Government of West Bengal

Terms of Reference (ToR) for Consultancy Services

for

Assessment & demarcation of Flood Prone Areas of the State of West Bengal using temporal satellite imagery

for

IRRIGATION & WATERWAYS DEPARTMENT

July, 2021

In connection with

REQUEST FOR EXPRESSION OF INTEREST(REOI) No. : WBIW/EE/IPDS/REOI-01 / 21-22

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1.

Introduction

Natural disasters are a major cause of devastation in the entire world. An estimated 96% of deaths related to natural disasters in the past decade occurred in developing countries. Flooding is one of the greatest water-related environmental disasters and is the major concern in the State of West Bengal in India. The number of people vulnerable to devastating floods in the State is high due to high density of population, large-scale urbanization, population growth in flood-prone areas, land-use changes, climate change and rising sea levels apart from its contributions to the biodiversity and sustainability of ecosystems and to many other human activities. Although the number of fatalities has declined over the years due to improved communication systems, economic losses have continued to rise with increased urbanization in flood-hazard areas. The recurring floods cause loss of life, destruction and damages to existing infrastructure, including roads, bridges, embankments and agricultural land. This stresses the need for identification of flood prone areas. It is needless to mention that identification of flood prone areas becomes the primary task in adopting appropriate measures for mitigation of floods.

1. Background

West Bengal being the lowermost riparian State of Ganga-Brahmaputra basins, has both Inter-State catchment areas (of 57,624 Sq. Km.) & International catchment areas (of 34,252 Sq. Km.) and thus has no control over influx from the upper catchment areas. Outfall tidal conditions often turns situation worse & River Bank Erosion, Coastal Erosion, Waterlogging, Tidal Inundation, Cyclones/Depressions are common phenomena of the State. The State extends from the snow-capped mountains of the Himalayas to the Bay of Bengal and manifests every aspect of floods and drainage problems. The monsoon rainfall normally starts from June and ends in October. The districts in the southern parts of the State experience heavy precipitation particularly in the months of September and October. Consequently, upon development of low pressure/depressions in the Bay of Bengal during this period, major floodshave been noticed to have occurred during this crucial period.

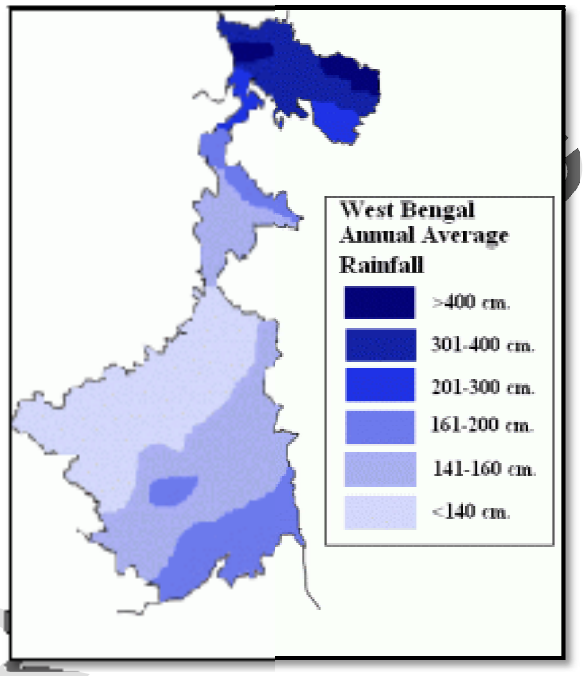
Some of the years of extensive flood occurrence are 1913, 1916, 1942, 1946, 1954, 1955, 1956, 1958, 1959, 1961, 1965, 1968, 1971, **1978**, 1979, 1983, **1984**, 1985, 1986, 1987, 1988, 1990, **1991**, 1993, 1995, 1996, 1997, 1998, 1999, **2000**, 2001, 2002, 2003, 2004, 2005, 2006, 2007.

- **Sources:**

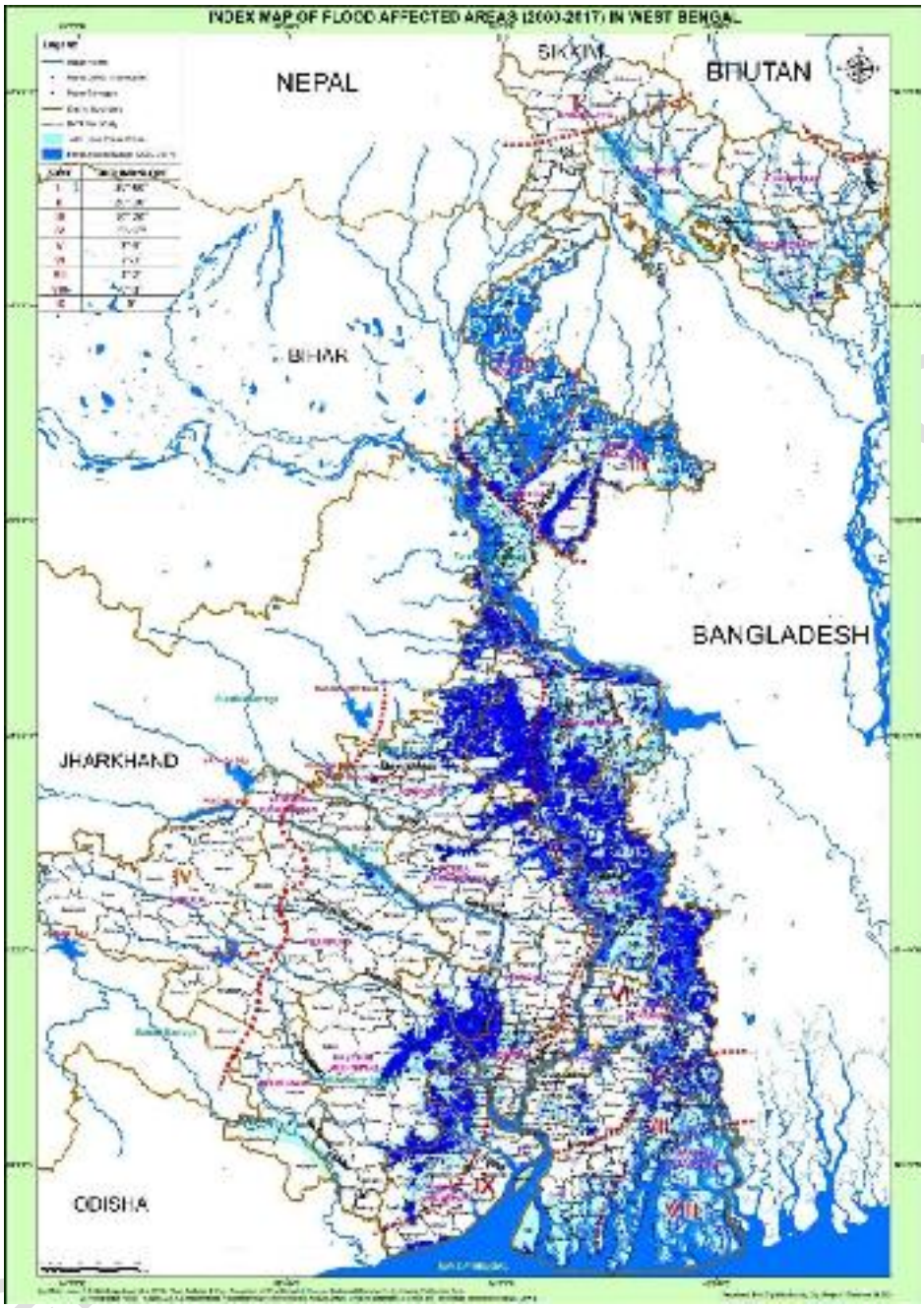
1) Samal N.R. et al (2014), **Six Years Major Historical Urban Floods in West Bengal State in India: Comparative Analysis Using Neuro-Genetic Model**, American Journal of Water Resources, 2014, Vol. 2, No.2, 41-53, Available online at http://pubs.sciepub.com/ajwr/2/2/3, © Science and Education Publishing, DOI:10.12691/ajwr-2-2-3.
2) Jha V.C.&Bairagya H. (2013), **Flood & Flood Plains of West Bengal, India: A Comparative Analysis,**RevistaEletrônicaGeoaraguaia. Barra do Garças-MT. Edição Especial. p. 01 - 10. Setembro. 2013 (*Electronic Magazine Geoaraguaia. Barra do Garças-MT. Special edition for 01 - 10 September 2013*).
3) **The Dartmouth Flood Observatory Global Archive of Large Flood Events, 2008.**
4) Government of West Bengal, Irrigation & Waterways Department (1962), **Final Report of the West Bengal Flood Enquiry Committee, 1959, Volume-I (Report)**, Superintendent, Government Printing, West Bengal Govt. Press, Alipore, West Bengal.

5) Som N.C. &Som D. (1997), **Flood Management in A Border District of West Bengal: A Case Study**, Proceedings of the 2nd International R&D Conference 1997, 21-24 October 1997, Vadodara, India, Central Board of Irrigation & Power, New Delhi.

6) Irrigation & Waterways Department, Government of West Bengal, Archived **ANNUAL FLOOD REPORTS**.



As per available historical data archives of Irrigation & Waterways Department, Government of West Bengal, flood prone area of the State is 37,760 sq. km. (3.776 MHa.) which is about 42.55% of the total geographical area (of 88,752 Sq. Km) of the State. As per records, historical flood of 1978 affected a total area of 30,607 sq. km. & in the year 2000, it affected an area of 23,971 sq. km.The flood affected areas over 20,000 sq. km. occurred in years 1978, 1984, 1991 & 2000.



There are various causes for flood in the state of West Bengal, of which the most important are:

- Very High intensity rainfall in the upper catchments causing large discharges to flow downstream through river sections having reduced hydraulic capacity due to various human interventions in the river channel like construction of roads, bridges, fills, residences and industries in the floodplains that put pressure on the water bodies, reducing their hydraulic capacity and causing overtopping/breach of embankments. This happens both in the northern and southern districts.

- Rapid urbanization and expansion in low-lying areas of the river basin, which has reduced infiltration capacity and speeded up the runoff of rain water.

- Heavy concentrated downpours in the central districts causes drainage congestions in some rivers which results in the areas remaining flooded for a considerable period of time.

- The lower basin is subjected to the effects of tides. The influence of the tides is more noticeable in the areas located in the southern and eastern districts. When heavy rain and high tide occur simultaneously the districts are affected.

- The southern districts open to the Bay of Bengal are liable to coastal floods during massive depressions resulting in violent storms formed over the Bay of Bengal.

Earlier in 1980, RashtriyaBarhAyog (RBA) of Govt. of India had estimated the inundated area of State to the tune of 2.65 MHa (26,500 Sq.Km.) and XII Plan Working Group (WG) of erstwhile Planning Commission constituted for Flood Management and Region-Specific Issues had updated the figure to3.08MHa (30,800 Sq.Km.). Recently (December 2018) I&WD, GoWB has also revised the data of vulnerable areas due to flood/tidal inundation from all field divisions for preparation of Statistical Handbook of the Department & cumulative flood prone area of the State is recorded as 37,760 sq.km.

Traditional methods of flood mapping are based on ground surveys and aerial observations, but when the phenomenon is widespread, such methods are time consuming and expensive; furthermore, timely aerial observations can be impossible due to prohibitive weather conditions. An alternative option is offered by satellite remote sensing (RS) technology. In recent decades optical data acquired by sensors onboard spacecraft have been used in many studies to map inundated areas over regions characterized by very different conditions in climate, morphology and land use. None of the estimates of the flood inundated areas in the state given above have been based on such latest technologies of remotely sensed satellite images, use of Geographic Information System (GIS) etc. Only in a very recent study in 2020 the Flood Prone Areas of the state of West Bengal has been delineated by CWC by processing the satellite images (Landsat and Sentinel data for last 35 yrs.). The total flood prone area of the state has been found by CWC to be about 1.251 MHa by employing the above process. Such a figure happens to very under estimated in comparison with the existing data available with the State Government. CWC's assessment of Flood Prone Area in West Bengal has been found to be not devoid of limitations and/or approximations to a substantial degree in analysing and getting the output in Google Earth Engine (GEE) and hence has been commented to be liable to be provide erroneous results in the form of numerous discrete, simplified polygons, huge no. of small polygons, especially in arid regions etc.Hence it has been decided that a proper scientific assessment of the flood prone area over the entire state needs to be done using latest technologies and available RS and GIS data. The present consultancy work has been envisaged to take up the above task.

2. Objectives of the consultancy

The purpose of this consultancy is to determine a technically sound, accurate and up to date flood prone area map of the state of West Bengal for the purpose of drainage

management, asset and development planning and risk management for the Government of West Bengal.

The investigation is required to identify and map areas of inundation due to various causes (embankment overtopping / breach, coastal flooding, heavy concentrated downpour or any other) for various flood frequencies.

The consultant shallacquire satellite imagery and carry outscientificanalysisusing suitable RS-GIS software to determine the flood prone areas over the entire state of West Bengal with a view to:

- Determine district-wise flood prone area maps corresponding to different flood return periods,say 5 yrs., 10 yrs, 15 yrs, 25yrs, 50 yrs. and 100 yrs.
- Develop year-wise flood inundation maps from historical available data / images.

3. Scope of the Consultancy

The scope of the consultancy is broadly classified as follows:

Preparatory work

i. Collect, review and analyze all available historic and current datasets from various available resources.Departmental historical/field data, as available, will be providedby the client.

ii. Acquire satellite imagery of flood inundation areas of the entire state for various flood events from available sources.

iii. Collect, pre-process and review and analyze all available field level data/maps.

Analysis work

i. Literature Review and analysis of current practices in flood prone area mapping.

i. Scanning, Digitization & Geo-referencing of all available maps.

ii. Preprocessing of satellite images for noise reduction, rectification of distortions, georeferencing etc. as necessary.

iii. Processing of satellite images usingsuitablealgorithm (Supervised classification of satellite imaginaries and imposition of suitable index viz. NDWI, in order to find out water spread area after subtraction of rivers, channels, lakes and natural waterbodies) in ArcGIS / ERDAS-Imagineplatform or any other suitable high-endversatileanalytic platform.

iv. Develop flood inundation maps by superimposition of different layers for different flood years.

v. Develop district wise Flood Prone Area (FPA) maps in different layers for different flood return periods as per CWC norms.

Validation work and training

i. Validation of flood maps with available field level data/historic maps.

ii. ***Mandatory*** validation of developed maps with Dartmouth flood observatory inundation images; wherever available or other globally accepted images.

iii. Providing training to designated officers of the department to enable them to carry out updating of flood maps for future flood events and to perform necessary modifications when required.

Final submission

i. Development of polygon KMZ files of all the year-wise flood maps and flood prone area maps.

ii. Uploading/integration of developed maps to the departmental website (www.wbiwd.gov.in)

iii. Submission of final report on assessed Flood Prone Area maps (both in Hard and softcopies) with adopted methodology.

iv. Suggesting recommendations for technical improvement,if any.

4. Deliverables

The deliverables will include but will not be limited to:

- Inception Reportin five sets.
- Draft Final Report in five sets and soft copiesinExternal Hard Drive/DVD.
- FinalReportcontaining hard copy of FPA maps in A0/A1 sizes as well as soft copies in External Hard Drive/DVD.
- Archive of satellite imaginaries used for the project as well as digitized historical flood mapsinExternal Hard Drive/DVD.

5. Responsibility of the Consultant

The responsibility of the consultant will include the following tasks:

- Conduct and complete the consultancy as per the agreed TOR and scope of the consultancy subject to the full satisfaction of the TechnicalSub-Committee within the stipulated time period.

- Collect data and information required for flood mapping from available sources.

- Acquire satellite imagery from available sources. Mostly open-source data need to be utilized. However, if such data are found to be unavailable for select dates

or incapable of providing desired outputs, images may be procured from relevant authorities. In such cases, the costs will have to be borne by the consultant.

- Plan and develop suitable methodology/algorithm of analysis of the satellite imagery in consultation with the client for achievement of the best output.

- Conduct suitable analysis of satellite imagery to develop flood inundation/prone area maps.

- Validate output of analysis with field data or any other data available.

- Train a selected group of officers from the Department, enabling them to carry out future updating and modifications.

- Hand over all software, hardware, data, imagerythat were in public domain or that were developed as part of this project after the completion of the consultancy to the client.

6. Schedule for completion of tasks

The time schedule for the proposed deliverables is given below:

Deliverables	Description	Timing
1. Inception Report	Review of data availability and data quality, literature review of current practices&detailedmethodology planned for the analysis exercise.	T + 3 month
2. DraftFinalReport	The draft final reports shouldprovide complete details such as data analysis, outcome and results, recommendations, etc.	T+5 months
3. Final Report	Covering all the tasks described in the ToRandaddressing all the observations of the client on draft final reports	T + 6 months
* T is the time in month from signing of the contract		

7. Handling Restricted Data

The Consultant shall not, either during the term or even after the expiration of this contract, disclose any proprietary or confidential information related to the Project, the services, this contract, or the Client's business or operations without the prior written consent of the Client.

8. Data Services and Facilities to be Provided by the client

The following amenities will be provided by the Client:

- Facilitation of the data collection by way of recommendation letters, as required.
- Designated staff of the Department for training.

9. Administration

For the purposes of this assignment, the Consultant will periodicallyreporttoaTechnical Committee comprising ofofficers from the Departmentand two senior officers of Central Water Commission (CWC) and National Remote Sensing Centre (NRSC), for guidance and review of works/reports. The Consultant will work closely with the Technical Committee throughout this assignment – specially to discuss interim results and on methodology.

10. Desirable Experience of Consulting Firm and their Key Team Members

The lead organization for the project shall meet the following criteria:

- Minimum five years of experience in providing consultancy services in the RS-GIS especially for water sector, with particular emphasis and a track record of having successfully delivered major analytical projects requiring development of flood prone/hazard maps.
- Demonstrated experience in carrying out similar Jobs of development of flood maps, and experience of working with governments/ state owned enterprises.
- The firm(s) / research institutes bidding on this project, including the JV partners and sub-consultants, should have the key professionals, including the Team Leader as permanent employees.
- Track record of providing solutions to water sector problems, with specific reference to the last five years.
- Ability to quickly deploy a team (professionals with relevant experience and qualifications) either from the lead organization or through sub-contracting arrangements.

Consultant Team

Sl. No.	Designation	No	Minimum Qualifications and Experience	Suggested Man Months
1.	Team Leader/	1	Relevant advanced academic degree in Hydraulics / Hydrology/ Water Resources	1×6= 6

Sl. No.	Designation	No	Minimum Qualifications and Experience	Suggested Man Months
	Senior RS-GIS Expert		with 15 years of work experience in water resource sector. Preferably has the knowledge of RS-GIS applications in water sector.	
2.	GIS Specialist	3	Post Graduate in Geoinformatics / Equivalent Degree with 5 years' experience in RS/GIS applications for resource mapping especially in water sector, preparation and integration of GIS data sets. Preferably has the experience in hydrologic applications, analysis and customization and experience in flood area delineation and inundation mapping from satellite data.	2×6=12
3	Other support staff	2	Graduation in any discipline	1x6=6

11. Duration of Consultancy

The duration of consultancy will be **6 months.**