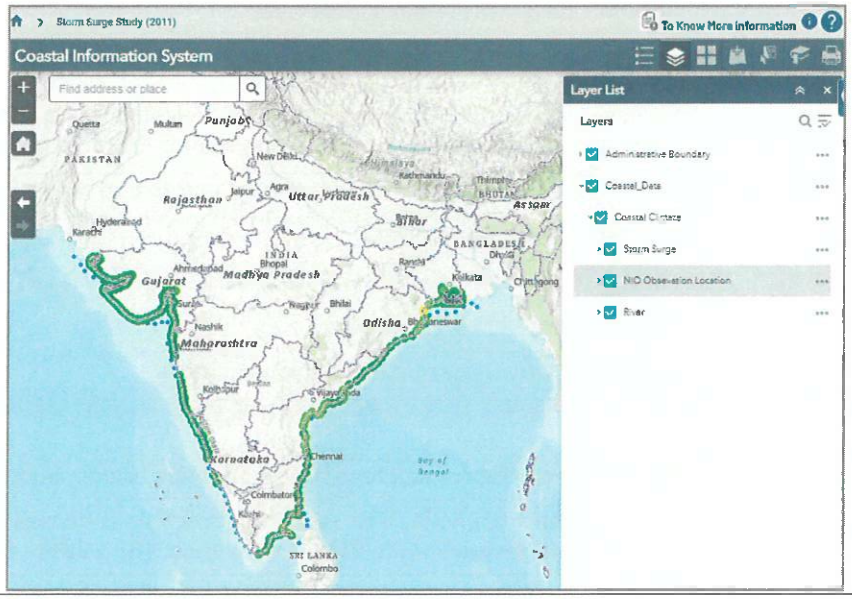
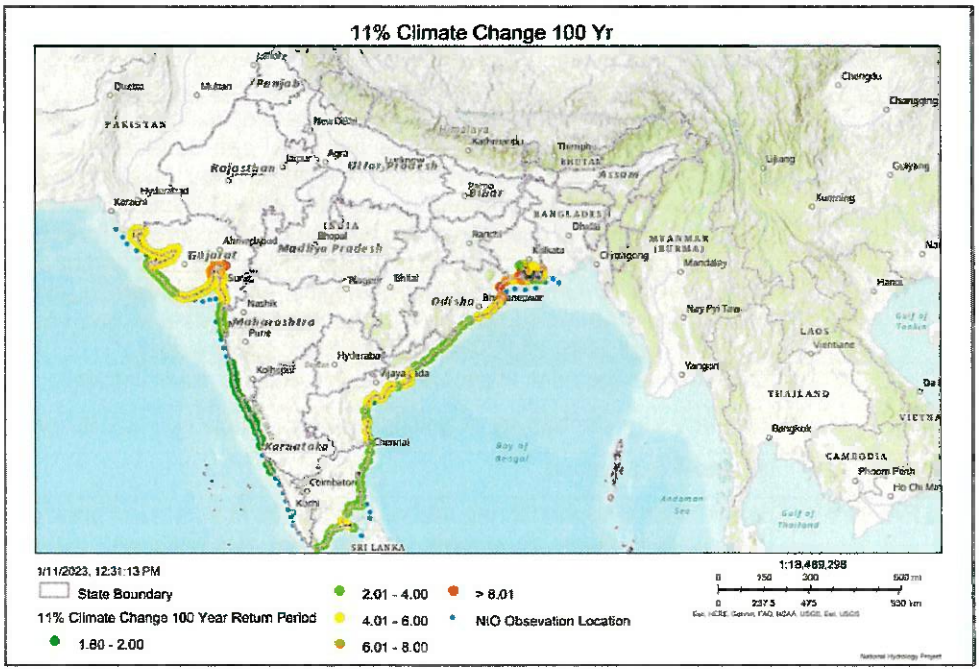
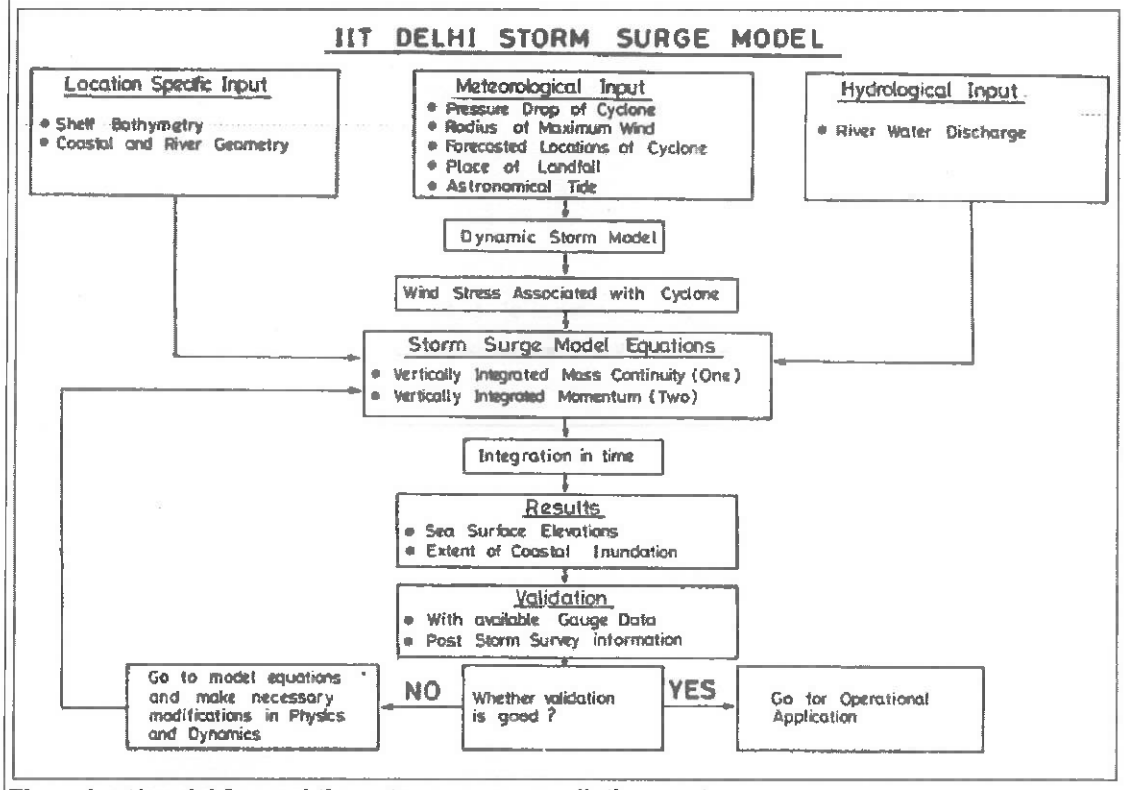
Business Specific Requirements	
Theme	Self Service Analytics
Application	WRIS- Allied themes
Use Case	Storm Surge Study (2011)
Use Case ID	WRIS-SSA-01
Other linked Use Case	Coastal Information Management System (WIMS-SWR-18), Coastal Flood analysis and allied themes i.e., Shore line changes (CFA-UC-04) etc.
Description	The storm surge is the biggest natural hazard causing people and property loss in the coastal zone. The sea level rise directly causes the initial sea surface of storm surge water increase and the increase of high tide level, which not only aggravates the storm surge hazard degree but also causes the increase of hazard frequency, causing more losses of life and property. It is a comprehensive database related to oceanographic and meteorological data for the entire coast of India. Storm Surge data are provided at a distance of 10 km for Gujarat, Maharashtra, and West Bengal and rest of the coast line at 50 km interval. Meteorological and wave data is generated 20 km offshore at varying interval from 10 km to 50 km. For the variables, data is generated for three scenarios - baseline (present) and 2040 and 2080 (climate change scenarios).
Used by	Coastal Management, Planners, Decision makers, administrators, academicians, and the gen. public
Priority	**Low Priority:** Probability of getting required data is very low as well as limited application use
Phase	**Phase-1** Subsumed
Business Problem	**Issue:** Real time monitoring and warning of storm surge is of great concern for Indian coastal regions. The study is highly dependent on prediction modelling with major inputs from oceanographic and meteorological departments. **Approach:** The data which is generated through modelling exercise by the National knowledge institutions are not in the purview of NWIC, therefore data excercised can directly be accessed through respective department website. ex. IMD, CWC, ESSO-Indian National Centre for Ocean Information Services (INCOIS) etc.
Output	All coastal climate data for different scenarios under Storm Surge Study for the year 2011
Outcome	The model projections include present (no climate change scenario) and two other scenarios based on climate change at different return periods on 10, 50 and 100years available for visualization
Visualization	1. **Map** – The interactive map facilitates the visualization of oceanographic and meteorological data for different scenario – present and average and extreme climate change scenario (7% and 11%) and for various probability of occurrence – 10, 50 and 100 years. The key variables - storm surge (without tide effect and with tide effect) for no climate change, 7% and 11% climate change at 100-year return period; sea level rise projection at RCP 4.5 for 2100 and RCP 8.5 for 2100; significant wave height projection for Hindcast, medium and extreme at 100 year return period are available for viewing and all coastal climate data for different scenarios are available for downloading. 

	2. **Output in tabular and PDF map format:** Data can be downloaded (in csv and xls format) for user specified locations as well as at State level. Map with symbology is also available  3. **Information available for individual NIO observation locations** State Name Geography Area Type Latitude Longitude Serial Number Unique ID 7% Climate Change Return Period 10 Years 7% Climate Change Return Period 50 Years 7% Climate Change Return Period 100 Years 11% Climate Change Return Period 10 Years 11% Climate Change Return Period 50 Years 11% Climate Change Return Period 100 Years No Climate Change Return Period 10 years No Climate Change Return Period 50 years No Climate Change Return Period 100 years
Frequency	Once time study (2011) initiated by CWC
Measures of Success (KPIs)	The Coastal Climate Information System (CCIS) storm surge database will help in getting a first-hand idea of the coastal vulnerability which will be a preliminary required for any coastal developmental activities. However, for any design of high investment coastal infrastructure, site specific detailed investigation is required. Early warning system will help to mitigate after effects.
Input Data Required	Observation site (Location) with other parameters and model inferences in tabular format
	Geospatial Time Series Data: • **Frequency:** One time (2011) studied data. Updation is required • **Resolution:** - NA - (Point data) • **Extent of Coverage:** Coastal regions of India
Process	
Algorithm/Tool	**Methodology brief for sea level trend analysis, wave, and storm surge** **Sea-level trend analysis:** Sea level trend analysis is carried out using the altimeter based gridded sea level data product of AVISO for the period 1993-2015. This data is correlated with measured data at three locations (tide gauge observation stations–Paradip, Vishakhapatnam, and Chennai)

and trend analysis is carried out. The sea level trend and standard error is estimated for the locations closest to the east coast of India.

Wave data analysis: Numerical modelling of waves is carried out for the coast of India for a period of 46 years (1970-2015) using historical modelled wind data from NCEP/NCAR re-analysis data. Wave data for a period of 40 years (2026-2045; 2081-2100) was obtained from forecast modelled wind for medium green-house gas emission scenario (RCP4.5) and high green-house gas emission scenario (RCP8.5) with three different GCM models viz., ACCESS1.0, GFDL--CM3 and MRI-CGCM3. Overall, seven cases have been considered viz., Hindcast, RCP4.5-Access1.0, RCP4.5-GFDL-CM3, RCP4.5-MRI-CGCM3, RCP8.5-Access1.0, RCP8.5-GFDL-CM3, and RCP8.5- MRI-CGCM3.

From the model results, hourly wave data is extracted at 51 points on the east coast of India, spaced about 50km interval along the 20m water depth contour. The wave data extracted for at each point is subjected to extreme value statistical analysis to obtain the extreme value estimates of wave height for 1 in 1, 10, 50 and 100 years. Joint distribution tables of wave height and wave period as well as wave height and wave direction are provided to obtain the predominant wave periods and wave directions for each point and for each of the modelling case.



Flow chart/model for real time storm surge prediction system

Storm surge analysis: Probable maximum water level elevations (storm surge) due to tropical cyclone in Arabian Sea and Bay of Bengal were computed using ADCIRC model. The model is applied with the maximum pressure-drop value for a set of synthetic tracks which are generated by composing actual tracks as well as from theoretical ones, ensuring that each coastal district is covered. Using different pressure-drop values for different return periods, the simulations of surges have been carried out for the west coast of India. The model also incorporates the tides so that the non-linear interaction of tide and surge is comprehensively taken care. In order to study the climate change scenario, the cyclonic wind stress is increased by 7% (an average value) and of 11% (extreme value) over the present (normal) scenario. These projections include present (no climate change scenario) and two other scenarios based on climate change at different return periods on 10, 50 and 100years

Storm surge prediction model: ADCIRC used by ESSO-INCOIS

	ADCIRC is a (parallel) ADvanced CIRCulation model for oceanic, coastal and estuarine waters developed by Dr. R.A. Luettich, Jr, University of North Carolina **Process involved in data integration & development:(by NWIC)** 1. Conversion of excel/csv files with attribute into native GIS formats as point data layer 2. Importing cleaning point data layer in designed Geodatabase schema with attributes 3. Publish web map service and appropriate data table for final integration & GUI development **Note*** The data is generated through modelling exercise by the National knowledge institutions – Storm Surge and Cyclone data by IIT Delhi, Meteorological data by IIT Bombay, Wave and Sea Level-Rise data by NIO Goa. The data is generated as part of the ADB project "CLIMATE-RESILIENT COASTAL PROTECTION AND MANAGEMENT PROJECT" implemented by the Ministry of Water Resources, Ganga Rejuvenation and River Management through ANZDEC, New Zealand.
Data Validations	Site location from hard copy maps and excel formats requires geospatial as well as attribute validation. Initial screening is required before integrating raster/vector and attribute data received from mapping agencies for its completeness and accuracy.
Software Requirement (specific if any)	ARC GIS Desktop/Enterprise
Dependencies & Risks	Data availability from concerned agencies, Efficient handling and acquisition of parameters required in modelling storm surge
User Acceptance Testing (UAT) By	NWIC
Development Responsibility	NWIC
Reference material	1. Dube SK (IIT,Delhi) et al.: Storm Surge in the Bay of Bengal and Arabian Sea: The problem and its prediction (Article//Mausam:April1997) 2. ESSO - Indian National Centre for Ocean Information Services (http://www.incois.gov.in/portal/stormsurge) 3. Storm surge early warning system (https://tsunami.incois.gov.in/itews/ssm/hudhud.html)

For any communication/clarification on the BSR, the following Officer may be contacted.		
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Organization:	National Water Informatics Centre	
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BSR prepared by Subject Matter Expert (SME), Name & Designation:	Dr. Dharmesh Singh Hydrologist	**Signature :** 21/03/23
Organization:	NWIC	
Contact No.: **Email id:**	8447025987 hydrologist.nwic@gmail.com	

This is to certify that the above BSR has been vetted and found satisfactory.

Details of Domain Organization SPOC and SME for Verification and Approval of above BSR

21/3/23	21.3.23
(Signature of SPOC)	**(Signature of SME)**
SPOC Name: Dr. Rakesh Singh	**SME Name:** Sh. Karthic S.R.
SPOC Designation: Deputy Director	**SME Designation:** Deputy Director
Organization: NWIC	**Organization:** NWIC