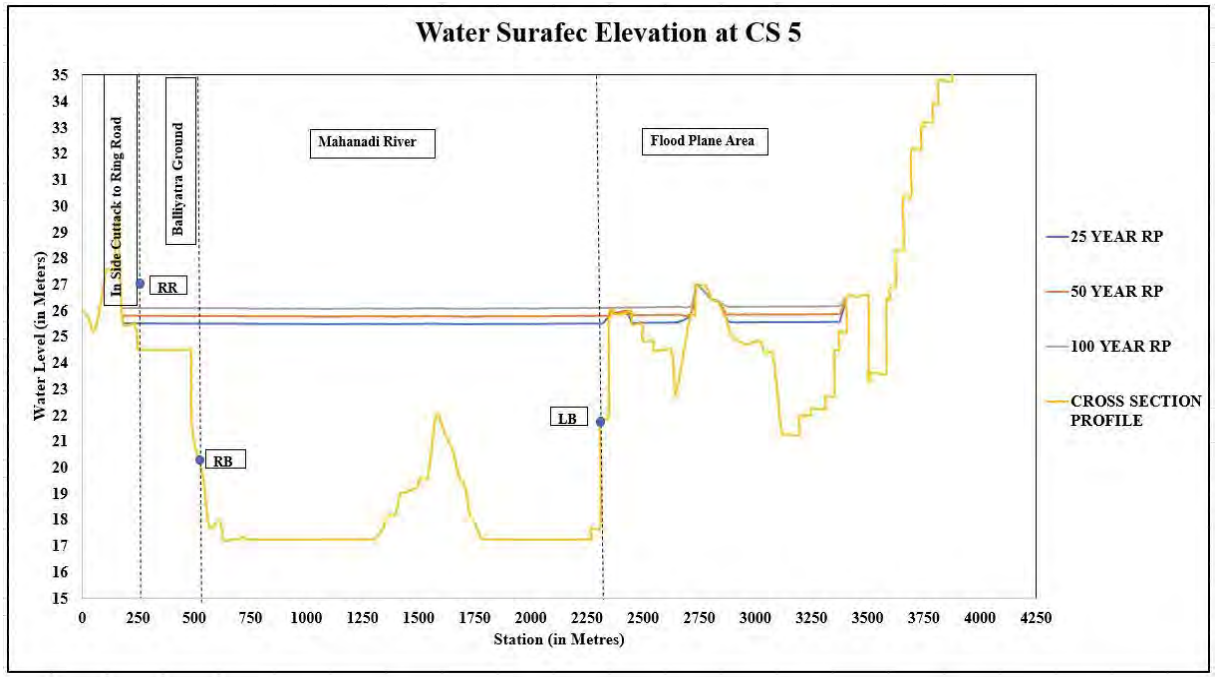


Figure 13: Water Surface Elevation Map at Cross Section 5 (48 Years CWC Data)

The flood of 25 year return period is most likely to affect about 38 villages in and around the Cuttack city between Munduli and up to the lower reach (Figure 14), while another 66

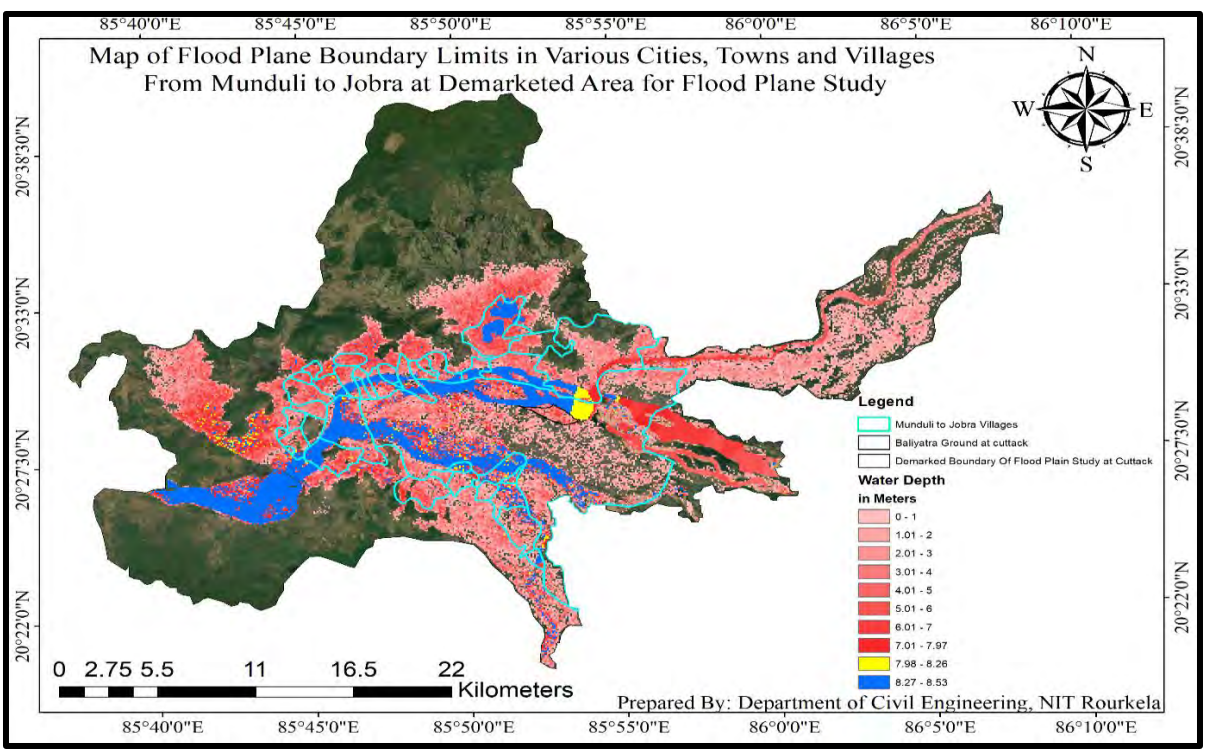


Figure 14: Map showing the villages and other inhabitation areas located within the floodplain zones of 25 year return period flood that are likely to be affected

villages are expected to be partially affected. List of these 38 villages and the submergence area are given in Table 21 and Figure 14 respectively.

Table 21: List of villages expected to be affected during the passage of 25 year return period flood in periphery outer zones

Most Likely to be Affected Village List		
1. Balipur	2. Pahilabar	3. Talagar
4. Baula	5. Lalitabisakhapur	6. Chhagan
7. Madhyakachha	8. Agrahat	9. Nuapatana
10. Sankarpur	11. Jhatia	12. Shrirangapur
13. Bhabadeipur	14. Katkiasahi	15. Jagannatarapur
16. Nuasasan	17. Mangalpur	18. Ramshyampur
19. Badasantarapur	20. Jemadeipur	21. Arilo
22. Suniamunha	23. Bhuinbarei	24. Kotar
25. Bandhahata	26. Sarakuan	27. Paikerapur
28. Sardarkharida	29. Brahmanbasta	30. Nuagada
31. Kalankipur	32. Anantapur	33. Prabatia
34. Jagmohanpur	35. Baghua	36. Similihanda
37. Badapadagaon	38. Sanakakhadi	

8. Results and Discussions

1. Statistical parameters C_v and C_s of the CWC data series are less than the corresponding values of Odisha WRD data series both for the original as well as log transferred values. This indicates that the dispersion characteristics and the skewness of the CWC data are less than the Odisha WRD data which weighed in favour of opting for CWC data. Again, since the interest is to choose the extreme values, the obvious choice is for the Gumble's Extreme Value analysis. Therefore Q_{25} of CWC data of 40, 063 m^3/s is considered as the flood for floodplain mapping.
2. To check the best fit distribution for the present data a request was made to Dr A K Lohani, Scientist-G, NIH Roorkee, who as a joint committee member assisted us and carried out various L-moments for 7 types of frequency distributions (EV1, GEV, LOGISTIC, GEN LOGISTIC, GEN PARETO, NORMAL, and LOG NORMAL) and concluded that the log normal distribution has the best fit amongst all with respect to different performance indicators such as ADA, ADR, EFFICIENCY and DINDEX. The values of Q_{25} for log-normal distribution is higher than the Pearson Type-III and the Log Pearson Type-III, while it is slightly less than the Gumble's Extreme Value distribution. Therefore, in the present study, Gumble's Extreme Value Analysis is

selected against the others. Moreover, the difference between Log Normal value of Q_{25} of 38,291 m^3/s and Gumble's distribution value of Q_{25} 40,063 m^3/s may not have much difference in the submergence potential in the study area.

3. Flood of 25 year return period (Q_{25}) can be considered as adequate for modelling and identifying the floodplain inundation area in the present locality. Observed discharge at Munduli (Naraj Railway bridge site) by Odisha WRD on 20th September, 2008 was reported as 44,768 m^3/s, while almost the same magnitude of discharge was recorded on 31st August, 1982 (not tabled here). The corresponding values by CWC at Tikarapara are 31,050 and 33050 m^3/s respectively. These CWC values are proportioned to 32, 954 and 35,066 m^3/s at the Naraj bridge site (located below Munduli but above the bifurcation point of the Mahanadi River). These values at the two sites are disproportioned to each other. Considering the goodness of CWC data, the Q_{25} value of 40, 063 m^3/s can be quite acceptable for the present study.

   This flood is quite specific to the location as the difference in flood depths between Q_{25} and Q_{100} is not found to be significant. This may be due to the river at this stretch is quite wide and thus, it is in a position to pass the flood of various return periods starting from Q_{25} to Q_{100} without appreciable change in the floodplain submergence width.

4. While routing this Q_{25} flood it can be seen that the depth of water over the Baliyatra ground during the propagation of this flood just exceeds its average formation level of RL 24.5 m. Therefore, any development activities in this area can be suitably planned keeping in mind the submergence of this rehabilitated area can be expected at least once in 25 years.

5. The flood of 25 year return period is most likely to affect about 38 villages in and around the Cuttack city between Munduli and up to the lower reach, while another 66 villages are expected to be partially affected. These villages can be located on the outer sides of both Kathjodi and Main Mahanadi branches and towards the country sides. Developmental activities can also be suitably planned in the adjoining areas of Mahanadi as marked in the inundation map during the propagation of Q_{25} flood waves in the main river and the adjoining floodplain.

6. The mean and maximum velocity of flow at cross-section CS 5.1 (having sand dune) areas are 0.493 m/s and 1.051 m/s, while at cross-section CS 1.1 (having no sand dune) the corresponding values area 0.62 m/s and 1.155 m/s. The same values at cross-section CS 3.1, which is close to the Jobra barrage are 0.527 m/s and 1.02 m/s. From this, it can be observed that the removal of sand dunes has increased the velocity of flow at the section.

7. The level of ring road near the IOCL pump house is about 25.3 m and at this line of location the level of Baliyatra ground is 24.50 m, while the river bed level is 16.0 m. In a parallel study, it is found that the water level during the propagation of Q_{25} flood of 42451 m^3/s by considering the data of Odisha WRD from 1997 to 2020 (against the CWC Q_{25} of 40063 m^3/s) at Jobra is 24.47 m, while at the location in line with IOCL pump house is about 25.1 m. This indicates that even during the propagation of this higher flood, the water level is below the level of ring road at this location.

8. The Odisha state water plan 2004 (ANX-G) on the flood during 31st August, 1982 highlights a high flood at Naraj Railway Bridge with discharge of 44,749 m^3/s (1,580,535 cusecs). At Jobra, the peak level had reached to 23.54 m (77.20') surpassing the recorded level 23.23m (76.20') in 1955. If this flood of 44,749 m^3/s has actually come (which is not in proportion with the CWC record of 31,050 m^3/s on that day) the flood did not submerge the ring road.

9. The flood of September, 1980 indicate that the total volume of high flood in Mahanadi system decreased to 36% where as in Kathjodi system is increased to 64%. The observed flood of 31st August, 1982 records the discharges in Mahanadi as 42%, whereas the discharges in the Kathjodi system were 58%. These two show the uneven distribution of flood between the two branches of the river system, the standard distribution percentages being 55% for Mahanadi branch and 45% Kathajodi branch respectively.

10. Crosschecking of the water spread of the study area with satellite imagery cannot be made as the satellite imageries are not available on the flood date of 19-20th September, 2008. However, the flood levels of the area at Jobra site on the flood dates are found to be below the levels of ring road and they are below the levels of model outputs.

9. Conclusions and Recommendation

1. From the derived statistical parameters of the CWC as well as Odisha WRD data, the value of 25 years return period flood (Q_{25}) of magnitude 40,063 m^3/s (from CWC data) is considered for floodplain mapping of the study area. During the passage of floods of Q_{25} and Q_{100}, the difference in flood depths over the study areas are not found to be significant. This may be due to the river at this stretch is quite wide and thus, it is in a position to pass the flood of various return periods without appreciable change in the floodplain submergence geometry.
2. While routing this Q_{25} flood, it can be seen that the depth of water over the Baliyatra ground during the propagation of this flood just exceeds its average formation level of 24.5 m, but below the RL of ring road. Records from Odisha WRD indicate that water level during the passage of the flood of 44,768 m^3/s was less than the RL of ring road, which further strengths the present finding on the safety of passage of the flood. Therefore, any development activities in this area can be suitably planned keeping in mind the possible submergence of this Baliyatra rehabilitated area can be expected at least once in 25 years.
3. The flood of 25 year return period is most likely to affect about 38 villages in and around the Cuttack city between Munduli and up to the lower reach, while another 66 villages may be partially affected. These villages are on the outer periphery of both Kathjodi and Main Mahanadi branches.
4. The mean and maximum velocity of flow at cross-section 5 (having sand dune) areas are 0.493 m/s and 1.051 m/s, while at cross-section 1 (having no sand dune) the corresponding values area 0.62 m/s and 1.155 m/s. The same values at cross-section 3 which is very close to the Jobra barrage are 0.527 m/s and 1.02 m/s. From this, it can be observed that the removal of sand dunes has increased the velocity of flow at the section.
5. National Disaster Management Authorities (NDMA) Guidelines (https://ndma.gov.in/Governance/Guidelines), and all other design codes need to be followed while implementing any concepts for the utilization of Baliyatra Ground at Cuttack. Scope of the allowed and non-allowed facilities under the Priority-1, 2 and 3 may be referred in the Appendex-2.

10. Limitations of the Study

The present floodplain zoning study for the identified stretches of Mahanadi river basin has been carried out based on the discharge data provided by the (i) Central Water Commission (CWC) as well as Odisha Water Resources Department (WRD), (ii) DEM Provided by National Remote Sensing Centre (NRSC), (iii) Reduced levels of baliyatra and other points by Odisha Water Resources Department (WRD), and (iv) Modelling through HEC-RAS 6.0. The study has the following limitations:

- The flood inundation area has been computed from the CARTOSAT DEM which is not verified from the ground survey and DGPS.
- Some water resources projects (both storage projects and diversion schemes) are expected to come up in future in the upstream catchment areas that is expected to store more water and moderate floods leading to reduce its peak at the Baliyatra site.
- The study has the limitations inherent to the modelling through the software, quality and accuracy of the data, accuracy of the DEM, and all other associated parameters.

Prof K C Patra
Professor HAG
Civil Engineering Department,
NIT Rourkela- 769008
Ph.: - 9437220994, 7008372760
Email: - kcpatra@nitrkl.ac.in Prof_kcpatra@yahoo.com

Appendex-1

L-MOMENTS are
LEMDA1= 21412.8000
LEMDA2= 4494.2930
LEMDA3= 191.3086
LEMDA4= 465.2109
L-CV= 0.2099
L-CS= 0.0426
L-CK= 0.1035

QUANTILE VALUES USING LMOMENTS								
F	T	EV1	GEV	LOGIS	GENLOGIS	G.PARETO	NORMAL	L.NOR
0.3	1.43	16466.65	16912.19	17604.8	17369.16	15884.76	17239.7	17001.14
0.5	2	20046.67	21036.22	21412.8	21098.17	20979.87	21412.8	21067.39
0.8	5	27395.69	28143.79	27643.22	27496.96	29370.26	28114.09	27996.99
0.9	10	32261.38	32001.37	31287.78	31418.83	32573.95	31620.37	31829.69
0.95	20	36928.67	35172.95	34645.98	35154.38	34367.79	34515.11	35106.25
0.96	25	38409.19	36083.07	35695.91	36346.89	34756.5	35358.21	**36080.18**
0.98	50	42970	38627.94	38903.79	40064.7	35589.87	37772.18	**38918.76**
0.99	100	47497.12	40808.87	42064.63	43840.16	36056.49	39943.11	**41536.19**
0.995	200	52007.73	42686.48	45202.47	47701.63	36317.77	41929.71	43986.29
0.998	500.01	57958.69	44779.63	49334.13	52964.34	36495.77	44336.99	47027.25
0.999	1000.01	62456.23	46114.84	52453.84	57076.79	36563.73	46025.47	49208.34
0.9991	1111.15	63139.83	46301.32	52927.9	57712.4	36571.03	46273.58	49532.23
0.9993	1428.58	64769.79	46729.68	54058.16	59239.4	36586.04	46856.8	50297.06
0.9994	1666.72	65769.8	46981.53	54751.53	60184.29	36593.81	47209	50761.29
0.9995	1999.91	66951.76	47268.89	55571.03	61309.09	36601.79	47620.01	51305.3
0.9996	2499.96	68399.12	47606.15	56574.48	62698.31	36610.03	48115.83	51964.82
0.9997	3333.44	70265.06	48018.29	57868.09	64508.82	36618.63	48743.47	52804.8
0.9998	5000.66	72895.02	48558.55	59691.26	67098.46	36627.71	49607.26	53970.27
0.9998	6665.56	74758.55	48914.49	60983.07	68960.62	36632.52	50205.48	54783.88
0.9999	9998.34	77387.71	49381.56	62805.58	71626.82	36637.61	51031.23	55915.71

	ADA	ADR	EFFICIENCY	DINDEX
EV1	7.4129	1.7248	92.9364	1.1203
GEV	4.3701	0.3976	96.3972	0.9461
LOGISTIC	6.6419	1.2058	96.2365	**0.7426**
GEN LOGISTIC	5.6849	0.6297	96.3503	0.7349
GEN PARETO	5.7572	2.0006	93.5769	1.1724
NORMAL	4.897	0.5453	96.4202	0.8493
LOG NORMAL	**4.3745**	**0.3853**	**96.6464**	**0.8732**

Appendex-2

Scope of the allowed and non-allowed facilities under Priority-1, 2 and 3

Categorization	Type of Structures permitted as per NDMA Guidelines	Basis of Prioritization and guidelines	Study Recommendations (Joint Committee may decide on the Activities following NDMA guidelines)
Priority - 1	• Defence installations • Industries • Public utilities like hospitals, electricity installations, water supply, telephone exchanges, aerodromes, railway stations, commercial centres, etc.	Buildings should be located in such a fashion that they are above the levels corresponding to a 100- year frequency or the maximum observed flood levels. Similarly they should also be above the levels corresponding to a 50-year rainfall and the likely submersion due to drainage congestion	Structures under Priority-1of the NDMA Guidelines is not permitted in the Baliyatra Ground.
Priority - 2	• Public institutions • Government offices • Universities • Public libraries • Residential areas	Buildings should be above a level corresponding to a 25-year flood or a 10-year rainfall. Stipulation that all buildings in vulnerable zones should be constructed on columns or stilts. (a) Plinth levels of all buildings should be 0.6 m above the drainage/flood submersion lines. (b) In the areas liable to floods, all the buildings should preferably be double and multiple storeys. (c) In urban areas ground floor to be utilised for non- residential purposes	Baliyatra Ground comes under floodplain zone, therefore construction of structures of permanent type, as in column 2 of this table (priority-2) may be prohibited Baliyatra Ground is within floodplain area and therefore non-permanent structures may be allowed subject to strict adherences to the NDMA guidelines, Building Codes and others. These structures should be planned as far as away from the river water lines and active during non-monsoon days so that there is no loss to the life and property.
Priority - 3	• Parks and playgrounds	Certain areas on either side of the existing and proposed drains (including rural drains) should be declared as green belts where no building or other activity should be allowed. This will not only facilitate improvement of these drains in future for taking discharges on account of growing urbanisation, but will also help in minimising the damage due to drainage congestion whenever rainfall of higher frequency than designed is experienced. These green belts, at suitable locations, can also be developed as parks and gardens.	Priority-3 activities such as developments of Parks, Play-grounds and creation of other facilities (such as Recreational Space, Urban Forests, Pedestrian Paths, Cycle Tracks, Solar Lighting, Rain Water Harvesting, Gardens, Footpaths, Cycle Tracks, Open Air Market, temporary Craft Bazar, Food Stalls, Open Air Auditorium) may be permitted following NDMA Guidelines in the Baliyatra Ground. These facilities should be active during non-monsoon periods so that there is no loss to the life and property.

Email **Mrinal Kanti Biswas**

Mahanadi Waterfront Concept Note

From : Swasti Das <Swasti.Das@ap.jll.com> Tue, Apr 13, 2021 06:39 PM
Subject : Mahanadi Waterfront Concept Note
To : Mrinal Kanti Biswas <mkbiswas.cpcb@nic.in>, biswasmrinal@gmail.com
1 attachment
Cc : ananya das17 <ananya.das17@gmail.com>

Dear Sir,

Kindly find enclosed the concept note on Mahanadi Waterfront Development.

Thanks & Regards,

Swasti Binayak Das
Team Leader – PMU, CDA
Strategic Consulting, Infrastructure
Cell: +91 9937022079

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Mahanadi Waterfront Concept Note.pdf
21 KB

Mahanadi Waterfront Development

Vision : To transform the quality of life for all in the Cuttack region by creating an Iconic Waterfront development on the 426 acres of reclaimed land that provides oppurtunities for *live - work - play* supported by robust infrastructure, a resilient and responsive water edge, and sustainable financial models.

The vision for the masterplan is guided by a 3 E principle: Environment, Economy and Equity to attract and develop economic energies, provide for social and civic infrastructure for all and create a sustainable development which transforms Cuttack to a *pull city* from a *push city*.

Based on the guiding principles, the masterplan development is divided into three parts

Environment

(i) **A buffer along the river edge is to be developed as a green eco sensitive recreational space for the city inclusive of floodable wetlands, bio diversity parks, urban forests etc.**

(ii) **A hierarchy of green spaces connected to a large central open space is planned for along with a robust network of pedestrian paths and cycle tracks**

(iii) **Several zones in the masterplan will be demarcated as no-vehicular zones**

(iv) **Solar lighting, rain water harvesting and other smart technologies will be mandatory in the development**

Equity

(i) **The masterplan will provide the residents of Cuttack and regional, national and international tourists equal access to world class public infrastructure such as parks, gardens, sports facilities, art galleries and museums**

(ii) **The entire area will be serviced by a hierarchy of roads with uniform travel lanes, shaded footpaths, designated cycle tracks, safe intersections and landscape and public space inclusion.**

(iii) **The masterplan will be serviced by robust networked infrastructure in terms of underground sewage, 24/7 water supply, uninterrupted access to power, telecom, and a sustainable solid waste management system**

Economy

(iv) **Portions of the masterplan will be developed as open air market, craft bazar, food stalls like Dilli Haat (New Delhi) & Ekamra Haat (Bhubaneswar) to promote local art & crafts as well as traditional works i.e. applique work, filigree work, Maniabandha Saree, Sambalpuri Sarees etc. to improve livelihood and create employment in the region.**

(v) **50 acres will be reserved for the Bali Jatra grounds – to hold the 9 day festival in November, and it will be used as a multifunctional events ground for the rest of the year**

(vi) **An open air auditorium also shall be planned for performance of Odissi dance and other Indian dance forms to promote culture & tourism in the State.**

An underlying principle and perhaps the most important of all is to build a strong link between the city and river, visually and physically with a nature responsive approach.

(i) The development will be volumetrically zoned to have terraced buildings, view points and vistas to capitalise the proximity to the river.
(ii) The river edge will be designed as a green edge with various edge engineering solutions to revive the riparian ecology and promote bio diversity
(iii) There shall be a green buffer zone i.e. no development zone which will protect the river and create a flood safe zone for the development

The impact of the development is to incrementally improve the economy, tourism and environment of Cuttack and create a magnet with improved access to all services and infrastructure as well as opportunity for a better quality of life.

Minutes of the 2nd Meeting of the seven membered Joint Committee constituted by Hon'ble NGT vide its order dated 07.02.2022 in the matter of Pradip Kumar Pattnaik Vs Union of India & Ors. in O.A. No. 68/2020(EZ) held on 27.05.2022 at 11:30 AM through video conferencing

In compliance to the Hon'ble NGT order dated 07.02.2022 in the matter of Pradip Kumar Pattnaik Vs Union of India & Ors in OA No. 68/2020(EZ), a Joint Committee of seven experts was constituted.

The 1st meeting of the aforesaid seven membered Joint Committee was held on 31.03.2022 at 3:30 P.M through video conferencing wherein it was decided that a preliminary field visit was to be conducted. As Prof. C. R. Babu was not in a state to carry out field visit due to health issues, therefore Dr. M. S. Hussain, a representative of Prof. C. R. Babu; Prof. P. C. Mishra, Professor & former Expert Member of NGT along with Dr. Sohan Giri, Regional Officer, SPCB, Odisha and Prof. K. C. Patra, Civil Engg. Dept., NIT Rourkela visited the impugned site on 17.04.2022. Based on the observations and inputs provided by Dr. M. S. Hussain and Prof. P. C. Mishra, a preliminary report was submitted by Prof. C. R. Babu and shared with the members. The report elaborated that dumping has been carried out in the impugned area which is an integral part of the pondage area of Jobra Barrage on Mahanadi River at Cuttack city. The report further emphasized that this dumping in the mentioned pondage area will provide resistance to floodwaters which may cause massive downstream flash floods having pronounced detrimental effects on river ecosystem, life and property.

The 2nd meeting of the Joint Committee was held on 27.05.2022 at 11:30 AM through video conferencing to discuss the above-mentioned preliminary report.

All the committee members as well as Prof. K. C. Patra and Dr. M. S. Hussain attended the meeting.

List of the participants attended the meeting is enclosed at Annexure I.

Shri M. K. Biswas, Regional Director, CPCB, Kolkata welcomed all the members and requested Prof. K. C. Patra to present his work on flood plain zoning of the concerned area and also to elaborate his view while considering the area within the floodplain zone of river Mahanadi. Many members expressed that the location of 426 acre structure within the reservoir need to be examined.

Discussions were also held on the representation received from the State Water Resources Department, Govt. of Odisha based on the technical committee constituted by the State.

Based on the deliberation made, the following were decided;

1. CPCB would request the concerned state department to provide the following information;
    a. Salient Features of the Jobra Barrage
    b. Designed pondage area of the reservoir and area submerged as a result of construction of barrage in the concerned site.
    c. Relevant maps and documents to justify the purpose or need of construction of the Jobra barrage.

d. Drone pictures of the barrage and its reservoir along with the 426 acres filled structure
e. Relevant information justifying the dredging and removal of the sand from the storage area

2. A field visit of the Joint Committee Members to the concerned area is to be undertaken during July, 2022 following the acquisition of the required documents and information from the State Govt.
3. The Applicant and concerned state department as well as respondents in the matter will be informed about the field visit and a meeting may be convened at Cuttack to hear the viewpoints/ representation by the Committee during the field visit.
4. As kindly agreed by Prof. Patra, a draft point wise reply would be prepared and shared with members before the meeting at Cuttack.
5. OSPCB may be requested to coordinate with the state departments to arrange to provide the requisite information/documents at the earliest and also to organize the meeting with concerned agencies and applicants during the field visit of the committee.
6. OSPCB may also be requested to arrange the logistic for the members and for Prof. Patra.

The meeting ended with a vote of thanks to and from the members.

*****

Annexure-I

List of participants

Sl. No	Name of the Participants	Organization	Designation	E-mail id
1	Prof. C.R. Babu	University of Delhi	Professor Emeritus & Ex-Pro-Vice-Chancellor	crb26@hotmail.com, crbabu26@gmail.com
2	Prof. P.C. Mishra,	Sambalpur University, NGT	Professor & former Expert Member of NGT	profpcmishra@gmail.com
3	Dr. A. K. Lohani	National Institute of Hydrology, Roorkee	Scientist 'G'	lohani.nihr@gov.in
4	Shri M. K. Biswas	CPCB, RD, Kolkata	Regional Director (Nodal Agency)	biswasmrinal@gmail.com
5	Dr. Sohan Giri	SPCB, Odisha	Regional Officer	giri.sohan@yahoo.com
6	Dr. M.R. Prasad	RO, Bhubaneswar	Scientist 'C'	secobhubaneshwarcwc@nic.in; cemero-cwc@nic.in
7	Dr. Amrish Pal Singh	CWC, Bhubaneswar	Superintending Engineer (C), M&ERO	prasad.mr@gov.in
8	Prof. K.C.Patra,	Civil Engg. Dept., NIT Rourkela	Professor	kcpatra@nitrkl.ac.in
9	Dr. M. Shah Hussain	Biodiversity Park Programme, CEMDE, University of Delhi	Scientist (Ecologist)	mshahhussain@rediffmail.com
10	Shri. Dilip Kumar Jena	Central Water Commission, WRD	Superintending Engineer	dkjena-cwc@nic.in

12	Ms. Pallavi Mukherjee	CPCB, RD, Kolkata	Research Associate	pallavimukherjenv@gmail.com

BEFORE THE NATIONAL GREEN TRIBUNAL,
EASTERN ZONE BENCH, KOLKATA.

O.A. NO. 68 / 2020 / EZ

PRADIP KUMAR PATTNAIK APPLICANT

VERSUS

UNION OF INDIA AND OTHERS RESPONDENTS

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CUTTACK
DT.20.05.2022

ADDL. GOVT. ADVOCATE

1184 20/05/2022

SPECIAL ADHESIVE

NOTARY S.P. MOHANTY CUTTACK TOWN Reg. No. 01/01 Govt. of Odisha

NOTARIAL

BEFORE THE NATIONAL GREEN TRIBUNAL,
EASTERN ZONE BENCH, KOLKATA.
O.A. NO. 68/2020/EZ

PRADIP KUMAR PATTNAIK APPLICANT

VERSUS

UNION OF INDIA AND OTHERS RESPONDENTS

OBJECTION TO THE AFFIDAVIT, FILED BY THE CENTRAL POLLUTION CONTROL BOARD (CPCB) DATED 04.10.2021 AND TO THE FLOOD PLAIN ZONING STUDY REPORT OF THE COMMITTEE UNDER ANNEXURE-3.

Babulal Behera

I, Shri Babulal Behera, aged about 55 years, son of late Padmalochan Behera, at present serving as the Superintending Engineer, Mahanadi Barrage Division, Gandarpur, At.- Gandarpur, PO. - College Square, in the district of Cuttack, do hereby solemnly affirm and state as follows;

1. That, I am the respondent no.6 to the original application and on being duly authorised by the other respondents, I am competent to swear this affidavit for self and on behalf of other State/Respondents.

2. That, the deponent craves leave of this Hon'ble Court to raise issues to the report prepared by the Joint Committee on flood plain

NOTARY S.P. MOHANTY CUTTACK TOWN Reg. No. 01/01 Govt. of Odisha

zoning study and respective part of the affidavit filed by the CPCB on 4th October, 2021.

3. That, it is respectfully submitted that on receipt of the flood plain zoning study report under Annexure-I to the affidavit of CPCB, the State Government by office order dated 02.02.2022 formed a technical committee comprising of nine members to undertake further studies on the report of the Joint Committee, formed by this Hon'ble Tribunal, to find out whether the said report is erroneous and at any place which may affect the interest of the State. A copy of the letter dated 02.02.2022 is filed as **Annexure-R/6/A**.

4. That, the state's technical committee, constituted by the government visited the site on 25.02.2022 and made detailed study on the issue vis-à-vis the report submitted by the Joint Committee formed by this Hon'ble Tribunal. After visiting the site the committee had a detailed analysis of the entire aspects, relating to the issue and came to the following conclusions;

a) During passage of Q25 flood the expected water level at Baliyatra ground will be around 23.7937m.

b) Due to Q100 flood the expected water level at Baliyatra ground will be around 24.497m.

c) The average formation level of Baliyatra ground is 24.5m and the average TBL of the ring road is 25.5m.

d) That, the highest ever flood passed in river Mahanadi during the year 1982 with flood discharge of 15.84 lakh cusses, the water level recorded at Baliyatra ground is 23.54m which is less than the computed Q25 water level (i.e. 23.79m). Although last 40 years record since the year 1982 reflects that, the flood water level is less than 25 year flood forecast i.e. Q25, it is arrived that in the meantime Q25 has passed and flood peak is below compute Q25.

e) As the expected water level at Baliyatra ground due to Q25 is less than and Q100 floods is about less than equal to the average formation level of the Baliyatra ground, some construction activities can be carried out as per guidelines of NDMA (National Disaster Management Authority).

f) That, as per the report of state's technical committee, since the land fill area is well bounded by two spurs on either side, two rows of sheet piles on the river side and ring road embankment on the southern side, a portion of the said area adjacent to the embankment (ring road) may be considered for permanent construction purposes by raising the plinth level about the Top Bank Level of the ring road which is at RL 25.5m. The structural safety aspect shall be given top priority while preparing the design.

g) The utilisation of the above land may be only for specific public utilities considering the present situation of Cuttack City and

Bahulal Behera

shall not be construed as an example to be implemented in other flood plains in the State.

h) Proposed storage projects or diversion scheme in Mahanadi and its tributaries between Hirakud and Mundali will be able to store some water and help to moderate future floods on the d/s side thereby reducing the chances of submergence of Baliyatra ground.

i) Record of submergence, peak discharge in Mahanadi was recorded in this year 1982 (15.84 lakh cusecs) and year 2008 (15.82 lakh cusecs) which are almost similar magnitude and the status of submergence in the history of flood is given below i.e on dtd.20.09.2008, only 13 nos. of villages affected in crop loss.

The finding/conclusions of the Technical Committee, as stated above, has been duly communicated to the CPCB, vide letter No. 1507 dated 28.04.2022, a copy of which is filed as **Annexure-R/6/B**.

5. That, the Technical Committee has arrived at the above conclusion after having a study of flood of 100 years return period (Q100) for identifying the flood plain area. It is hereby submitted that the joint committee formed by the NGT has made the assessment taking into consideration the flood of 25 years of return period (Q25).

It is to be made clear that as has been observed by the State's Technical Committee that taking 25 years return of flood period

(Q25), the expected water level at Baliyatra ground comes around 23.7937m. Hence, the averment made by CPCB at paragraph-II (iv) of the affidavit is not correct. In this context, it is further submitted that it is an incorrect assessment to say that the depth of water over Baliyatra ground during the propagation of Q25 flood exceeds it is average formation level of 24.5m.

6. That, further it is respectfully submitted that the averment taken at paragraph-10(c) and the corresponding finding in the report saying that the flood of 25 years of return period is most likely to affect 38 villages in and around the Cuttack City between Mundali and up to the lower reach, while another 66 villages may be partially affected which are on the outer periphery of both Kathajodi and main Mahanadi Branches, is not correct, as the same is based upon speculation which is apparent from the language used. It is further submitted that the joint committee should have been specific on the point that how many villages had been affected and should not have given a evasive conclusion saying most likely 38 villages would have been affected. Such finding of the joint committee need not be taken into consideration. But as per revenue records as found by state's technical committee during the flood of the year 2008 (of same discharge of 1982), only 13 nos of villages affected by crop loss only.

Babulal Behera

7. That, as has been observed by the technical committee, highest ever flood water level recorded at Baliyatra is 23.54m in the year 1982. It has been further observed that the average formation level of Baliyatra ground is 24.5m. and the average Top Bank Level (TBL) of the Ring Road is 25.5m. Hence, at no stretch of imagination it can be arrived at a just conclusion that the flood level can ever go above the average formation level of Baliyatra ground.

8. That, when the conclusions arrived at by the State's Technical Committee is clear and unambiguous, speculative conclusions of the Joint Committee may not be taken into consideration. Hence, permanent construction of any kind limiting to pome area, if proposed by raising the plinth level above the top bank level of the ring road giving priority to the structural safety aspect, may kindly be considered.

9. That, it is respectfully submitted that an area of 424 acres of land is lying vacant which can be utilised for many constructive purposes. Even though the constructions under priority No.-2 (at some places) and priority No.-3 have been suggested by the joint committee for giving permission, construction of priority No.-1 has not been suggested. In view of the conclusions of the Technical Committee and looking at the average TBL and average formation levelof Baliyatra ground at least 25% of the above area may be allowed for permanent construction alongside the ring road.

Prahlad Behra

embankment keeping in mind sustainable developments in every aspect. Cuttack being a millennium old city is thickly populated and having been bounded by two river delta, this embankment widening and fortification will help the social and safety requirement of the city.

10. That, in the above context it is most respectfully submitted that out of the 424 acres of reclaimed, the area that falls between the two spurs and adjacent to existing embankment (Cuttack ring road), which comes around 66.7 acres of land, can be developed by way of permanent construction, for the public purpose. It is apt to mention here that earlier the said area was under the occupation of slum dwellers. If the same portion would not be used for the purpose of public utilities, the said area, in all probability, is likely to be occupied again by the slum dwellers.

Bahulal Behra

11. That, it is further humbly submitted that the area where Baliyatra is being held has to be kept vacant and the government has no proposal for any kind of permanent construction over the same. It is submitted that so far as types of activities under priority no3 for public purpose, the State Government has absolute faith and hence leave it to the discretion of this Hon'ble Tribunal to decide on the types of activities to be undertaken to give a new life to population of Cuttack & Odisha as a whole.

For better appreciation of this Hon'ble Tribunal, a copy of tabular comparative analysis on the finding of the Joint Committee Report vis-à-vis the report of the Technical Committee, constituted by the Respondent no.6, is enclosed herewith as Annexure-R/6/B.

12. That, all the allegation which are not specifically admitted herein are deemed to have been denied and the deponent reserves the right to file further affidavit.

13. That, the facts stated above are true to the best of my knowledge, belief and based on records.

Identified by
Advocate

Babulal Behera
DEPONENT

CERTIFICATE

Certified that due to non-availability of cartridge papers, the instant object has been typed on thick white papers.

CUTTACK
DT. 20.05.2022

ADDL. GOVT.ADVOCATE

Annexture-R/6/A

GOVERNMENT OF ODISHA
DEPARTMENT OF WATER RESOURCES

*****

No.- WR-MAJIII-MISC-0002-2021: 2400 / WR, Dated: 2/2/2022

OFFICE ORDER

In supersession of this Department Office Order No. 1880 Dtd. 24.01.2022, the Technical Committee is hereby re-constituted with the following members.

1. Engineer-in-Chief, Water Resources - Chairman
2. CE&BM, Mahanadi Kathajodi System - Member
3. Chief Engineer, HH,GIS &CEM Member Convenor
4. Chief Engineer, Planning Member
5. Sri R.C.Tripathy, Ex-EIC, Water Resources - Member
6. Prof. R. Sunaravadivelu, IIT, Madras - Member
7. Prof.K.K.Khatua, NIT, Rourkela - Member
8. City Engineer, CMC, Cuttack - Member
9. Add. Chief Engineer, Eastern Circle-I - Member

The Committee shall undertake following studies and submit their report to this Department.

1. Historical flood level data of last 100 years of Mahanadi river near Cuttack city and the adjoining villages mentioned in the NGT report.
2. Guiding principle issued by NGT Committee and Study report prepared by NIT Rourkela on this matter.
3. Calculation of 100 year return flood and projected water level of river Mahanadi near Cuttack city and adjoining villages mentioned in the NGT report.

True Copy attested

Superintending Engineer
Mahanadi Barrage Division
Gandarpur, Cuttack

By order of Chief Secretary

Memo No. 2401 Dtd. 2/2/2022

Special Secretary to Government

Copy forwarded to OSD to Chief Secretary for kind information of the Chief Secretary

Special Secretary to Government

Memo No. 2402 Dtd. 2/2/2022

Copy forwarded to Sr. P.S to Additional Chief Secretary for kind information of the Additional Chief Secretary, DoWR.

02/2/2022
Deputy Secretary to Government

Memo No. 2403 Dtd. 2/2/2022

Copy forwarded to P. S. to Principal Secretary to Govt., H & UD Department for kind information of the Principal Secretary, H&UD Deptt.

02/02/2022
Deputy Secretary to Government

Memo No. 2404 Dtd. 2/2/2022

Copy forwarded to Members Concerned for kind information and necessary action.

02/02/2022
Deputy Secretary to Government

Memo No. 2405 Dtd. 2/2/2022

Copy forwarded to Collector, Cuttack/ Commissioner, CMC, Cuttack/ Sri Janmejaya Katikia, Addl. Govt. Advocate for kind information and necessary action.

02/02/2022
Deputy Secretary to Government

True Copy attested
Superintending Engineer
Mahanadi Barrage Division
Gandarpur, Cuttack-3

Annexure- N/6/B

Report of the Technical Committee

Methodology Adopted for Study

1. The committee considered the 48 years flow series at Tikerpada which has been used in the NGT report as source data for the model study.
2. The return flood hydrograph for 25 years (Q25) and 100 years (Q100) are taken as u/s condition to the HEC-RAS mathematical model.
3. Different Digital Elevation Models (DEM) have been tried in the analysis. Finally, the SRTM DEM has been adopted for the study.
4. Trials were performed using 2D and 1D modelling. Since, 2D model is more appropriate over 1D model in the deltaic region, the results of 2D model have been considered to draw the conclusions.

Conclusions

1. During passage of Q25 flood the expected water level at Baliyatra ground will be around 23.7937m.
2. Due to Q100 flood the expected water level at Baliyatra ground will be around 24.497m.
3. The average formation level of Baliyatra ground is 24.5m and the average TBL of the ring road is 25.5m.
4. Highest ever flood water level recorded at Baliyatra ground is 23.54m during the Year-1982.
5. As the expected water level at Baliyatra ground due to Q25 and Q100 floods are either less than or equal to the average formation level of the Baliyatra ground, some construction activities can be carried out as per guidelines of NDMA.
6. Since, the land fill area is well bounded by two spurs on either side, two rows of sheet piles on the river side and ring road embankment on the southern side, a portion of the said area adjacent to the embankment (ring road) may be considered for permanent construction purposes by raising the plinth level above the Top Bank Level of the ring road which is at RL 25.5m. The structural safety aspect shall be given top priority while preparing the design.

True Copy attested

Superintending Engineer
Mahanadi Barrage Division
Gandarpur, Cuttack-3

P.T.O

7. The utilisation of the above land may be only for specific public utilities considering the present situation of Cuttack city and shall not be construed as an example to be implemented in other flood plains in the State.

8. Proposed storage projects or diversion schemes in Mahanadi and its tributaries between Hirakud and Mundali will be able to store some water and help to moderate future floods on the d/s side there by reducing the chances of submergence of Baliyatra ground.

9. Record of Submergence: Peak discharge in Mahanadi was recorded in the Year:1982 (15.84 lakh cusecs) & Year:2008 (15.82 lakh cusecs). The status of submergence in the history of flood is given below.

- 20.09.2008: 13 villages (crop loss only)
- 11.09.2011: One village, namely Nuapatna (Tangi-Choudwar Block)

Engineer-in-Chief,
Water Resources

25/4/22
CCE&BM, Mahanadi Kathajodi System

25.4.22
CE, HH, GIS & CEM

25/04/22
Chief Engineer,
Planning

Sri R. C. Tripathy, Ex-EIC,
Water Resources

Prof. Sundaravadivelu,
IIT, Madras

Prof. K K Khatua,
NIT, Rourkela

25/4/22
City Engineer,
CMC, Cuttack

25/4/22
Addl. Chief Engineer,
Eastern Circle-I

True Copy attested

20/5/22
Superintending Engineer
Mahanadi Barrage Division
Gandarpur, Cuttack-3

Annexure-R/6/B

A comparative study of finding of Joint Committee Report vis-a-vis report of the Technical Committee constituted by Department of Water Resources, Odisha

Inputs for the study: The Flow series, Flood frequency analysis (25 Yrs & 100 Yrs) and Design flood hydrograph as used in the study of NIT, Rourkela has been used by the Technical Committee.

Sl No.	Description	As per NGT report	Findings of the Technical Committee
1	Expected level due to Q25 Flood (40,063 Cumecs)	While routing the 25 years return flood it can be seen that the depth of water over the Baliyatra ground during the propagation of this flood just exceeds its average formation level of 24.5m, but below the RL of ring road which is about 25.6m. (Reference Pg.37 Conclusion & Recommendations)	2D model is run and the expected water level due to Q25 flood is 23.7937m which is 0.7063 m below the average formation level . Highest recorded observed level during 1982 flood (31.08.1982) is RL.23.54m, which means that Q25 flood has never come across. 1D model also run and found the average level of 23.366 m i.e. below the observed R.L 23.54 m.
2	Expected level due to Q100 Flood (49,711 Cumecs)	During the passage of Q25 and Q100 flood the difference in flood depths over the study area are not found to be significant.	The expected water level due to Q100 flood is RL.24.497m which is 0.003m below the average formation level of RL.24.5m.
3	Submergence of villages	The flood of 25yrs return period is most likely to affect about 38 villages in and around Cuttack city between Mundali and up to the lower reach, while another 66 villages may be partially affected. These villages are on the outer periphery of both Kathajodi and main Mahanadi branches.	The submergence reported in the NGT report is based on Cadastral Map used. However, The committee information on submergence of adjoining areas due to historical flood was ascertained from revenue authorities. 20.09.2008: 13 villages (crop loss only) 11.09.2011: One village, namely Nuapatna (Tangi-Choudwar Block)

True Copy attested

Superintending Engineer
Mahanadi Barrage Division
Gandarpur, Cuttack-3

4	Dimension used in the HEC-RAS model	1-Dimension	2D model is more appropriate over 1D model in the deltaic region and hence used in the study.
5	Digital Elevation Model	CARTOSAT-DEM	CARTOSAT-DEM gives high negative values (i.e. the ground profile is below the Mean Sea Level) which is not appropriate at the deltaic region. SRTM, JAXA and CARTOSAT -1 Digital Elevation Models were tried. It was found that SRTM and JAXA DEMs are close to the observed levels. The SRTM DEM has been used to draw conclusions.
6	Sharing of parameters used for the model	Not shared with DoWR	-

True Copy attested
8/5/22
Superintending Engineer
Mahanadi Barrage Division
Gandarpur, Cuttack-3

RESPONSE TO THE REPORT OF TECHNICAL COMMITTEE (TC) OF DOWR BY PROF K C PATRA

A technical committee (TC) was constituted by the Department of Water Resources (DOWR), Government of Odisha to examine the recommendations of the 5 member Joint committee constituted by the CPCB following the orders of the Hon'ble NGT. The Technical committee of DOWR has carried out a 2D model study for the propagation of the flood waves of 25 (Q25) years and 100 (Q100) year return periods using the HEC – RAS software. After going through the findings of the Technical Committee report (as made available) vis-à-vis the recommendation of the joint committee the following suggestions are put up for consideration.

1. Routing of the flood wave using 1D modeling approach through HEC-RAS show that the water level during the propagation of flood wave of Q25 is RL 24.5 m, while that using 2D modeling approach by TC of DOWR is RL 23.7937 m. There is serious debate going on the goodness of 1D versus 2D approaches with *most of the researchers preferring 1D modeling approach as more suitable than 2D modeling approach*.

2. The joint committee in the report had accepted the data observed by the central water commission (CWC) as more authentic than the data recorded by DOWR. The proportioned highest flood that had ever come in Mahanadi at the upstream Munduli site was in 2008 with a value of 35,076 m^3/s and is not *a flood of magnitude of 44, 768 m^3/s as reported by the water resources department of Government of Odisha. A flood of 44, 768 m^3/s had never come in the observed history of records of CWC*. Therefore, flood height of RL 23.7937 m as reported by the DOWR are for a lesser flood of 35,076 m^3/s and not the Q25 of 40, 063 m^3/s

3. Looking at the photographs of the Baliyatra - Hadiapatha site, adjoining the Ring-road of the Cuttack city, there is no ambiguity on the sensitivity of the ground for high floods. *Therefore, at these critical locations, the higher values of model outputs are always considered keeping in mind the safety, security, risk and the vulnerability associated with the life and property of the area.* The routed flood height of RL 24.5 m for Q25 is higher than RL 23.7937 m and need to be considered for the present case.

4. *Therefore, the study outputs, which are recommended by the 5-member joint committee, be considered for acceptance*.

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2022/7/13 11:27

12/7/2022
corrected

Annexure-7

Salient Features of Jobra Barrage

1.	LOCATION		
	State /District	:	Odisha/ Cuttack/ 20^0 – 28′ – 30″ N/85^0 - 54′ - 0″ E
2.	HYDROLOGY		
	(a) Catchment (at Naraj)	:	1,32,085 Sq. Km.
	(b) Maximum Flood Discharge at Naraj	:	42,475 Cumecs.
3.	DESIGN DISCHARGE	:	15,300m^3 / Sec.
4.	H.F.L (INCLUDING AFFLUX)	:	R.L. 23.05m. (0.3)
5.	AFFLUX	:	0.3m
6.	POND LEVEL	:	21.20m.
7.	WATER WAY	:	(95 bays of 18m) (79 bays of spillway + 8 bays of under sluices right + 8 bays of under sluice left).
8.	LOOSENESS FACTOR	:	3.25
9.	PIER WIDTH	:	2.00 m.
10.	CREST LEVEL	:	
	(i) Under Sluices		RL 16.00m.
	(ii) Spillway	:	RL 18.50m.
11.	CISTERN LEVEL		
	(i) Under Sluices	:	RL. 13.50m.
	(ii) Spillway	:	RL. 13.50m.
12.	CISTERN LENGTH		
	(i) Under Sluices	:	RL. 28.30m.
	(ii) Spillway	:	RL. 22.10m.
13.	DIVIDE WALL (LENGTH)	:	Upstream 52.30m Downstream 48.50m.
14.	HEAD REGULATOR	:	Left Head Regulator: 107 Cumecs Right Head Regulator: 94 Cumecs
15.	CANAL F.S.L.	:	Taladanda Canal = 20.88m. Kendrapara Canal = 20.75m.

12/7/2022
Additional Chief Engineer
Eastern circle - I
Cuttack

a. **Designed Pondage Area of the reservoir and area submerged as a result of construction of barrage in the concerned site (Design Diagrams, maps, etc.)**

Jobra Barrage is not designed to provide storage of water like reservoirs in Dams. Barrages allow temporary pondage of water for heading up water on its up-stream side. This water level is the driving head for pushing water into the canal system from the pond side. Hence there is no pondage area. The Sill Level of barrage is kept almost equal to average river bed level at RL 17.10 m. In monsoon season, all 95 gates remain open for free flow of river discharge during floods above 3 lakh cusecs and canal gates are kept open for Kharif water supply. During Non-monsoon season, water level is maintained by gates only for canal supply in Rabi Season.

There was no submergence of land while constructing the barrage as it was built 60 m downstream of existing Jobra Anicut which was built in early 19th Century during British era.

b. **Relevant maps and documents to justify the purpose or need of construction of barrage.**

The present Jobra Barrage over River Mahanadi has been constructed in the year 1985-92 i.e. about 60m downstream of existing old Jobra Anicut built during early 19th Century. The approval for such construction was given by the Planning Commission vide Letter dated 11.04.1978. The 6th TAC Report of 1978 wherein the project was approved mentions that:-

"On the basis of report of Sir Arthur Cotton, during the year 1858, two nos. of rock dumped weirs were constructed across River Mahanadi and Birupa in the year 1864 and 1868 respectively to provide only Kharif Irrigation to 46,560 ha of land. The weir on river Mahanadi was called **Jobra Anicut.** Due to construction of Hirakud Reservoir and the perennial flow received from it, the CCA was increased to 1,83,211 ha providing Khariff benefits to 2,01,533 ha and Rabi benefits to 91605 ha. However, the condition of the weirs constructed in early 19th Century had deteriorated considerably. Deep scour in the loose apron in the main weir, undermining of body walls and loose apron in the scouring sluices, cavitation of foundation of piers of scouring sluices and settlement of body walls of main weirs were observed yar after year. These weirs were no longer considered safe and they were more than 100 years old. It was therefore proposed to replace these weirs with two new barrages. The new barrage across river Mahanadi is now known as Jobra Bararge or Mahanadi Barrage. The Mahanadi Barrage Project was approved by the Planning Commission vide Letter dated 11.04.1978. The final location of the barrage was decided upon by the Committee of experts headed by then CWC Chairman, Dr. KC Thomas."

(Source: 6th TAC Note of 1978 and 38th TAC Note of 1988)

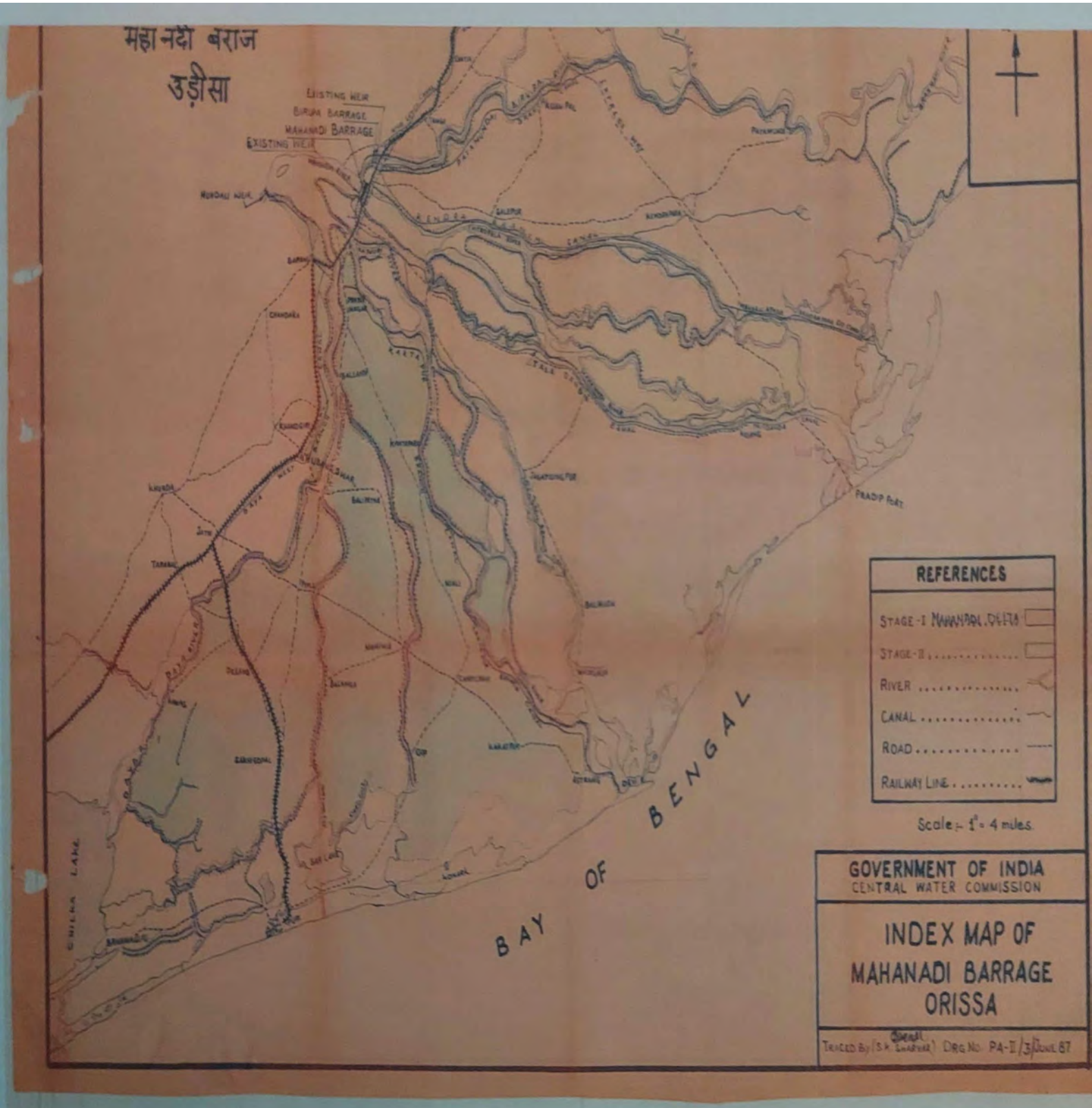

FIG: INDEX MAP FOR MAHANADI BARRAGE

c. Drone Pictures of the barrage and its reservoir along with 426 Acres of filled up Structure:

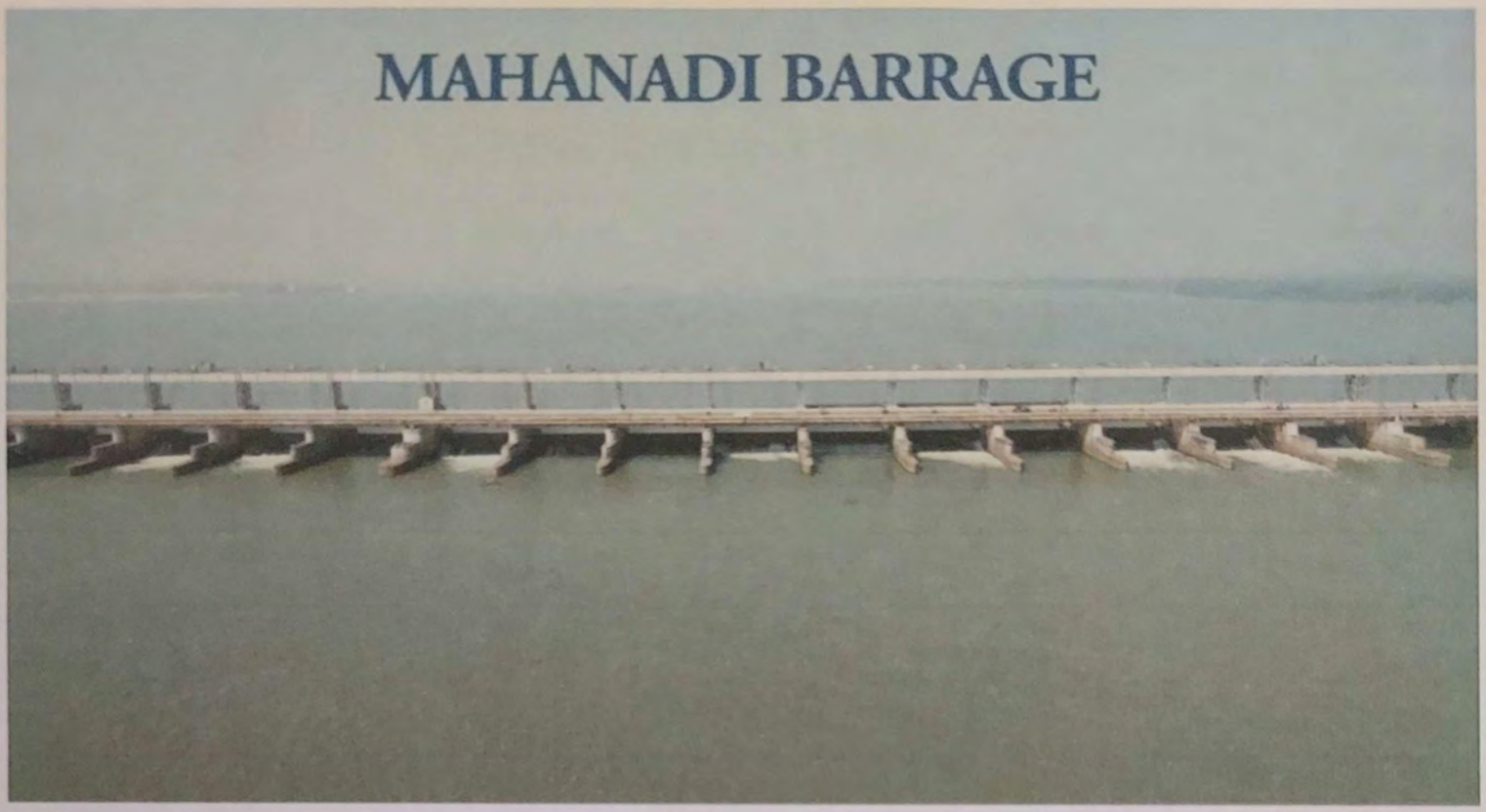

FIG: AERIAL VIEW OF MAHANADI BARRAGE

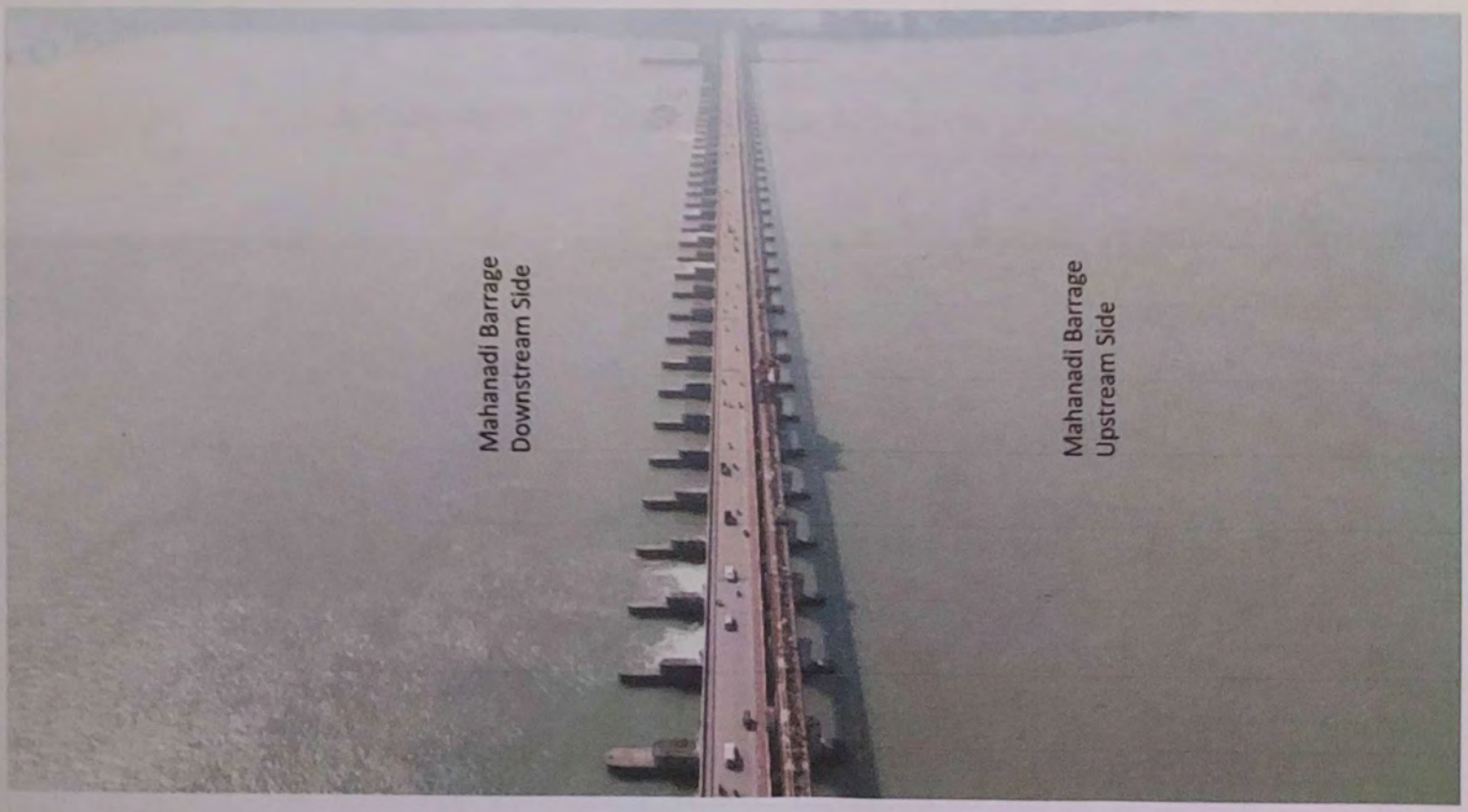

FIG: UPSTREAM AND DOWNSTREAM OF MAHANADI BARRAGE

FIG: AERIAL VIEW OF 426 ACRES OF FILLED UP LAND

FIG: GOOGLE EARTH IMAGE SHOWING FILLED UP LAND

d. Relevant Information justifying the dredging and removal of sand from the Storage Area:

The shoals on the upstream side were removed by dredging as per the orders of Hon'ble High court of Odisha. The Hon'ble High Court in its order dated 27.02.2012 in WPC No. 20283 of 2011 had stated that:

".....Keeping in view the aforesaid fact and after going through the report of Technical Expert Committee, we accept the report and direct the followings:

(1).....

(2).....

(3) With regard to the Removal of Shoal, as stated by the Secretary, Water Resource department as well as the Engineer-in-Chief, i.e. Bathymetry Survey is to be done through IIT Chennai as the State Government had already taken the expertise of IIT Chennai in some other projects. Cost of which shall be borne by the IOCL.

(5) So far as Dredging is concerned, it is also stated that the Dredging can also be done by the OCC with the help and expertise of Water Resources Department at the cost of IOCL and modalities of the same shall be decided by the officials of the Water Resource Department and IOCL and the executing agency. Hence such dredging shall be done as suggested above at the cost of IOCL.

(6) Regarding the strengthening of the existing City Protective Embankments, since it is stated in the affidavit of the Chief Engineer that usable earth from the dredging activities will have to be utilized for strengthening of the existing City Protective Embankments and the unusable earth will be utilized for filling of the low laying areas nearby."

In accordance with the order of Hon'ble High Court, IIT Chennai was entrusted with the Bathymetry Survey and as indicated in the report of IIT Madras, the dredging activities [redacted] carried out to serve the following purposes:

i. The removal of shoal will decrease the velocity of flow during flood time thus reduce overflow over banks and proposed two rows sheet pile protection wall at critical sections will protect the developed reclamation area.

ii. The flow will be increased uniformly in the Mahanadi River in both high and low flood times.

iii. The adjoining reclaimed area can be used for developmental activities which will serve as an additional advantage over and above the points mentioned above.

Pratik Dixit 04/7/22

Assistant Executive Engineer
Mahanadi Barrage Sub Division
Jobra, Cuttack

Superintending Engineer
Mahanadi Barrage Division
Cuttack

4/7/2022

Additional Chief Engineer
Eastern Circle-I
Cuttack

Item No.02 (Court No. 1)

BEFORE THE NATIONAL GREEN TRIBUNAL
SPECIAL BENCH

(By Video Conferencing)

Original Application No. 68/2020/EZ
&
I.A. Nos. 06/2021/EZ, 07/2021/EZ & 15/2022/EZ

Pradip Kumar Pattnaik Applicant

Versus

Union of India & Ors. Respondent(s)

Date of hearing: 07.02.2022

CORAM: HON'BLE MR. JUSTICE ADARSH KUMAR GOEL, CHAIRPERSON
HON'BLE MR. JUSTICE SUDHIR AGARWAL, JUDICIAL MEMBER
HON'BLE MR. JUSTICE B. AMIT STHALEKAR, JUDICIAL MEMBER
HON'BLE DR. NAGIN NANDA, EXPERT MEMBER
HON'BLE MR. SAIBAL DASGUPTA, EXPERT MEMBER
HON'BLE DR. AFROZ AHMAD, EXPERT MEMBER

Applicant: Mr. Prabhu Prasanna Behera, Advocate

Respondent(s): Mr. Janmejaya Katikia, AGA for R-2 to 8,
Mr. Gora Chand Roy Choudhury, Advocate for R-1&10
Mr. Surendra Kumar, Advocate for CPCB

ORDER

1. Grievance in this application is against the illegal sand filling in the Mahanadi river bed within the water area of Jobra Barrage at Cuttack. According to the applicant, the illegal action being undertaken is causing damage to the environment and the riverine ecosystem. The project called Balijatra River Front Improvement (BARFI) is an attempt to monetize the river bed for commercial purposes which will reduce the water retaining capacity of the river at Jobra Barrage at Cuttack. Free flow of water of the river bed will be affected in violation of judgment of

the Odisha High Court dated 27.02.2012 in W.P.(C) No. 20283/2011, *The National Lawyers Forum vs. State of Orissa and Ors.* This will affect supply of drinking water and obstruct dredging which is necessary. This will also add to the floods in the city.

2. During the hearing, learned Counsel for the applicant has also referred to the order of this Tribunal dated 15.12.2020 in O.A. No. 22/2020(EZ), *Dilip Kumar Samantaray vs. State of Odisha Board & Ors.*, wherein the Tribunal constituted a joint Committee as follows:

> *"16. Accordingly, we constitute a joint Committee comprising representatives of Central Water Commission (CWC), nominees of MoEF&CC, CPCB, National Institute of Hydrology, Roorkee and the State PCB* ***to consider the issue and lay down norms so as to ensure that the proposal of the State for construction of the medical college and river front development takes place in accordance with law, without damage to the flood plains of the Rivers. Flood plain zones need to be identified and demarcated in the light of such norms. The Committee may identify the extent of floodplain zone/active floodplain zone from the edge of the river. CPCB will be nodal agency for compliance.*** *The Committee is free to associate any other individual or institution. The Committee may complete its exercise within four months. The members of the Committee are free to interact by video conferencing or otherwise. If any grievance with regard to violation of environmental norms survives, the applicant will be free to take any further remedies as per law."*

3. The matter was considered on 21.01.2021. The applicant was permitted to represent grievance in this application to the Committee already constituted so that the Committee could file a consolidated report about all the issues and the statutory authorities could take remedial action to enforce the law.

4. At this stage, we may also note the observations in order dated 15.12.2020 in O.A. No. 22/2020(EZ), *Dilip Kumar Samantaray vs. State of Odisha Board & Ors.* about the legal framework and need for protection of flood plains in the interest of riverine ecology and the life

and property of people. Reference was made to the judgment of the Hon'ble Supreme Court dated 30.07.2009 in *D.D.A. vs. Rajendra Singh*, 2009 (8) SCC 582 mentioning the significance of protecting river beds and flood plains. Reference was also made to earlier order of this Tribunal dated 13.01.2015 in *OA No. 6/2012* and *OA No. 300/2013, Manoj Misra vs. Union of India & Ors.* reported in 2015 ALL (I) NGT REPORTER (1) (DELHI) 139, judgment of this Tribunal dated 13.07.2017 in OA No. 200/2014, *M.C. Mehta vs. Union of India & Ors.* reported in 2017 NGTR (3) PB 1 in the context of river Ganga. The Tribunal referred to the Notification dated 07.10.2016 issued by the Ministry of Water Resources with regard to Ganga River on the subject of protecting active flood plain areas of the river and its tributaries. Reference was also made to laws enacted on the subject in certain States including Manipur Flood Zoning Act, 1978 and the Uttarakhand Flood Plain Zoning Act, 2012. Apart from Rules/Guidelines, reference was made also to Wetland Rules and action plans prepared by River Rejuvenation Committees in all the States/UTs in pursuance of order of this Tribunal dated 21.09.2020 in *OA No. 673/2018, In Re: News item published in "The Hindu" authored by Shir Jacob Koshy, titled "More river stretches are now critically polluted: CPCB* to the extent of steps for protecting flood plains. The Tribunal finally observed that no project could be developed in a flood plain of the river even in absence of any statutory provision on the subject as doing so affects the riverine ecology adversely. Accordingly, the Tribunal constituted a joint Committee mentioned earlier to identify the extent of flood plain zones and to lay down norms to ensure that no project was developed on the flood plains in violation of laws, resulting in damage to flood plains.

5. Accordingly, CPCB has filed its affidavit dated 04.10.2021 annexing the report of the joint Committee. The affidavit of CPCB shows that CPCB sanctioned a project called "Floodplain Zoning Study for the Identified Stretches of Mahanadi River Basin" for mapping of the river using satellite imageries, digital elevation maps, land use and land cover map showing habitation, flood frequency analysis and demarcation of flood plain zones from the edge of the river under supervision of Prof. K.C. Patra, Civil Engineering Department, NIT Rourkela, who submitted his initial study report on 03.08.2021 on flood plain zoning of the area based on discharge data provided by (i) Central Water Commission (hereinafter referred as "CWC") as well as Odisha Water Resources Department (hereinafter referred as "WRD"), (ii) DEM provided by National Remote Sensing Centre (hereinafter referred as "NRSC"), (iii) Reduced levels of Baliyatra and other points by Odisha Water Resources Department (hereinafter referred as "WRD") and (iv) Modelling through HEC-RAS 6.0.The annexed report has following conclusions and recommendations:-

> ***"5.4 Conclusion and Recommendation as indicated in the study:***
>
> *The floodplain zoning study for the identified stretches of Mahanadi river basin was carried out based on the discharge data provided by the (i) Central Water Commission (CWC) as well as Odisha Water Resources Department (WRD), (ii) DEM Provided by National Remote Sensing Centre (NRSC), (iii) Reduced levels of Baliyatra and other points by Odisha Water Resources Department (WRD), and (iv) Modelling through HEC-RAS 6.0. For details results and discussion of the study,* ***page no. 35-37*** *may kindly be referred. As per the report following key conclusion and recommendations have been made;*
>
> 1. *From the derived statistical parameters of the CWC as well as Odisha WRD data, the value of 25 years return period flood (Q25) of magnitude 40,063 m3/s (from CWC data) is considered for floodplain mapping of the study area. During the passage of floods of Q25 and Q100, the difference in flood depths over the study areas are not found to be significant. This may be due to the river at this stretch is quite wide and thus, it is in a position to pass the*

flood of various return periods without appreciable change in the floodplain submergence geometry.

2. *While routing this Q25 flood, it can be seen that the depth of water over the Baliyatra ground during the propagation of this flood just exceeds its average formation level of 24.5 m, but below the Reduced Level (RL) of ring road. Records from Odisha WRD indicate that water level during the passage of the flood of 44,768 m3/s was less than the RL of ring road, which further strengths the present finding on the safety of passage of the flood. Therefore, any development activities in this area can be suitably planned keeping in mind the possible submergence of this Baliyatra rehabilitated area can be expected at least once in 25 years.*

3. ***The flood of 25 year return period is most likely to affect about 38 villages in and around the Cuttack city between Munduli and up to the lower reach, while another 66 villages may be partially affected. These villages are on the outer periphery of both Kathjodi and Main Mahanadi branches.***

4. *The mean and maximum velocity of flow at cross-section 5 (having sand dune) areas are 0.493 m/s and 1.051 m/s, while at cross-section 1 (having no sand dune) the corresponding values area 0.62 m/s and 1.155 m/s. The same values at cross-section 3 which is very close to the Jobra barrage are 0.527 m/s and 1.02 m/s. From this, it can be observed that the removal of sand dunes has increased the velocity of flow at the section.*

5. ***National Disaster Management Authorities (NDMA) Guidelines, 2008 and all other design codes need to be followed while implementing any concepts for the utilization of Baliyatra Ground at Cuttack.***

5.5Limitations of the study:

The study has the following limitations:

- *The flood inundation area has been computed from the CARTOSAT DEM which is not verified from the ground survey and DGPS.*

- *Some water resources projects (both storage projects and diversion schemes) are expected to come up in future in the upstream catchment areas that is expected to store more water and moderate floods leading to reduce its peak at the Baliyatra site.*

- *The study has the limitations inherent to the modelling through the software, quality and accuracy of the data, accuracy of the DEM, and all other associated parameters.*

6.0 Recommendation of the joint committee

To comply with the directions committee carried out the study by the expert institutes and agreed with the findings of the study. The point wise compliance status of the directions are as follows;

6.1 Identification and demarcation of Floodplain

Flood plain zoning study ***(Annexure:*** *3) was conducted by NIT Rourkela and was agreed upon by the committee members. In this study, Flood Zone Mapping and Inundation Map was done using the latest version of HEC-RAS V-6.0 (1-D Modelling). As per the study, it was found that flood of 25 year return period (Q_{25}) can be considered for modelling and identifying the floodplain inundation maps in the concerned stretch as the difference in flood depths between Q25 and $Q10_0$ is not found to be significant. It was further found that the flood of 25 year return period is expected to affect about 38 villages in and around the Cuttack city from the Munduli barrage to the downstream of Jobra barrage as depicted in Figure 6-1. A list of these villages is also provided in Table 2. Based on the analysis it was observed that the depth of water over the Baliyatra ground during the propagation of Q_{25} flood exceeds its average formation level of 24.5 m, but is below the RL of ring road.*

Table 2: List of villages expected to be affected during the passage of 25 year return period flood in periphery outer zones

Most Likely to be Affected Village List					
1.	*Balipur*	*2.*	*Pahilabar*	*3.*	*Talagar*
4.	*Baula*	*5.*	*Lalitabisakhapur*	*6.*	*Chhagan*
7.	*Madhyakachha*	*8.*	*Agrahat*	*9.*	*Nuapatana*
10	*Sankarpur*	*11.*	*Jhatia*	*12.*	*Shrirangapur*
13	*Bhabadeipur*	*14*	*Katkiasahi*	*15.*	*Jagannatarapur*
16.	*Nuasasan*	*17.*	*Mangalpur*	*18.*	*Ramshyampur*
19.	*Badasantarapur*	*20.*	*Jemadeipur*	*21.*	*Arilo*
22.	*Suniamunha*	*23.*	*Bhuinbarei*	*24.*	*Kotar*
25.	*Bandhahata*	*26.*	*Sarakuan*	*27.*	*Paikerapur*
28.	*Sardarkharida*	*29.*	*Brahmanbasta*	*30.*	*Nuagada*
31.	*Kalankipur*	*32.*	*Anantapur*	*33.*	*Prabatia*
34.	*Jagmohanpur*	*35.*	*Baghua*	*36.*	*Similihanda*
37.	*Badapadagaon*	*38.*	*Sanakakhadi*		

6.2 Construction of the medical college and river front development as per norms

Based on the meeting taken by the committee with all the concerned agencies on 7th April, 2021 at Cuttack, the concept note on Mahanadi Waterfront Development describing the proposed construction activity was provided by Cuttack Development Authority (CDA). The same has been considered by the committee.

Based on the study, Baliyatra Ground comes under floodplain zone, therefore construction of structures of permanent type, as in column 2 of this Table 3 (priority-2) may be prohibited and only non-permanent structures may be allowed subject to

strict adherences to the NDMA guidelines, Building Codes and others. These structures should be planned as far as away from the river water lines and active only during non-monsoon days so that there is no loss to the life and property.

Although most of the activities proposed in the CDA concept note fall under priority 3 and may be allowed following the guidelines, • however, a few construction activities like art galleries, museums etc. fall under priority 2 and therefore may not be permitted. The construction or extension of the Medical college has neither been proposed in the CDA note nor is it permissible as per NDMA Guidelines, as this kind of structure falls under Priority 1 activities.

Categorization of the construction activities proposed by the Cuttack Development Authority (CDA) under the Mahanadi Waterfront Development is provided in Table 3.

Table 3; Categorization of the construction activities proposed by the Cuttack Development Authority (CDA) under the Mahanadi Waterfront Development

Proposed Construction Activities	***Priority 1***	***Priority 2***	***Priority 3***
public infrastructure such as parks, gardens, sports facilities			✓
public infrastructure art galleries and museums		✓	
roads with uniform travel lanes, shaded footpaths, designated cycle tracks, safe intersections and landscape and public space inclusion.			✓
open air market, craft bazar, food stalls like Dilli Haat (New Delhi) & Ekamra Haat (Bhubaneswar) to promote local art & crafts as well as traditional works			✓
An open-air auditorium			✓
Bali Jatra grounds			✓

”

6. Appendix-2 annexed to the report about the scope of allowed and not allowed facilities is as follows:-

“Scope of the allowed and non-allowed facilities under Priority-1, 2 and 3

Categorization	Type of structures permitted as per NDMA Guidelines	Basis of Prioritization and guidelines	Study Recommendations (Joint Committee may decide on the Activities following NDMA guidelines)
Priority -1	• Defence installations • Industries • Public utilities like hospitals, electricity installations, water supply, telephone exchanges, aerodromes, railway stations, commercial centres, etc.	Buildings should be located in such a fashion that they are above the levels corresponding to a 100- year frequency or the maximum observed flood levels. Similarly they should also be above the levels corresponding to a 50-year rainfall and the likely submersion due to drainage congestion.	Structures under Priority-1 of the NDMA Guidelines is not permitted in the Baliyatra Ground.
Priority -2	• Public institutions • Government offices • Universities • Public libraries • Residential areas	Buildings should be above a level corresponding to a 25-year flood or a 10-year rainfall. Stipulation that all buildings in vulnerable zones should be constructed on columns or stilts. (a) Plinth levels of all buildings should be 0.6 m above the drainage/flood submersion lines. (b) In the areas liable to floods, all the buildings should preferably be double and multiple storeys. (c) In urban areas ground floor to be utilised for non-residential purposes	Baliyatra Ground comes under floodplain zone, therefore construction of structures of permanent type, as in column 2 of this table (priority-2) may be prohibited. Baliyatra Ground is within floodplain area and therefore non-permanent structures may be allowed subject to strict adherences to the NDMA guidelines, Building Codes and others. These structures should be planned as far as away from the river water lines and active only during non-monsoon days so that there is no loss to the life and property.
Priority -3	• Parks and playgrounds	Certain areas on either side of the existing and proposed drains (including rural drains) should be declared as green belts where no building or other activity should be allowed. This will not only facilitate improvement of these drains in future for taking discharges on account of growing urbanisation, but will also help in minimising the damage due to drainage congestion whenever rainfall of higher frequency than designed is experienced. These green belts, at suitable locations, can also be developed as parks and gardens.	Priority-3 activities such as developments of Parks, Playgrounds and creation of other facilities (such as Recreational Space, Urban Forests, Pedestrian Paths, Cycle Tracks, Solar Lighting, Rain Water Harvesting, Gardens, Footpaths, Cycle Tracks, Open Air Market, temporary Craft Bazar, Food Stalls, Open Air Auditorium) may be permitted following NDMA Guidelines in the Baliyatra Ground. These facilities should be active during non-monsoon periods so that there is no loss to the life and property.

"

7. We have heard learned Counsels for the parties. Learned Counsel for the applicant submitted that while the report considers engineering aspects in light of guidelines issued by National Disaster Management Authority, it does not consider ecological and hydrological aspects in terms of order of this Tribunal dated 15.12.2020 in O.A. No. 22/2020(EZ), *Dilip Kumar Samantaray (Supra).* Such consideration is essential for protection of flood plain zone and associated issues relating to the ecology, environment and biodiversity. Ecological vulnerability and combined hazard vulnerability are required to be studied in light of observation of this Tribunal in order dated 15.12.2020 and safeguards need to be identified for protection of the flood plains. It requires constitution of joint Committee comprising Experts in the field of Hydrology, remote sensing and Ecology.

8. We do not see any reason not to accept the suggestion for such further study to consider appropriate directions in the interest of environment. Accordingly, we direct a joint Committee of seven Experts, with five members in the earlier Committee and two other Experts viz. Prof. C.R. Babu, eminent ecologist and environmentalist and Prof. P.C. Mishra, former Expert Member of NGT to undertake the study in light of above observations so as to include ecological and hydrological aspects and vulnerability, adding these components in the report and to make detailed recommendations identifying the steps required for protecting the flood plain zone and the environment within three months. It will be open to the applicant as well as State of Odisha to place their respective view point before the Committee. CPCB will be the nodal agency to carry out the entire exercise. Report may be filed before the Tribunal on or before 30.04.2022 by e-mail at judicial-ngt@gov.in preferably in the form

of searchable PDF/ OCR Support PDF and not in the form of Image PDF on or before 30.04.2022. Report may also be placed on the website of CPCB for response by any stakeholder before the next date of hearing.

9. I.A. No. 06/2021/EZ and I.A. No. 07/2021/EZ seek injunction against any construction in the river bed and I.A. No. 15/2022/EZ seeks time for filing response of the State Government. No construction of permanent nature will be allowed in the flood plain in question pending further order. The IAs will stand disposed of accordingly.

List for further consideration on 23.05.2022.

Adarsh Kumar Goel, CP

Sudhir Agarwal, JM

B. Amit Sthalekar, JM

Dr. Nagin Nanda, EM

Saibal Dasgupta, EM

Dr. Afroz Ahmad, EM

February07, 2022
Original Application No. 68/2020/EZ
& I.A. Nos. 06/2021/EZ, 07/2021/EZ & 15/2022/EZ
SN

केन्द्रीय प्रदूषण नियंत्रण बोर्ड
CENTRAL POLLUTION CONTROL BOARD
(पर्यावरण, वन एवं जलवायु परिवर्तन मंत्रालय, भारत सरकार)
(Ministry of Environment, Forest & Climate Change, Government of India)
क्षेत्रीय निदेशालय, कोलकाता
Regional Directorate, Kolkata

Hon'ble NGT Matter
Date: 22.03.2022

OFFICE ORDER

Constitution of Joint Committee in compliance to the Hon'ble National Green Tribunal (NGT) Order dated dated 07.02.2022 in the matter of Pradip Kumar Pattnaik Vs Union of India & Ors in OA No. 68/2020(EZ)

In compliance to the Hon'ble NGT order dated 07.02.2022 in the matter of Pradip Kumar Pattnaik Vs Union of India & Ors in OA No. 68/2020(EZ), a Joint Committee *of seven Experts, with five members in the earlier Committee and* ***two other Experts*** is hereby constituted comprising of the following members;

i. Prof. C.R. Babu, Professor Emeritus & Ex-Pro-Vice-Chancellor, University of Delhi
ii. Prof. P.C. Mishra, former Expert Member of NGT
iii. Dr. A. K. Lohani, Scientist 'G', National Institute of Hydrology, Roorkee
iv. Shri Amrish Pal Singh, Superintending Engineer (C), M&ERO, CWC, Bhubaneswar
v. Dr. Sohan Giri, Regional Officer, Odisha State Pollution Control Board
vi. Shri M. R. Prasad, Scientist 'C', MoEF&CC, Bhubaneswar
vii. Shri M. K. Biswas, Regional Director, CPCB RD, Kolkata (Nodal Agency)

CPCB is directed to be the nodal agency to carry out the entire exercise and the report is to be filed before the Tribunal on or before 30.04.2022.

The Terms of Reference (ToR) of the Committee shall be as follows:

1. To undertake the study in light of above observations so as to include ecological and hydrological aspects and vulnerability components in the report prepared by the five members committee as per NGT order dated 15/12/2020 in OA 22/2020(EZ) on flood plain zoning study of the identified stretches on Mahanadi River.
2. To make detailed recommendations identifying the steps required for protecting the flood plain zone and the environment.
3. The Committee has to give its report by 30.04.2022 for uploading in the CPCB website.
4. The expenditure shall be booked under NGT(EC) funds as per the prevailing orders.

This is issued with the approval of Competent Authority, Central Pollution Control Board.

(M. K. Biswas)
Regional Director & Nodal Agency

To

All the committee members

Copy for kind information to:

1. AO to MS, CPCB, Delhi
2. DH, Law, CPCB, Delhi

(M.K. Biswas)

Head Office:
Parivesh Bhawan, CBD cum Office Complex,
East Arjun Nagar, Delhi-110 032
Tel: 011-43102030, 22305792
Website: www.cpcb.nic.in

Regional Directorate:
502, Southend Conclave
1582, Rajdanga Main Road, Kolkata- 700107
Tel: 033-2441 6634/4289/4677/6003
e-mail: rdkolkata.cpcb@gov.in

भारत सरकार / Government of India
पर्यावरण, वन एवं जलवायु परिवर्तन मंत्रालय / Ministry of Environment, Forest and Climate Change
एकीकृत क्षेत्रीय कार्यालय / Integrated Regional Office
ए/3, चंद्रशेखरपुर / A/3, Chandrasekharpur
भुवनेश्वर - 751 023, ओडिशा / Bhubaneswar - 751 023, Odisha
सत्यमेव जयते
Telephone: 0674 - 2301213, 2302432, 2301248, 2302452, 2302453. E-mail: roez.bsr-mef@nic.in

No. 107-436/21/EPE /409 Date 07.07.2022

To

The Regional Director
CPCB, Kolkata
Sector E, East Kolkata Twp,
Kolkata, West Bengal 700107
E-mail- mscb.cpcb@nic.in

Sub: O.A. No. 68 of 2020 in the matter Pradip Kumar Pattnaik Vs U.O.I. & Ors- reg.

Ref: your letter dated 04.07.2022

Sir,

This is in reference to your mail dated 05.07.2022 regarding the second meeting of the seven membered Joint Committee constituted by the Hon'ble NGT vide its order dated 07.02.2022 in the matter of Pradip Kumar Pattnaik Vs Union of India & Ors. in O.A. No. 68/2020(EZ).

In this regard, it is intimated that the previously nominated officer Shri M. R Prasad Scientist 'C', from this office has been transferred to Ranchi. Therefore it is informed that Dr T.H Mahato Scientist 'D' will represent IRO Bhubaneswar. The details are as follows:

Name	:	Dr. T. H. Mahato
Designation	:	Scientist 'D'
Address	:	Ministry of Environment,Forest & Climate Change, Integrated Regional Office,A/3, Chandraskeharpur, Bhubaneswar, Odisha – 751 023
Email ID	:	roez.bsr-mef@nic.in ,
Mobile No	:	9523425019

This is for Kind Information & necessary action.Please

Yours faithfully,

Encl: As Above

RA(PM)

THMahato

(Dr T. H Mahato)
Scientist-'D'

-400
-22/7/22

STATE POLLUTION CONTROL BOARD, ODISHA

[Department of Forest, Environment & Climate Change, Government of Odisha]

A/118, Nilakanthanagar, Unit-8, Bhubaneswar-751012, Odisha

Tel: 2563810, Email: paribesh1@ospcboard.org, Web: www.ospcboar.org

No. 15339 / MS/03 Dated, the 25/8/22 /

To

The Regional Director,
Central Pollution Control Board,
502, Southend Conclave, 1582, Rajdanga Main Road,
KOLKATA-700107
Email : rdkolkata.cpcb@gov.in

Sub: Submission of Objection report of Dr. Sohan Giri, Member of (5 members & 7 Members) joint committee formed by Hon'ble NGT vide O.A.No.68/2020/EZ.

Sir,

The report of Dr. Sohan Giri, Member of (5 members & 7 Members) joint committee formed by Hon'ble NGT vide O.A.No.68/2020/EZ alongwith its enclosures are submitted herewith for necessary inclusion in the final report of the Central Pollution Control Board to be submitted to Hon'ble NGT for hearing on 07.09.2022.

Yours faithfully,

Encl : As above.

25/8

MEMBER SECRETARY

Memo No. 15340 /Dt. 25/8/22.

Copy forwarded to the Member Secretary, Central Pollution Control Board, Delhi for information and necessary action. (mscb.cpcb@nic.in)

Encl : As above.

25/8

MEMBER SECRETARY

OBJECTION REPORT OF DR. SOHAN GIRI. MEMBER OF (5& 7 MEMBERS) JOINT COMMITTEE FORMED BY HON'BLE NGT VIDE O.A.NO.68/2020/EZ

1. I, Dr. Sohan Giri, Regional Officer, SPCB, Odisha is the Member of the 5 Member Joint Committee initially formed as per the Hon'ble NGT Order dt. 21.1.2021 as well as the 7 Member Joint Committee initially formed as per the Hon'ble NGT Order dt.7.2.2022.in the case matter of O.A. No.68/2020/EZ

2. Initially as per the Hon'ble NGT Order dt. 21.1.2021 constituted a 5 member committee which had studied the above matter and suggested the above matter and suggested that "Priority-3 and some section of Priority-2 of the NDMA guidelines. It has been permitted in the scope of allowed and not be allowed facilities and presented before the Hon'ble NGT during hearing on 7.2.2022 and the said is being mentioned in the Hon'ble NGT Order dt. 7.2.2022 **(Annexure-I).**

   The said is given in the Hon'ble NGT Order dt. 7.2.2022 in Section 6 (Sub Section 6.2) is mentioned below:

6.2 Construction of the medical college and river front development as per norms

Based on the meeting taken by the committee with all the concerned agencies on 7th April, 2021 at Cuttack, the concept note on Mahanadi Waterfront Development describing the proposed construction activity was provided by Cuttack Development Authority (CDA). The same has been considered by the committee.

Based on the study, Baliyatra Ground comes under floodplain zone, therefore construction of structures of permanent type, as in column 2 of this Table 3 (priority-2) may be prohibited and only non-permanent structures may be allowed subject to strict adherences to the NDMA guidelines, Building Codes and others. These structures should be planned as far as away from the river water lines and active only during nonmonsoon days so that there is no loss to the life and property.

Although most of the activities proposed in the CDA concept note fall under priority 3 and may be allowed following the guidelines, however, a few construction activities like art galleries, museums etc. fall under priority 2 and therefore may not be permitted. The construction or extension of the Medical college has neither been proposed in the CDA note nor is it permissible as per NDMA Guidelines, as this kind of structure falls under Priority 1 activities.

Categorization of the construction activities proposed by the Cuttack Development Authority (CDA) under the Mahanadi Waterfront Development is provided in Table 3.

Table 3: Categorization of the construction activities proposed by the Cuttack Development Authority (CDA) under the Mahanadi Waterfront Development

Proposed Construction Activities	Priority 1	Priority 2	Priority 3
Public infrastructure such as parks, gardens, sports facilities			√
Public infrastructure art galleries and museums		√	

Roads with uniform travel lanes, shaded footpaths, designated cycle tracks, safe intersections and land scape and public space inclusion			√
Open air market, craft bazar, food stalls like Dilli Hat (New Delhi) &EkamraHatt (Bhubaneswar) to promote local art and crafts as well as traditional works			√
An open air auditorium			√
Bali Jatra grounds			√

Appendix-2 annexed to the report about the scope of allowed and not allowed facilities is as follows: "Scope of the allowed and non-allowed facilities under Priority 1, 2 and 3"

Categorization	**Type of structures permitted as per NDMA Guidelines**	**Basis of Prioritization and guidelines**	**Study Recommendations (Joint Committee may decide on the Activities following NDMA guidelines)**
Priority 1	• Defence installations • Industries • Public utilities like hospitals, electricity installations, water supply, telephone exchanges, aerodromes, railway stations, commercial centres, etc.	Buildings should be located in such a fashion that they are above the levels corresponding to a 100-year frequency or the maximum observed flood levels. Similarly they should also be above the levels corresponding to a 50-year rainfall and the likely submersion due to drainage congestion.	Structures under Priority-1 of the NDMA Guidelines is not permitted in the Baliyatra Ground.
Priority 2	• Public institutions • Government offices • Universities • Public libraries • Residential areas	Buildings should be above a level corresponding to a 25-year flood or a 10-year rainfall. Stipulation that all buildings in vulnerable zones should be constructed on columns or stilts. (a) Plinth levels of all buildings should be 0.6 m above the drainage/flood submersion lines. (b) In the areas liable to floods, all the buildings should preferably be	Baliyatra Ground comes under floodplain zone, therefore construction of structures of permanent type, as in column 2 of this table (priority-2) may be prohibited. Baliyatra Ground is within floodplain area and therefore non-permanent structures may be allowed subject to strict adherences to the NDMA guidelines, Building Codes and others. These structures should be planned as far as away from the river water lines and active only

		double and multiple storeys. (c) In urban areas ground floor to be utilised for non-residential purposes	during nonmonsoon days so that there is no loss to the life and property.
Priority 3	• Parks and playgrounds	Certain areas on either side of the existing and proposed drains (including rural drains) should be declared as green belts where no building or other activity should be allowed. This will not only facilitate improvement of these drains in future for taking discharges on account of growing urbanisation, but will also help in minimising the damage due to drainage congestion whenever rainfall of higher frequency than designed is experienced. These green belts, at suitable locations, can also be developed as parks and gardens.	Priority-3 activities such as developments of Parks, Playgrounds and creation of other facilities (such as Recreational Space, Urban Forests, Pedestrian Paths, Cycle Tracks, Solar Lighting, Rain Water Harvesting, Gardens, Footpaths, Cycle Tracks, Open Air Market, temporary Craft Bazar, Food Stalls, Open Air Auditorium) may be permitted following NDMA Guidelines in the Baliyatra Ground. These facilities should be active during non-monsoon periods so that there is no loss to the life and property.

3. The Hon'ble NGT vide its order 7.2.2022 directed a joint committee of Seven Experts with all five members of the earlier Committee and two other Experts viz. Prof. C.R. Babu, eminent ecologist and environmentalist and Prof. P. C. Mishra, former Expert Member of NGT to undertake the study in light of above observation so as to include ecological and hydrological aspects and its vulnerability, adding these components in the report and to make detail recommendations identifying the steps required for protecting the flood plain zone and the environment within three months.

4. In this regard a meeting was convened on Dt. 11.7.2022, in the Head Office of State Pollution Control Board, Odisha, Bhubaneswar attended by the representatives of State of the Odisha and the petitionersto make their view points. Accordingly, the representatives of the State of Odisha clearly stated that since 2 nos. of spurs has been constructed for length of 690 meters (Spur 1) and 810 meters (Spur 2) approx.) constructed during the year 1983 before even construction of Mahanadi Barrage and in the Google time line photograph it clearly depictsthere is no through passing of channel crossing the spurs.

5. Their commendations presented with respect to the buried channels, it seems from the imagery that it is a localized depression inbetween 2 spurs and it just catches the

natural water during the monsoon and in no way, it is connected with the main river Mahanadi. The suggestion to again create the old channel buried under sand is unwarranted.

6. The State of Odisha i.e., DoWR (**Respondent No. 6)** has filed an Objection Affidavit activity submitted on Dt. 20.5.2022 and in the Point No. 5, 9 and 10 has mentionedas below:

OBJECTION FILED BY THE Respondent No. 6 on dated 20.5.2022:

Point No. 5: That the Technical Committee has arrived at the above conclusion after having a study of flood of 100 years return period (Q100) for identifying the flood pain area. It is hereby submitted that the joint committee formed by the NGT has made the assessment taking into consideration the flood of 25 years of return period (Q25).

It is made clear that as has been observed by the State's Technical Committee that taking 25 years return of flood period (Q25), the expected water level at Baliyatra ground comes around 23.7937 m. Hence, the averment made by CPCB of Paragraph-II (iv) of the affidavit is not correct. In this context, it is further submitted that it is an incorrect assessment to say that the depth of water over Baliyatra ground during the propagation of Q25 flood exceeds it is average formation level of 24.5 m.

Point No. 9: That, it is respectively submitted that an area of 424 acres of land is lying vacant which can be utilized for many constructive purposes. Even though the construction under Priority No. 2 (at some places) and Priority No. 3 has been suggested by the Joint Committee for giving permission, construction of Priority No. 1 has not been suggested. In view of the conclusion of the Technical Committee and looking at the average TBL and average formation level of Baliyatra ground at least 25% of the average area may be allowed for permanent construction alongside the ring road embankment keeping in mind sustainable development in every aspect. Cuttack being a millennium old city is thickly populated and having being bounded by two river delta, this embankment widening and fortification will help the social and safety requirement of the city.

Point No. 10: That, in the above context it is most respectfully submitted that out of the 424 acres of reclaimed, the area that falls between the two spurs and adjacent to existing embankment (Cuttack ring road), which comes around 66.7 acres of land, can be developed by way of permanent construction, for the public purpose. It is apt to mention here that earlier the said area was under the occupation of slum dwellers. If the same portion would not be used for the purpose of public utilities, the said area, in all probability is likely to be occupied again by the slum dwellers.

The State of Odisha i.e. DoWR has filed an Objection Affidavit activity submitted on Dt. 20.5.2022 (**Annexure-II**):

7. However, in the Recommendations given by the Second Joint Committee although I am a signatory to it but have a divergent view on the recommendation given in Sl. No. 2 (iii) "The whole reclaimed land (426-34 + 392 acres) except the 34 acre of Balijatra

ground may be used for plantation with appropriate Local species and the area may be developed into a Biological Park reviving the old channels buried under sand".

8. My humble suggestion will be:

For Sl. No. 2(iii) Now, this land of 392 acres has become a breathing space for the Cuttack city as this old city is already congested in terms of place and traffic. Apart from the above said activities, this new space (i.e. 426-34+ 392 acres) can also be utilized for various facilities for the public. Since, the area has been created to remove unauthorized/illegal habitations and encroachment and looking into its recreational activity and also developing it in an aesthetic manner for the public. Some land along the ring road can be also allowed for construction purposes as well as other public facilities like art galleries, museum etc. which I had already raised the issue in our earlier Joint Committee meetings. The new sand raised land is of a vast area of 392 acres and the facilities highlighted in "Priority – 3" and some part of Priority-2 may be allowed as per the of NDMA guidelines. Further, as regards to the revival of the old buried channel, I am of the opinion that the suggestion to again create the old channel buried under sand is not required.

9. I conclude as such, technically major part can be used for open space for facilities highlighted in "Priority-2, & 3 as per the NDMA guidelines and a small part can be allowed for permanent construction along the ring road. In my opinion it will have no harm to the river ecology. I put it in record that the recommendation of the report of the 1st joint committee may be taken into consideration for judicious views in light of better management of developed and evicted vast area for a better environment for the people of Cuttack.

25/8/2022

Dr. Sohan Giri
(5 & 7 Joint Committee Member)
REGIONAL OFFICER
SPCB, Odisha, Bhubaneswar

Annexure-I

Item No.02 (Court No. 1)

BEFORE THE NATIONAL GREEN TRIBUNAL
SPECIAL BENCH

(By Video Conferencing)

Original Application No. 68/2020/EZ
&
I.A. Nos. 06/2021/EZ, 07/2021/EZ & 15/2022/EZ

Pradip Kumar Pattnaik — Applicant

Versus

Union of India & Ors. — Respondent(s)

Date of hearing: 07.02.2022

CORAM: **HON'BLE MR. JUSTICE ADARSH KUMAR GOEL, CHAIRPERSON**
HON'BLE MR. JUSTICE SUDHIR AGARWAL, JUDICIAL MEMBER
HON'BLE MR. JUSTICE B. AMIT STHALEKAR, JUDICIAL MEMBER
HON'BLE DR. NAGIN NANDA, EXPERT MEMBER
HON'BLE MR. SAIBAL DASGUPTA, EXPERT MEMBER
HON'BLE DR. AFROZ AHMAD, EXPERT MEMBER

Applicant: Mr. Prabhu Prasanna Behera, Advocate

Respondent(s): Mr. Janmejaya Katikia, AGA for R-2 to 8,
Mr. Gora Chand Roy Choudhury, Advocate for R-1&10
Mr. Surendra Kumar, Advocate for CPCB

ORDER

1. Grievance in this application is against the illegal sand filling in the Mahanadi river bed within the water area of Jobra Barrage at Cuttack. According to the applicant, the illegal action being undertaken is causing damage to the environment and the riverine ecosystem. The project called Balijatra River Front Improvement (BARFI) is an attempt to monetize the river bed for commercial purposes which will reduce the water retaining capacity of the river at Jobra Barrage at Cuttack. Free flow of water of the river bed will be affected in violation of judgment of

the Odisha High Court dated 27.02.2012 in W.P.(C) No. 20283/2011, *The National Lawyers Forum vs. State of Orissa and Ors.* This will affect supply of drinking water and obstruct dredging which is necessary. This will also add to the floods in the city.

2. During the hearing, learned Counsel for the applicant has also referred to the order of this Tribunal dated 15.12.2020 in O.A. No. 22/2020(EZ), *Dilip Kumar Samantaray vs. State of Odisha Board & Ors.*, wherein the Tribunal constituted a joint Committee as follows:

> *"16. Accordingly, we constitute a joint Committee comprising representatives of Central Water Commission (CWC), nominees of MoEF&CC, CPCB, National Institute of Hydrology, Roorkee and the State PCB* ***to consider the issue and lay down norms so as to ensure that the proposal of the State for construction of the medical college and river front development takes place in accordance with law, without damage to the flood plains of the Rivers. Flood plain zones need to be identified and demarcated in the light of such norms. The Committee may identify the extent of floodplain zone/active floodplain zone from the edge of the river. CPCB will be nodal agency for compliance.*** *The Committee is free to associate any other individual or institution. The Committee may complete its exercise within four months. The members of the Committee are free to interact by video conferencing or otherwise. If any grievance with regard to violation of environmental norms survives, the applicant will be free to take any further remedies as per law."*

3. The matter was considered on 21.01.2021. The applicant was permitted to represent grievance in this application to the Committee already constituted so that the Committee could file a consolidated report about all the issues and the statutory authorities could take remedial action to enforce the law.

4. At this stage, we may also note the observations in order dated 15.12.2020 in O.A. No. 22/2020(EZ), *Dilip Kumar Samantaray vs. State of Odisha Board & Ors.* about the legal framework and need for protection of flood plains in the interest of riverine ecology and the life

and property of people. Reference was made to the judgment of the Hon'ble Supreme Court dated 30.07.2009 in *D.D.A. vs. Rajendra Singh*, 2009 (8) SCC 582 mentioning the significance of protecting river beds and flood plains. Reference was also made to earlier order of this Tribunal dated 13.01.2015 in *OA No. 6/2012* and *OA No. 300/2013, Manoj Misra vs. Union of India & Ors.* reported in 2015 ALL (I) NGT REPORTER (1) (DELHI) 139, judgment of this Tribunal dated 13.07.2017 in OA No. 200/2014, *M.C. Mehta vs. Union of India & Ors.* reported in 2017 NGTR (3) PB 1 in the context of river Ganga. The Tribunal referred to the Notification dated 07.10.2016 issued by the Ministry of Water Resources with regard to Ganga River on the subject of protecting active flood plain areas of the river and its tributaries. Reference was also made to laws enacted on the subject in certain States including Manipur Flood Zoning Act, 1978 and the Uttarakhand Flood Plain Zoning Act, 2012. Apart from Rules/Guidelines, reference was made also to Wetland Rules and action plans prepared by River Rejuvenation Committees in all the States/UTs in pursuance of order of this Tribunal dated 21.09.2020 in *OA No. 673/2018, In Re: News item published in "The Hindu" authored by Shir Jacob Koshy, titled "More river stretches are now critically polluted: CPCB* to the extent of steps for protecting flood plains. The Tribunal finally observed that no project could be developed in a flood plain of the river even in absence of any statutory provision on the subject as doing so affects the riverine ecology adversely. Accordingly, the Tribunal constituted a joint Committee mentioned earlier to identify the extent of flood plain zones and to lay down norms to ensure that no project was developed on the flood plains in violation of laws, resulting in damage to flood plains.

5. Accordingly, CPCB has filed its affidavit dated 04.10.2021 annexing the report of the joint Committee. The affidavit of CPCB shows that CPCB sanctioned a project called "Floodplain Zoning Study for the Identified Stretches of Mahanadi River Basin" for mapping of the river using satellite imageries, digital elevation maps, land use and land cover map showing habitation, flood frequency analysis and demarcation of flood plain zones from the edge of the river under supervision of Prof. K.C. Patra, Civil Engineering Department, NIT Rourkela, who submitted his initial study report on 03.08.2021 on flood plain zoning of the area based on discharge data provided by (i) Central Water Commission (hereinafter referred as "CWC") as well as Odisha Water Resources Department (hereinafter referred as "WRD"), (ii) DEM provided by National Remote Sensing Centre (hereinafter referred as "NRSC"), (iii) Reduced levels of Baliyatra and other points by Odisha Water Resources Department (hereinafter referred as "WRD") and (iv) Modelling through HEC-RAS 6.0.The annexed report has following conclusions and recommendations:-

> ***"5.4 Conclusion and Recommendation as indicated in the study:***
>
> *The floodplain zoning study for the identified stretches of Mahanadi river basin was carried out based on the discharge data provided by the (i) Central Water Commission (CWC) as well as Odisha Water Resources Department (WRD), (ii) DEM Provided by National Remote Sensing Centre (NRSC), (iii) Reduced levels of Baliyatra and other points by Odisha Water Resources Department (WRD), and (iv) Modelling through HEC-RAS 6.0. For details results and discussion of the study,* ***page no. 35-37*** *may kindly be referred. As per the report following key conclusion and recommendations have been made;*
>
> 1. *From the derived statistical parameters of the CWC as well as Odisha WRD data, the value of 25 years return period flood (Q25) of magnitude 40,063 m3/s (from CWC data) is considered for floodplain mapping of the study area. During the passage of floods of Q25 and Q100, the difference in flood depths over the study areas are not found to be significant. This may be due to the river at this stretch is quite wide and thus, it is in a position to pass the*

flood of various return periods without appreciable change in the floodplain submergence geometry.

2. *While routing this Q25 flood, it can be seen that the depth of water over the Baliyatra ground during the propagation of this flood just exceeds its average formation level of 24.5 m, but below the Reduced Level (RL) of ring road. Records from Odisha WRD indicate that water level during the passage of the flood of 44,768 m3/s was less than the RL of ring road, which further strengths the present finding on the safety of passage of the flood. Therefore, any development activities in this area can be suitably planned keeping in mind the possible submergence of this Baliyatra rehabilitated area can be expected at least once in 25 years.*

3. ***The flood of 25 year return period is most likely to affect about 38 villages in and around the Cuttack city between Munduli and up to the lower reach, while another 66 villages may be partially affected. These villages are on the outer periphery of both Kathjodi and Main Mahanadi branches.***

4. *The mean and maximum velocity of flow at cross-section 5 (having sand dune) areas are 0.493 m/s and 1.051 m/s, while at cross-section 1 (having no sand dune) the corresponding values area 0.62 m/s and 1.155 m/s. The same values at cross-section 3 which is very close to the Jobra barrage are 0.527 m/s and 1.02 m/s. From this, it can be observed that the removal of sand dunes has increased the velocity of flow at the section.*

5. ***National Disaster Management Authorities (NDMA) Guidelines, 2008 and all other design codes need to be followed while implementing any concepts for the utilization of Baliyatra Ground at Cuttack.***

5.5Limitations of the study:

The study has the following limitations:

- *The flood inundation area has been computed from the CARTOSAT DEM which is not verified from the ground survey and DGPS.*

- *Some water resources projects (both storage projects and diversion schemes) are expected to come up in future in the upstream catchment areas that is expected to store more water and moderate floods leading to reduce its peak at the Baliyatra site.*

- *The study has the limitations inherent to the modelling through the software, quality and accuracy of the data, accuracy of the DEM, and all other associated parameters.*

6.0 Recommendation of the joint committee

To comply with the directions committee carried out the study by the expert institutes and agreed with the findings of the study. The point wise compliance status of the directions are as follows;

6.1 Identification and demarcation of Floodplain

*Flood plain zoning study (**Annexure:** 3) was conducted by NIT Rourkela and was agreed upon by the committee members. In this study, Flood Zone Mapping and Inundation Map was done using the latest version of HEC-RAS V-6.0 (1-D Modelling). As per the study, it was found that flood of 25 year return period (Q_{25}) can be considered for modelling and identifying the floodplain inundation maps in the concerned stretch as the difference in flood depths between Q25 and $Q100$ is not found to be significant. It was further found that the flood of 25 year return period is expected to affect about 38 villages in and around the Cuttack city from the Munduli barrage to the downstream of Jobra barrage as depicted in Figure 6-1. A list of these villages is also provided in Table 2. Based on the analysis it was observed that the depth of water over the Baliyatra ground during the propagation of Q_{25} flood exceeds its average formation level of 24.5 m, but is below the RL of ring road.*

Table 2: List of villages expected to be affected during the passage of 25 year return period flood in periphery outer zones

Most Likely to be Affected Village List					
1.	Balipur	2.	Pahilabar	3.	Talagar
4.	Baula	5.	Lalitabisakhapur	6.	Chhagan
7.	Madhyakachha	8.	Agrahat	9.	Nuapatana
10	Sankarpur	11.	Jhatia	12.	Shrirangapur
13	Bhabadeipur	14	Katkiasahi	15.	Jagannatarapur
16.	Nuasasan	17.	Mangalpur	18.	Ramshyampur
19.	Badasantarapur	20.	Jemadeipur	21.	Arilo
22.	Suniamunha	23.	Bhuinbarei	24.	Kotar
25.	Bandhahata	26.	Sarakuan	27.	Paikerapur
28.	Sardarkharida	29.	Brahmanbasta	30.	Nuagada
31.	Kalankipur	32.	Anantapur	33.	Prabatia
34.	Jagmohanpur	35.	Baghua	36.	Similihanda
37.	Badapadagaon	38.	Sanakakhadi		

6.2 Construction of the medical college and river front development as per norms

Based on the meeting taken by the committee with all the concerned agencies on 7th April, 2021 at Cuttack, the concept note on Mahanadi Waterfront Development describing the proposed construction activity was provided by Cuttack Development Authority (CDA). The same has been considered by the committee.

Based on the study, Baliyatra Ground comes under floodplain zone, therefore construction of structures of permanent type, as in column 2 of this Table 3 (priority-2) may be prohibited and only non-permanent structures may be allowed subject to

strict adherences to the NDMA guidelines, Building Codes and others. These structures should be planned as far as away from the river water lines and active only during non-monsoon days so that there is no loss to the life and property.

Although most of the activities proposed in the CDA concept note fall under priority 3 and may be allowed following the guidelines, • however, a few construction activities like art galleries, museums etc. fall under priority 2 and therefore may not be permitted. The construction or extension of the Medical college has neither been proposed in the CDA note nor is it permissible as per NDMA Guidelines, as this kind of structure falls under Priority 1 activities.

Categorization of the construction activities proposed by the Cuttack Development Authority (CDA) under the Mahanadi Waterfront Development is provided in Table 3.

Table 3; Categorization of the construction activities proposed by the Cuttack Development Authority (CDA) under the Mahanadi Waterfront Development

Proposed Construction Activities	Priority 1	Priority 2	Priority 3
public infrastructure such as parks, gardens, sports facilities			✓
public infrastructure art galleries and museums		✓	
roads with uniform travel lanes, shaded footpaths, designated cycle tracks, safe intersections and landscape and public space inclusion.			✓
open air market, craft bazar, food stalls like Dilli Haat (New Delhi) & Ekamra Haat (Bhubaneswar) to promote local art & crafts as well as traditional works			✓
An open-air auditorium			✓
Bali Jatra grounds			✓

6. Appendix-2 annexed to the report about the scope of allowed and not allowed facilities is as follows:-

"Scope of the allowed and non-allowed facilities under Priority-1, 2 and 3

Categorization	Type of structures permitted as per NDMA Guidelines	Basis of Prioritization and guidelines	Study Recommendations (Joint Committee may decide on the Activities following NDMA guidelines)
Priority -1	• Defence installations • Industries • Public utilities like hospitals, electricity installations, water supply, telephone exchanges, aerodromes, railway stations, commercial centres, etc.	Buildings should be located in such a fashion that they are above the levels corresponding to a 100- year frequency or the maximum observed flood levels. Similarly they should also be above the levels corresponding to a 50-year rainfall and the likely submersion due to drainage congestion.	Structures under Priority-1 of the NDMA Guidelines is not permitted in the Baliyatra Ground.
Priority -2	• Public institutions • Government offices • Universities • Public libraries • Residential areas	Buildings should be above a level corresponding to a 25-year flood or a 10-year rainfall. Stipulation that all buildings in vulnerable zones should be constructed on columns or stilts. (a) Plinth levels of all buildings should be 0.6 m above the drainage/flood submersion lines. (b) In the areas liable to floods, all the buildings should preferably be double and multiple storeys. (c) In urban areas ground floor to be utilised for non-residential purposes	Baliyatra Ground comes under floodplain zone, therefore construction of structures of permanent type, as in column 2 of this table (priority-2) may be prohibited. Baliyatra Ground is within floodplain area and therefore non-permanent structures may be allowed subject to strict adherences to the NDMA guidelines, Building Codes and others. These structures should be planned as far as away from the river water lines and active only during non-monsoon days so that there is no loss to the life and property.
Priority -3	• Parks and playgrounds	Certain areas on either side of the existing and proposed drains (including rural drains) should be declared as green belts where no building or other activity should be allowed. This will not only facilitate improvement of these drains in future for taking discharges on account of growing urbanisation, but will also help in minimising the damage due to drainage congestion whenever rainfall of higher frequency than designed is experienced. These green belts, at suitable locations, can also be developed as parks and gardens.	Priority-3 activities such as developments of Parks, Playgrounds and creation of other facilities (such as Recreational Space, Urban Forests, Pedestrian Paths, Cycle Tracks, Solar Lighting, Rain Water Harvesting, Gardens, Footpaths, Cycle Tracks, Open Air Market, temporary Craft Bazar, Food Stalls, Open Air Auditorium) may be permitted following NDMA Guidelines in the Baliyatra Ground. These facilities should be active during non-monsoon periods so that there is no loss to the life and property.

7. We have heard learned Counsels for the parties. Learned Counsel for the applicant submitted that while the report considers engineering aspects in light of guidelines issued by National Disaster Management Authority, it does not consider ecological and hydrological aspects in terms of order of this Tribunal dated 15.12.2020 in O.A. No. 22/2020(EZ), *Dilip Kumar Samantaray (Supra)*. Such consideration is essential for protection of flood plain zone and associated issues relating to the ecology, environment and biodiversity. Ecological vulnerability and combined hazard vulnerability are required to be studied in light of observation of this Tribunal in order dated 15.12.2020 and safeguards need to be identified for protection of the flood plains. It requires constitution of joint Committee comprising Experts in the field of Hydrology, remote sensing and Ecology.

8. We do not see any reason not to accept the suggestion for such further study to consider appropriate directions in the interest of environment. Accordingly, we direct a joint Committee of seven Experts, with five members in the earlier Committee and two other Experts viz. Prof. C.R. Babu, eminent ecologist and environmentalist and Prof. P.C. Mishra, former Expert Member of NGT to undertake the study in light of above observations so as to include ecological and hydrological aspects and vulnerability, adding these components in the report and to make detailed recommendations identifying the steps required for protecting the flood plain zone and the environment within three months. It will be open to the applicant as well as State of Odisha to place their respective view point before the Committee. CPCB will be the nodal agency to carry out the entire exercise. Report may be filed before the Tribunal on or before 30.04.2022 by e-mail at judicial-ngt@gov.in preferably in the form

of searchable PDF/ OCR Support PDF and not in the form of Image PDF on or before 30.04.2022. Report may also be placed on the website of CPCB for response by any stakeholder before the next date of hearing.

9. I.A. No. 06/2021/EZ and I.A. No. 07/2021/EZ seek injunction against any construction in the river bed and I.A. No. 15/2022/EZ seeks time for filing response of the State Government. No construction of permanent nature will be allowed in the flood plain in question pending further order. The IAs will stand disposed of accordingly.

List for further consideration on 23.05.2022.

Adarsh Kumar Goel, CP

Sudhir Agarwal, JM

B. Amit Sthalekar, JM

Dr. Nagin Nanda, EM

Saibal Dasgupta, EM

Dr. Afroz Ahmad, EM

February07, 2022
Original Application No. 68/2020/EZ
& I.A. Nos. 06/2021/EZ, 07/2021/EZ & 15/2022/EZ
SN

Annexure-II

BEFORE THE NATIONAL GREEN TRIBUNAL,
EASTERN ZONE BENCH, KOLKATA.

O.A. NO. 68 / 2020 / EZ

PRADIP KUMAR PATTNAIK APPLICANT

VERSUS

UNION OF INDIA AND OTHERS RESPONDENTS

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CUTTACK
DT.20.05.2022

ADDL. GOVT. ADVOCATE

1184 20/10

BEFORE THE NATIONAL GREEN TRIBUNAL,
EASTERN ZONE BENCH, KOLKATA.
O.A. NO. 68/2020/EZ

PRADIP KUMAR PATTNAIK APPLICANT

VERSUS

UNION OF INDIA AND OTHERS RESPONDENTS

OBJECTION TO THE AFFIDAVIT, FILED BY THE CENTRAL POLLUTION CONTROL BOARD (CPCB) DATED 04.10.2021 AND TO THE FLOOD PLAIN ZONING STUDY REPORT OF THE COMMITTEE UNDER ANNEXURE-3.

Babulal Behera

I, Shri Babulal Behera, aged about 55 years, son of late Padmalochan Behera, at present serving as the Superintending Engineer, Mahanadi Barrage Division, Gandarpur, At.- Gandarpur, PO. - College Square, in the district of Cuttack, do hereby solemnly affirm and state as follows;

1. That, I am the respondent no.6 to the original application and on being duly authorised by the other respondents, I am competent to swear this affidavit for self and on behalf of other State/Respondents.

2. That, the deponent craves leave of this Hon'ble Court to raise issues to the report prepared by the Joint Committee on flood plain

NOTARY S.P. MOHANTY CUTTACK TOWN Reg. No. 01/01 Valid 23/04/2028 GOVT. OF ODISHA

zoning study and respective part of the affidavit filed by the CPCB on 4th October, 2021.

3. That, it is respectfully submitted that on receipt of the flood plain zoning study report under Annexure-I to the affidavit of CPCB, the State Government by office order dated 02.02.2022 formed a technical committee comprising of nine members to undertake further studies on the report of the Joint Committee, formed by this Hon'ble Tribunal, to find out whether the said report is erroneous and at any place which may affect the interest of the State. A copy of the letter dated 02.02.2022 is filed as **Annexure-R/6/A**.

4. That, the state's technical committee, constituted by the government visited the site on 25.02.2022 and made detailed study on the issue vis-à-vis the report submitted by the Joint Committee formed by this Hon'ble Tribunal. After visiting the site the committee had a detailed analysis of the entire aspects, relating to the issue and came to the following conclusions;

a) During passage of Q25 flood the expected water level at Baliyatra ground will be around 23.7937m.

b) Due to Q100 flood the expected water level at Baliyatra ground will be around 24.497m.

c) The average formation level of Baliyatra ground is 24.5m and the average TBL of the ring road is 25.5m.

d) That, the highest ever flood passed in river Mahanadi during the year 1982 with flood discharge of 15.84 lakh cusses, the water level recorded at Baliyatra ground is 23.54m which is less than the computed Q25 water level (i.e. 23.79m). Although last 40 years record since the year 1982 reflects that, the flood water level is less than 25 year flood forecast i.e. Q25, it is arrived that in the meantime Q25 has passed and flood peak is below compute Q25.

e) As the expected water level at Baliyatra ground due to Q25 is less than and Q100 floods is about less than equal to the average formation level of the Baliyatra ground, some construction activities can be carried out as per guidelines of NDMA (National Disaster Management Authority).

f) That, as per the report of state's technical committee, since the land fill area is well bounded by two spurs on either side, two rows of sheet piles on the river side and ring road embankment on the southern side, a portion of the said area adjacent to the embankment (ring road) may be considered for permanent construction purposes by raising the plinth level about the Top Bank Level of the ring road which is at RL 25.5m. The structural safety aspect shall be given top priority while preparing the design.

g) The utilisation of the above land may be only for specific public utilities considering the present situation of Cuttack City and

Babulal Behera

shall not be constru ed as an example to be implemented in other flood plains in the State.

h) Proposed storage projects or diversion scheme in Mahanadi and its tributaries between Hirakud and Mundali will be able to store some water and help to moderate future floods on the d/s side thereby reducing the chances of submergence of Baliyatra ground.

i) Record of submergence, peak discharge in Mahanadi was recorded in this year 1982 (15.84 lakh cusecs) and year 2008 (15.82 lakh cusecs) which are almost similar magnitude and the status of submergence in the history of flood is given below i.e on dtd.20.09.2008, only 13 nos. of villages affected in crop loss.

The finding/conclusions of the Technical Committee, as stated above, has been duly communicated to the CPCB, vide letter No. 1507 dated 28.04.2022, a copy of which is filed as **Annexure-R/6/B**.

5. That, the Technical Committee has arrived at the above conclusion after having a study of flood of 100 years return period (Q100) for identifying the flood plain area. It is hereby submitted that the joint committee formed by the NGT has made the assessment taking into consideration the flood of 25 years of return period (Q25).

It is to be made clear that as has been observed by the State's Technical Committee that taking 25 years return of flood period

(Q25), the expected water level at Baliyatra ground comes around 23.7937m. Hence, the averment made by CPCB at paragraph-II (iv) of the affidavit is not correct. In this context, it is further submitted that it is an incorrect assessment to say that the depth of water over Baliyatra ground during the propagation of Q25 flood exceeds it is average formation level of 24.5m.

6. That, further it is respectfully submitted that the averment taken at paragraph-10(c) and the corresponding finding in the report saying that the flood of 25 years of return period is most likely to affect 38 villages in and around the Cuttack City between Mundali and up to the lower reach, while another 66 villages may be partially affected which are on the outer periphery of both Kathajodi and main Mahanadi Branches, is not correct, as the same is based upon speculation which is apparent from the language used. It is further submitted that the joint committee should have been specific on the point that how many villages had been affected and should not have given a evasive conclusion saying most likely 38 villages would have been affected. Such finding of the joint committee need not be taken into consideration. But as per revenue records as found by state's technical committee during the flood of the year 2008 (of same discharge of 1982), only 13 nos of villages affected by crop loss only.

7. That, as has been observed by the technical committee, highest ever flood water level recorded at Baliyatra is 23.54m in the year 1982. It has been further observed that the average formation level of Baliyatra ground is 24.5m. and the average Top Bank Level (TBL) of the Ring Road is 25.5m. Hence, at no stretch of imagination it can be arrived at a just conclusion that the flood level can ever go above the average formation level of Baliyatra ground.

8. That, when the conclusions arrived at by the State's Technical Committee is clear and unambiguous, speculative conclusions of the Joint Committee may not be taken into consideration. Hence, permanent construction of any kind limiting to pome area, if proposed by raising the plinth level above the top bank level of the ring road giving priority to the structural safety aspect, may kindly be considered.

9. That, it is respectfully submitted that an area of 424 acres of land is lying vacant which can be utilised for many constructive purposes. Even though the constructions under priority No.-2 (at some places) and priority No.-3 have been suggested by the joint committee for giving permission, construction of priority No.-1 has not been suggested. In view of the conclusions of the Technical Committee and looking at the average TBL and average formation levelof Baliyatra ground at least 25% of the above area may be allowed for permanent construction alongside the ring road

Prabhulal Behera

embankment keeping in mind sustainable developments in civic aspect. Cuttack being a millennium old city is thickly populated and having been bounded by two river delta, this embankment widening and fortification will help the social and safety requirement of the city.

10. That, in the above context it is most respectfully submitted that out of the 424 acres of reclaimed, the area that falls between the two spurs and adjacent to existing embankment (Cuttack ring road), which comes around 66.7 acres of land, can be developed by way of permanent construction, for the public purpose. It is apt to mention here that earlier the said area was under the occupation of slum dwellers. If the same portion would not be used for the purpose of public utilities, the said area, in all probability, is likely to be occupied again by the slum dwellers.

Babulal Behra

11. That, it is further humbly submitted that the area where Baliyatra is being held has to be kept vacant and the government has no proposal for any kind of permanent construction over the same. It is submitted that so far as types of activities under priority no3 for public purpose, the State Government has absolute faith and hence leave it to the discretion of this Hon'ble Tribunal to decide on the types of activities to be undertaken to give a new life to population of Cuttack & Odisha as a whole.

For better appreciation of this Hon'ble Tribunal, a copy of tabular comparative analysis on the finding of the Joint Committee Report vis-à-vis the report of the Technical Committee, constituted by the Respondent no.6, is enclosed herewith as Annexure-R/6/B.

12. That, all the allegation which are not specifically admitted herein are deemed to have been denied and the deponent reserves the right to file further affidavit.

13. That, the facts stated above are true to the best of my knowledge, belief and based on records.

Identified by
Advocate

Babulal Behra
DEPONENT

CERTIFICATE

Certified that due to non-availability of cartridge papers, the instant object has been typed on thick white papers.

CUTTACK
DT. 20.05.2022

ADDL. GOVT.ADVOCATE

Annexure-6/A

GOVERNMENT OF ODISHA
DEPARTMENT OF WATER RESOURCES

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No.- WR-MAJHI-MISC-0002-2021: 2400 / WR, Dated: 2/2/2022

OFFICE ORDER

In supersession of this Department Office Order No. 1880 Dtd. 24.01.2022, the Technical Committee is hereby re-constituted with the following members

1. Engineer-in-Chief, Water Resources - Chairman
2. CE&BM, Mahanadi Kathajodi System - Member
3. Chief Engineer, HH,GIS &CEM Member Convenor
4. Chief Engineer, Planning Member
5. Sri R.C.Tripathy, Ex-EIC, Water Resources - Member
6. Prof. R. Sunaravadivelu, IIT, Madras - Member
7. Prof.K.K.Khatua, NIT, Rourkela - Member
8. City Engineer, CMC, Cuttack - Member
9. Add. Chief Engineer, Eastern Circle-I - Member

The Committee shall undertake following studies and submit their report to this Department.

1. Historical flood level data of last 100 years of Mahanadi river near Cuttack city and the adjoining villages mentioned in the NGT report.
2. Guiding principle issued by NGT Committee and Study report prepared by NIT Rourkela on this matter.
3. Calculation of 100 year return flood and projected water level of river Mahanadi near Cuttack city and adjoining villages mentioned in the NGT report.

Copy attested

By order of Chief Secretary

Special Secretary to Government

Superintending Engineer
Mahanadi Barrage Circle Division
Gandarpur, Cuttack

No. 2401 Dtd. 2/2/2022

Copy forwarded to OSD to Chief Secretary for kind information of the Chief Secretary

Special Secretary to Government

Memo No. 2402 Dtd. 2/2/2022

Copy forwarded to Sr. P.S to Additional Chief Secretary for kind information of the Additional Chief Secretary, DoWR.

02/2/2022
Deputy Secretary to Government

Memo No. 2403 Dtd. 2/2/2022

Copy forwarded to P. S. to Principal Secretary to Govt., H & UD Department for kind information of the Principal Secretary, H&UD Deptt.

02/02/2022
Deputy Secretary to Government

Memo No. 2404 Dtd. 2/2/2022

Copy forwarded to Members Concerned for kind information and necessary action.

02/02/2022
Deputy Secretary to Government

Memo No. 2405 Dtd. 2/2/2022

Copy forwarded to Collector, Cuttack/ Commissioner, CMC, Cuttack/ Sri Janmejaya Katikia, Addl. Govt. Advocate for kind information and necessary action.

02/02/2022
Deputy Secretary to Government

True Copy attested

Superintending Engineer
Mahanadi Barrage Division
Gandarpur, Cuttack-3

Report of the Technical Committee

Methodology Adopted for Study

1. The committee considered the 48 years flow series at Tikerpada which has been used in the NGT report as source data for the model study.

2. The return flood hydrograph for 25 years (Q25) and 100 years (Q100) are taken as u/s condition to the HEC-RAS mathematical model.

3. Different Digital Elevation Models.(DEM) have been tried in the analysis. Finally, the SRTM DEM has been adopted for the study.

4. Trials were performed using 2D and 1D modelling. Since, 2D model is more appropriate over 1D model in the deltaic region, the results of 2D model have been considered to draw the conclusions.

Conclusions

1. During passage of Q25 flood the expected water level at Baliyatra ground will be around 23.7937m.

2. Due to Q100 flood the expected water level at Baliyatra ground will be around 24.497m.

3. The average formation level of Baliyatra ground is 24.5m and the average TBL of the ring road is 25.5m.

4. Highest ever flood water level recorded at Baliyatra ground is 23.54m during the Year-1982.

5. As the expected water level at Baliyatra ground due to Q25 and Q100 floods are either less than or equal to the average formation level of the Baliyatra ground, some construction activities can be carried out as per guidelines of NDMA.

6. Since, the land fill area is well bounded by two spurs on either side, two rows of sheet piles on the river side and ring road embankment on the southern side, a portion of the said area adjacent to the embankment (ring road) may be considered for permanent construction purposes by raising the plinth level above the Top Bank Level of the ring road which is at RL 25.5m. The structural safety aspect shall be given top priority while preparing the design.

Copy attested

Executive Engineer
Irrigation Division
Cuttack-3

7. The utilisation of the above land may be only for specific public utilities considering the present situation of Cuttack city and shall not be construed as an example to be implemented in other flood plains in the State.

8. Proposed storage projects or diversion schemes in Mahanadi and its tributaries between Hirakud and Mundali will be able to store some water and help to moderate future floods on the d/s side there by reducing the chances of submergence of Baliyatra ground.

9. Record of Submergence: Peak discharge in Mahanadi was recorded in the Year:1982 (15.84 lakh cusecs) & Year:2008 (15.82 lakh cusecs). The status of submergence in the history of flood is given below.

- 20.09.2008: 13 villages (crop loss only)
- 11.09.2011: One village, namely Nuapatna (Tangi-Choudwar Block)

Engineer-in-Chief, Water Resources	25/4/22 CCE&BM, Mahanadi Kathajodi System	25.4.22 CE, HH, GIS & CEM
25/04/22 Chief Engineer, Planning	Sri R. C. Tripathy, Ex-EIC, Water Resources	Prof. Sundaravadivelu, IIT, Madras
Prof. K K Khatua, NIT, Rourkela	25/4/22 City Engineer, CMC, Cuttack	25/4/22 Addl. Chief Engineer, Eastern Circle-I

True Copy attested

20/5/22
Superintending Engineer
Mahanadi Barrage Division
Gandarpur, Cuttack

Annexure-R/6/B

A comparative study of finding of Joint Committee Report vis-a-vis report of the Technical Committee constituted by Department of Water Resources, Odisha

Inputs for the study: The Flow series, Flood frequency analysis (25 Yrs & 100 Yrs) and Design flood hydrograph as used in the study of NIT, Rourkela has been used by the Technical Committee.

Sl No.	Description	As per NGT report	Findings of the Technical Committee
1	Expected level due to Q25 Flood (40,063 Cumecs)	While routing the 25 years return flood it can be seen that the depth of water over the Baliyatra ground during the propagation of this flood just exceeds its average formation level of 24.5m, but below the RL of ring road which is about 25.6m. (Reference Pg.37 Conclusion & Recommendations)	2D model is run and the expected water level due to Q25 flood is 23.7937m which is 0.7063 m below the average formation level Highest recorded observed level during 1982 flood (31.08.1982) is RL.23.54m, which means that Q25 flood has never come across. 1D model also run and found the average level of 23.366 m i.e. below the observed R.L 23.54 m.
2	Expected level due to Q100 Flood (49,711 Cumecs)	During the passage of Q25 and Q100 flood the difference in flood depths over the study area are not found to be significant.	The expected water level due to Q100 flood is RL.24.497m which is 0.003m below the average formation level of RL.24.5m.
3	Submergence of villages	The flood of 25yrs return period is most likely to affect about 38 villages in and around Cuttack city between Mundali and up to the lower reach, while another 66 villages may be partially affected. These villages are on the outer periphery of both Kathajodi and main Mahanadi branches	The submergence reported in the NGT report is based on Cadastral Map used. However, The committee information on submergence of adjoining areas due to historical flood was ascertained from revenue authorities. 20.09.2008: 13 villages (crop loss only) 11.09.2011: One village, namely Nuapatna (Tangi-Choudwar Block)

True Copy attested

Superintending Engineer
Barrage Division