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DECISION SUPPORT SYSTEM: EARLY FLOOD WARNING SYSTEM, MAPPING & RISK ASSESSMENT

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1.0 INTRODUCTION

In the recent past, extreme events such as flash floods and droughts are increasingly causing significant damages in terms of human lives, property loss, irrigation productivity, etc. across India. This might be due to erratic behaviour of climatic pattern, land use changes, population burst and subsequently increasing water demand. These circumstance lead to water governance crisis and resource management could become under substantial pressure. Drivers such as demographics and uncertainties further increase the stress on water resources planners and managers. There is a major constraint and a prime cause for lapses in efficient water resources management for non-availability of reliable, real time information from the water infrastructure. The traditional fragmented approach has to give way for adopting more holistic approach for sustainable water resources management.

In spite of the large investments made in dams and reservoirs across India, most of the hydraulic structures are still being operated on the basis of experience, rules of thumb or static rules established at the time of construction. Manual calculations on flood forecasting and water supply, manual operations of dam spillway gates and canal gates. The prevailing limitations of analytical applications of rainfall and hydrological data in the catchment areas, which are crucial for flood forecasting, reservoir management and water use planning. The regulations of water through dams, canals and other hydraulic structures are having vital during monsoon as well as dry seasons. Technology is led and provided by governmental agencies and most countries are blind to data and its use. Businesses are reactive to extreme weather events, water, crop and cannot link business to expected impact. 90% of businesses cannot understand what water, crop, extreme weather events like, flood & drought data means for them. Existing providers gives repackage Models; Simulations; forecasts; – lack of accuracy, resolution, and limited and Could not overcome the multi vertical complexity of extreme events impact. Also, they provide services (not sustainable solutions oriented services). They Provide solutions based on raw data and not actionable/decision making business insights. The fact is 85% of the globe doesn't have reliable real time and forecast weather and hydrological data. Due to the advancement in IT technologies in the field of water resources engineering can be used for real-time inflow forecasting to mitigate flood and regulate water efficiently by functioning short-term and long-term reservoir operations. For real-time applications, forecast information on reservoir inflow is used to optimize short-term benefits by minimizing spills and maximizing the economic value of water for hydropower production and other water uses. The use of Cyberinfrastructure Requirements for Climate and Hydrologic Information Development, such as

Dashboard Platform present the data in intuitive/compelling ways

- Real time Data
  - Coordination of work across an organisation
- Sensor data, GPS locations, social media, etc.
- Other Data
  - GIS server
  - Online content & Services

Following Disruptive Technologies for Climate & Hydrologic Information Delivery integrates above features into global hydrological forecasting models and decision support systems.

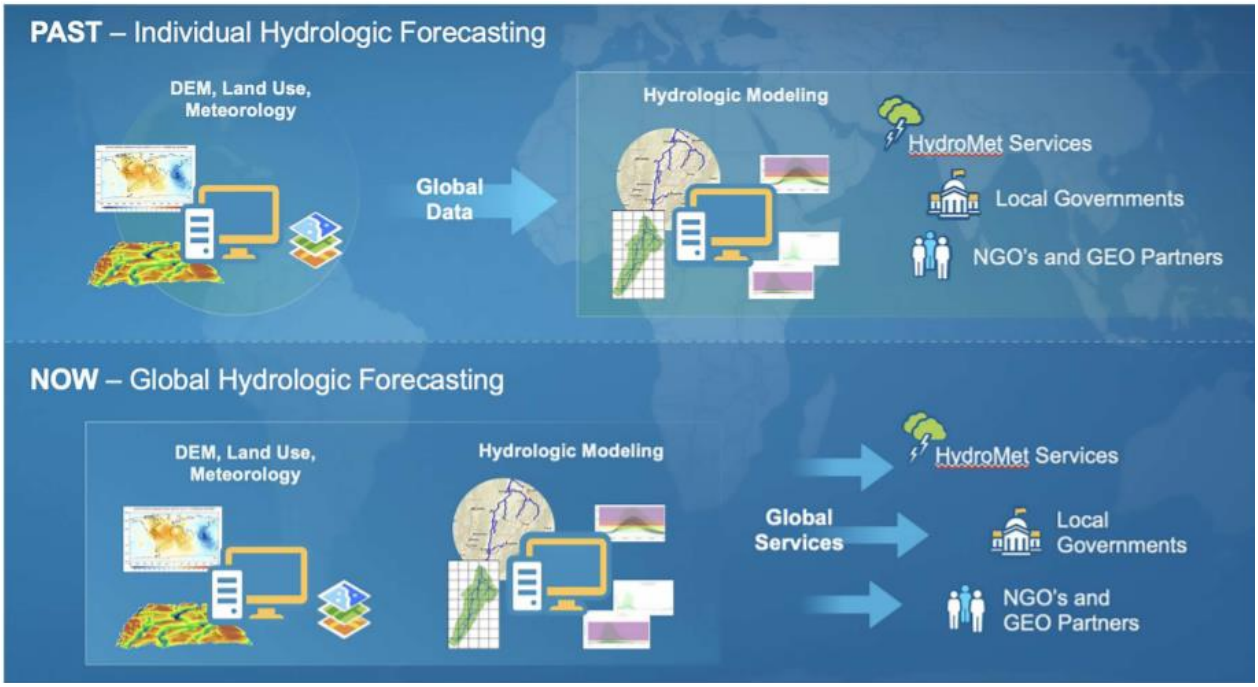


Fig. 1 : Disruptive Technologies for Climate & Hydrologic Information Delivery (Source: ECMWF)

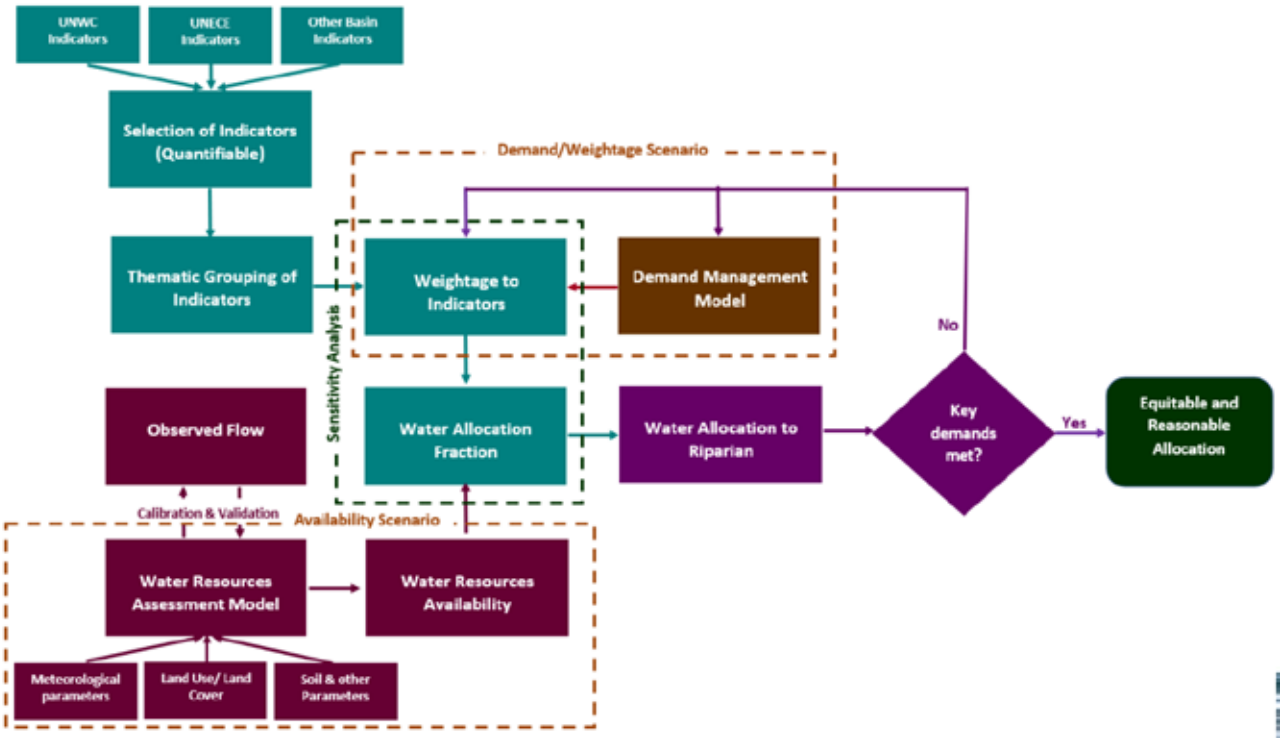


Fig. 2 : Modelling as a Solution

1.1 Decision Support System: Extended Hydrological Predictions

1.1.1 *Why needed?*

- Gaps in Observed Data
- Hydrological Model Biases and Post-Processing
- Origin of Seasonal & Hyper Local Hydrological Forecast Skill
- User Requirements for Hydro-meteorological Forecasts at Seasonal Time Scales as well as hyper local scale

1.1.2 *Our Vision for Future*

- Numerical Model Advancements
- Improved Earth Modelling and Human Water Modelling
- Interaction between Forecasters and Users to Improve Forecasts
- From Early Warning to Early Action

1.2 Our Technology: We make best use of Data sets, Models & SaaS

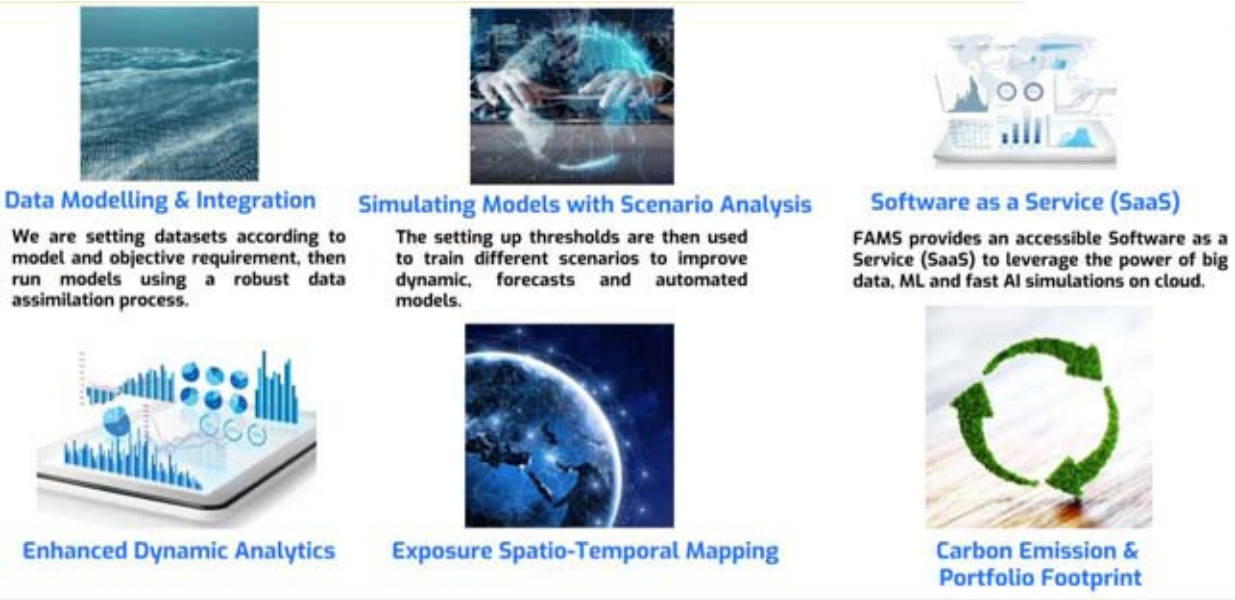
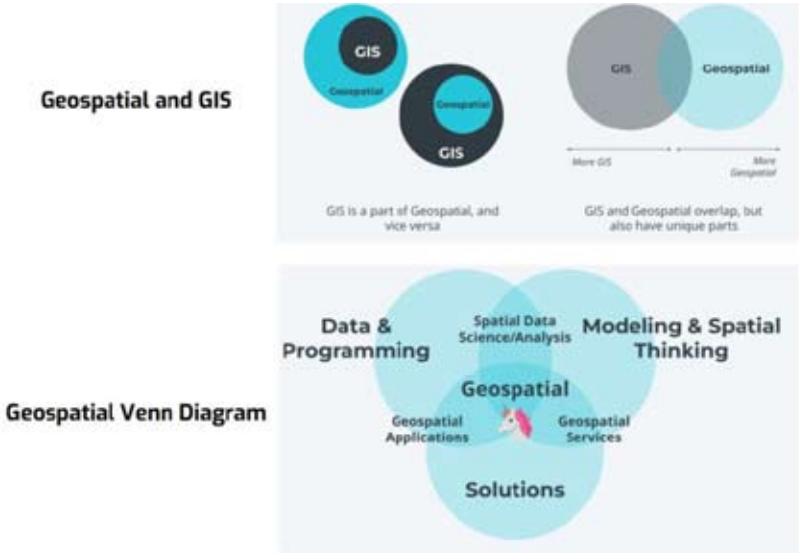


Fig. 3 : FAMS Technology: Best use of data sets, models & SaaS

1.2.1 *Integrating Technology*



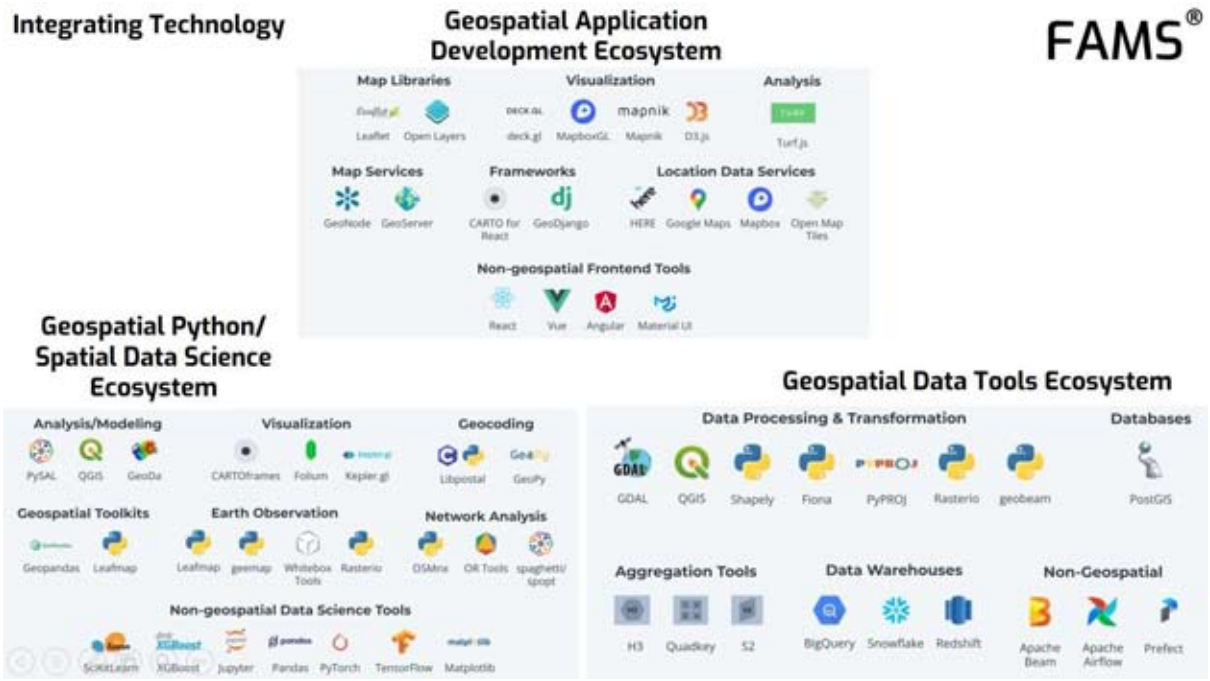


Fig. 4 : Geospatial AI, Machine Learning and Prediction Models

1.3 Early Warning to Early Action

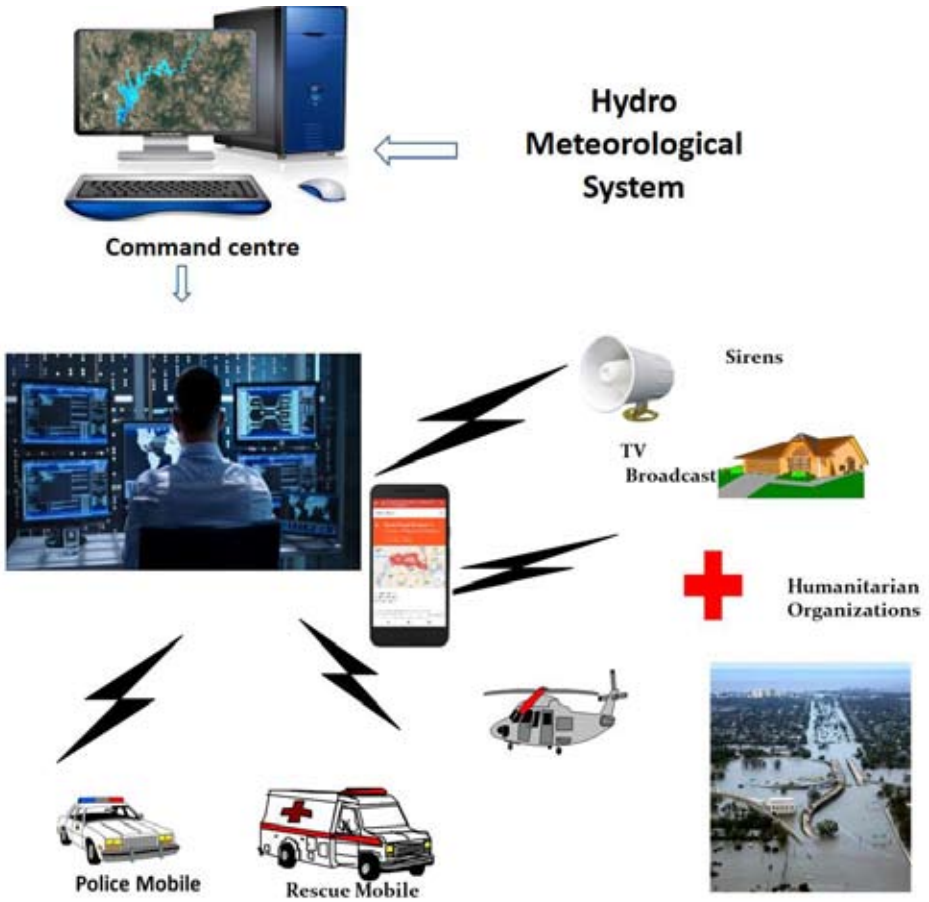


Fig. 5 : DSS information dissemination

1.3.1 *Key Features*

- Informed Decision Support System
- Instantaneous decision making
- Numerical Weather Predictions
- Real-time and forecast Warning System Planning & Development
- Integrating Data & Models
- Historical, Real Time, Forecast Data Analytics
- Monitoring and Predictive Analytics
- Interactive Actionable Insight Dashboard
- Early flood warning decision support system for flood mitigation
- Strategic Planning for Flood Disaster Management
- SMS alerts through mobile applications to the stakeholders during disaster emergency

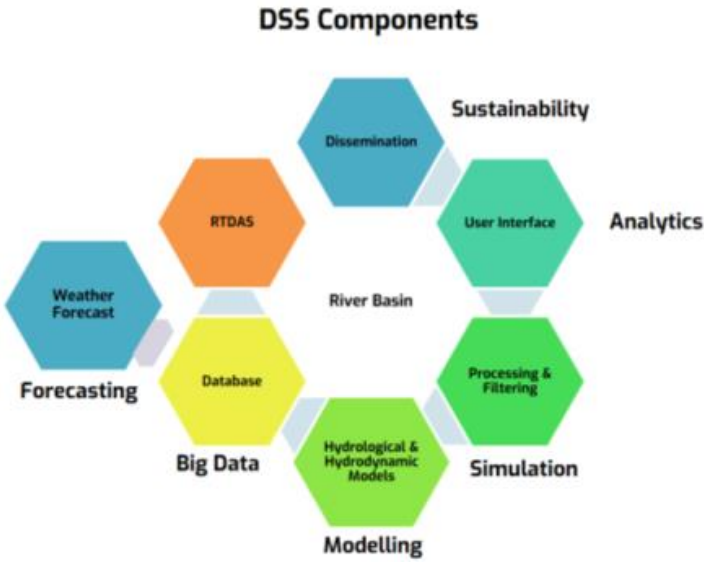
1.3.2 *DSS Objective*

- To review and suggest solutions to basin management issues
- To create the Hydro-meteorological and GIS database
- Development and customization of modelling tools
- River Basin Planning using RBM
- Training and Capacity Building

1.3.3 *DSS Components*

Integrated water resource planning for

- Multi Week Forecast
- Flood Forecast
- Surface water planning
- Integrated operation of reservoirs
- Planning for conjunctive use of surface water and groundwater
- Drought management



1.3.4 *Methological Framework*

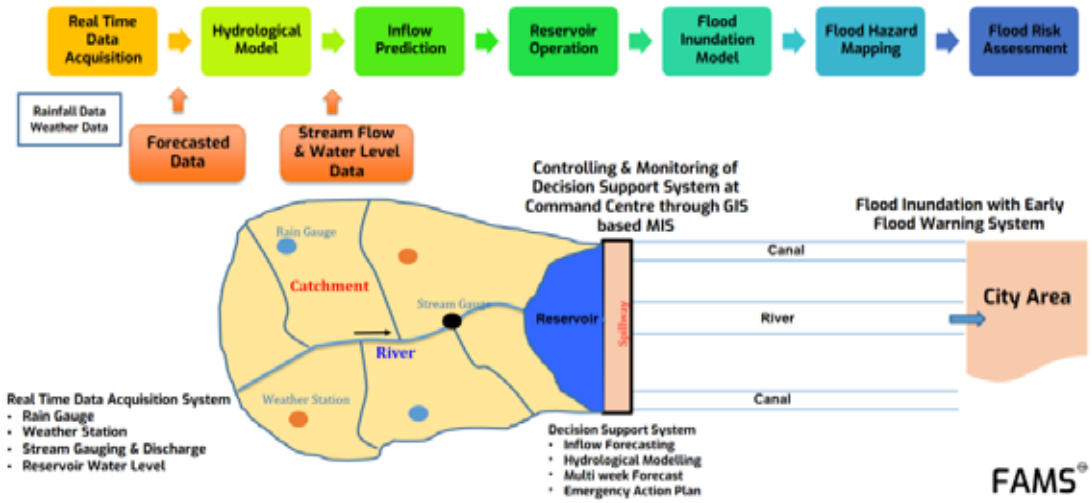


Fig. 6 : Methodological Framework

1.5 FAMS Intelligence: Decision Support System Portal

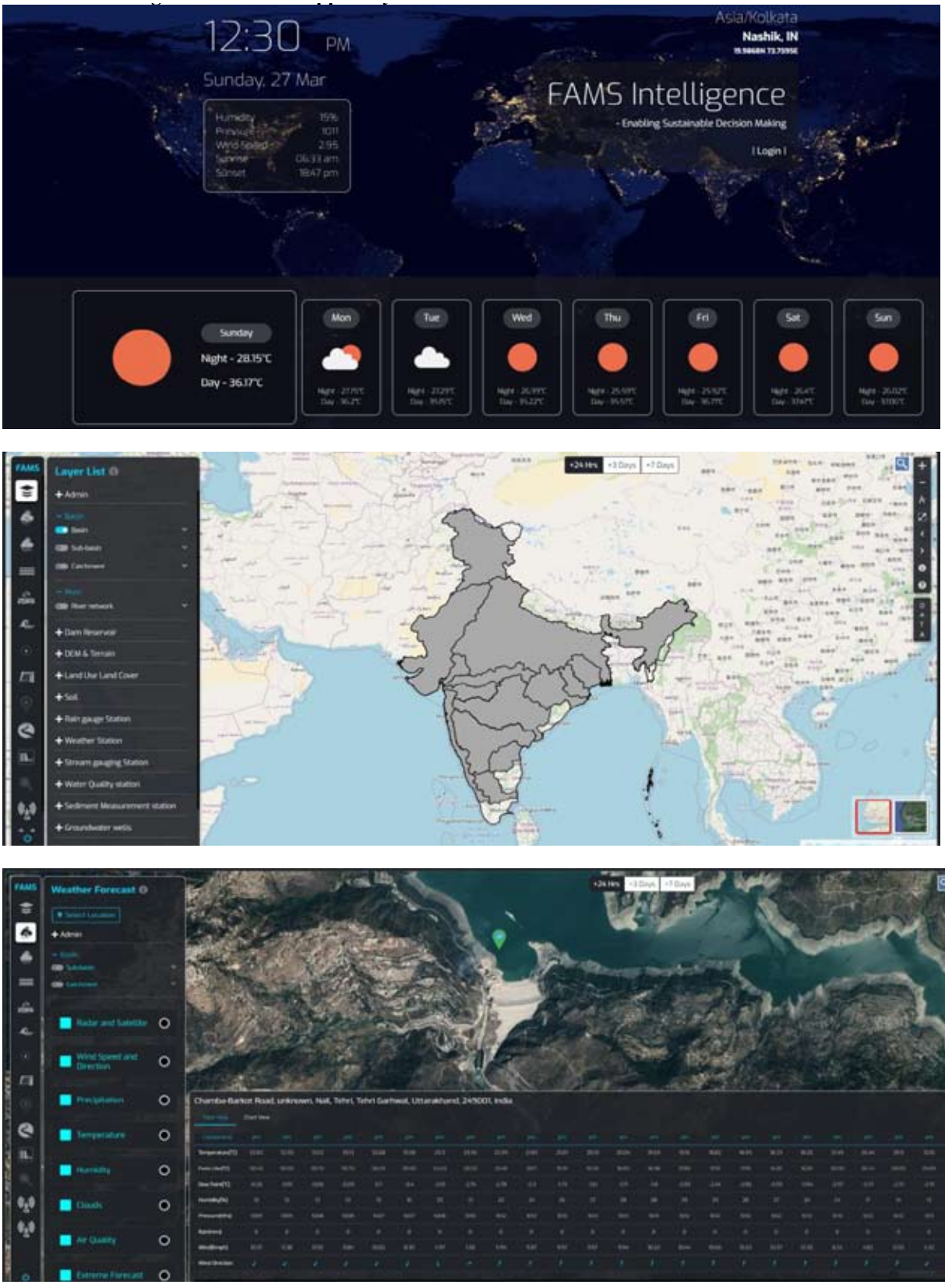


Fig. 7 : Weather Forecast Module

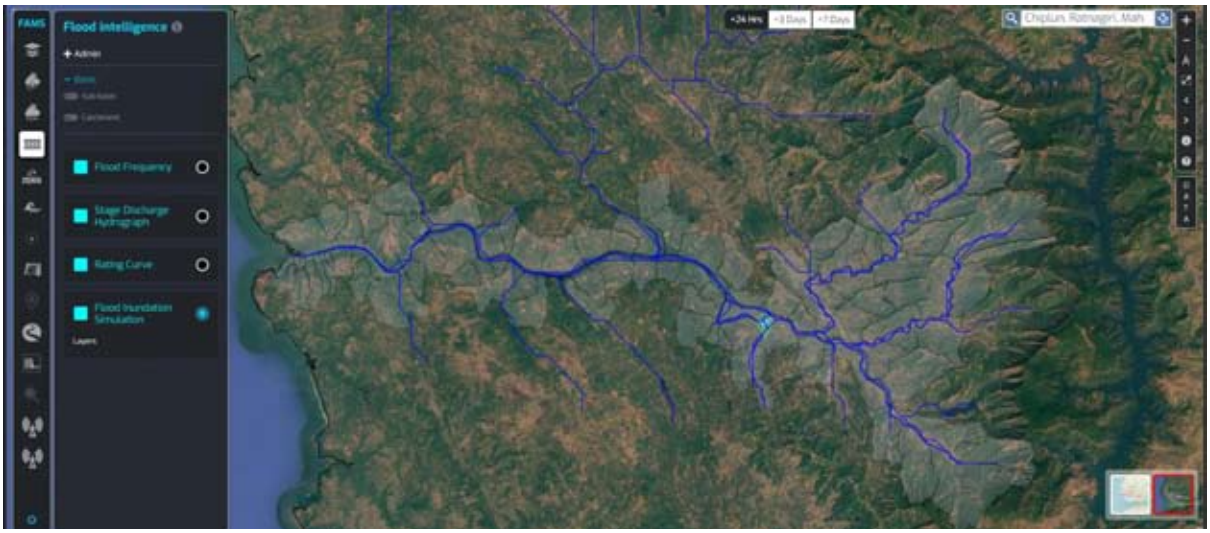
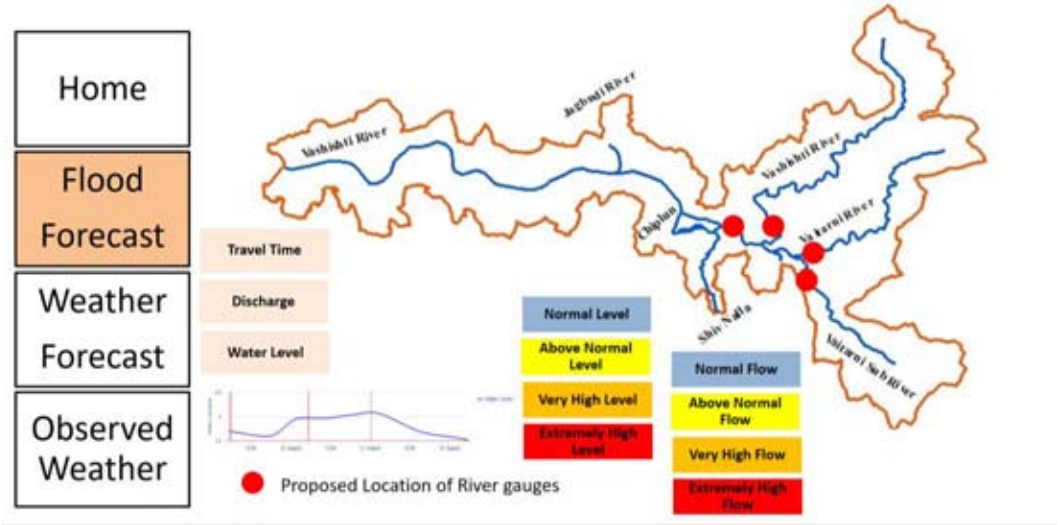


Fig. 8 : Flood Forecast Module



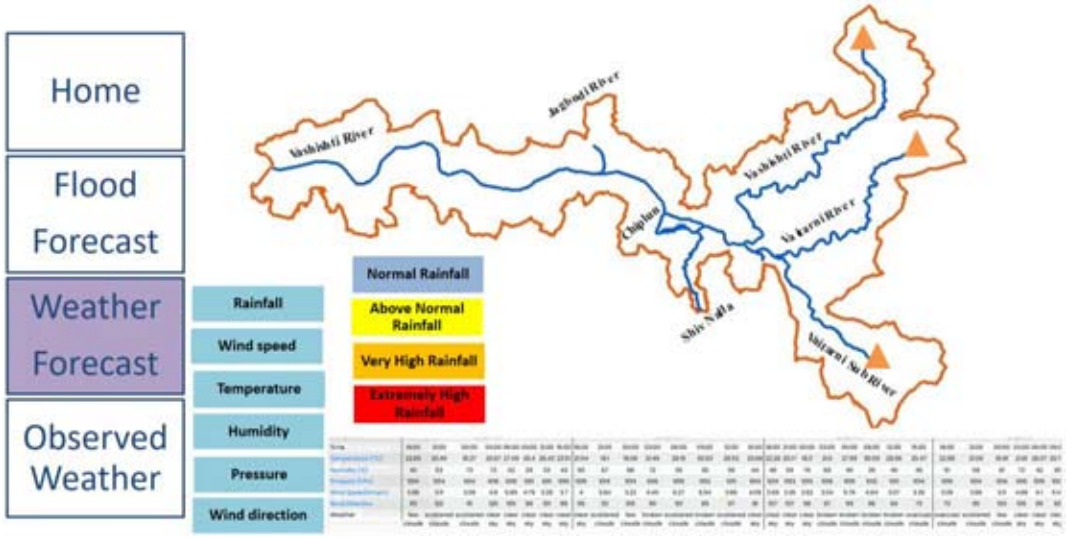


Fig. 9 : Flood Early Warning System

- **Decision Support Portal and Mobile App for City Flood Early Warning System**
- Providing Right Information with actionable insights to stakeholders
- Access continuously updated, accurate information, historical, real time, and forecast
- Equipping stakeholders' operations with invaluable insights
- Interactive dashboard to transform data into decision impact and driving actions
- Driving collaborations with decision making actions
- Improve safety by sending notifications to customers and stakeholders
- Train models based on accurate historical data and providing sustainable decision making performance

1.6 Flood Forecasting Tool

- We suggest a **flood forecasting tool** that is based on the ECMWF (European center for medium range forecasts) and NOAA (U.S national ocean and atmospheric administration) Hydro-Meteorological global products.
- The **flood model can be calibrated for every location based on historical time series of flow simulations**.
- An ensemble of **hourly River flow predictions is calculating up to 15 days in advance**, according to flood risk levels and River flow return periods and probability of exceedance.

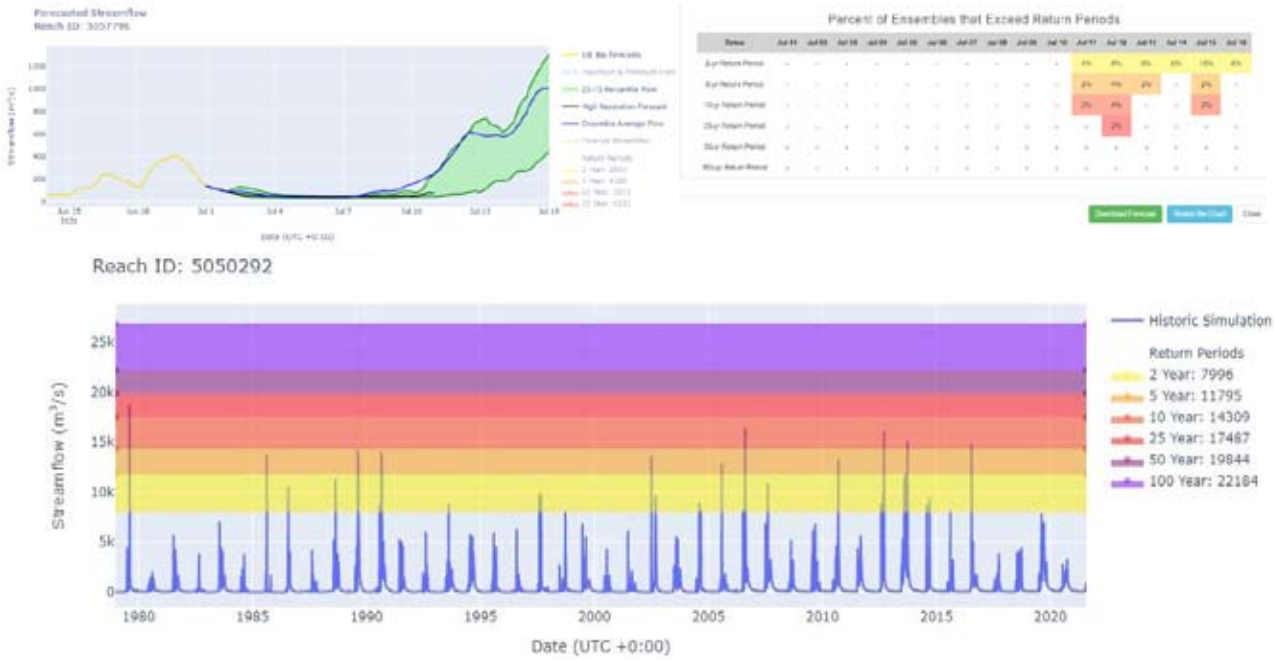
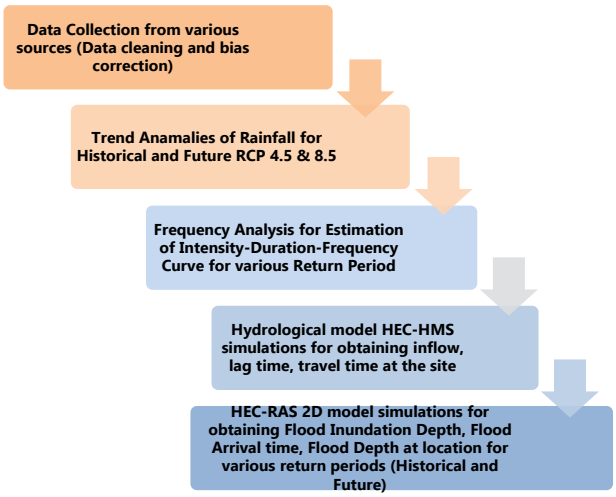


Fig. 10 : Historical Flood Predictions using Hydrodynamic Models

2.0 CASE STUDY: CLIMATE & FLOOD RISK ASSESSMENT: SOLAR POWER PROJECT, SPAIN



Subbasin	Area (sq km)	Longest Flow Path (Km)	Longest Flow Path Slope	Basin Slope	Reach	Length (km)	Slope	Sinuosity
B1	104.61	29.93	0.02	0.10	R2-3	4.3349	0.00231	1.43267
B2	31.45	14.52	0.03	0.07	R3-4	6.10925	0.00246	1.20014
B3	9.92	6.27	0.01	0.06	R5-4	7.53822	0.00133	1.55788
B4	103.60	31.47	0.01	0.12	R-6	2.25342	0.00444	1.38607
B5	25.64	11.88	0.01	0.04	R-7-J	3.4293	0.00204	1.28527
B6	36.52	16.65	0.01	0.04				
B7	1.90	2.90	0.01	0.03				
B8	3.18	4.29	0.00	0.04				

Subbasin	Lfp (Km)	Lfp (m)	Lf/slope	Time of concentration (T_c) (min)	Time of concentration (T_c) (hr)	Lag Time (T_L) (min)	Lag Time (T_L) (hr)
B1	29.926	29926.44	0.019	249.98	4.17	149.99	2.50
B2	14.522	14522.43	0.032	117.85	1.96	70.71	1.18
B3	6.268	6268.12	0.007	109.28	1.82	65.57	1.09
B4	31.468	31467.8	0.013	298.74	4.98	179.24	2.99
B5	11.879	11879.07	0.006	192.95	3.22	115.77	1.93
B6	16.650	16649.8	0.007	228.24	3.80	136.95	2.28
B7	2.898	2897.68	0.007	61.85	1.03	37.11	0.62
B8	4.289	4289.37	0.004	98.28	1.64	58.97	0.98

Return Period (Year)	AEP (%)	Max. depth (m)	Precipitation Depth (mm)	Number of Events (days)			Duration of Inundation (hrs)		
				Historical	RCP 4.5	RCP 8.5	Historical	RCP 4.5	RCP 8.5
2	50	0.013	43.15817	16	48	64	0	0	0
5	20	0.035	55.11384	1	15	13	2.486623	40.85845	31.93772
10	10	0.04	63.02953	9	11	18	43.89498	60.80396	101.4627
25	4	0.049	73.03103	0	0	4	0	0	41.99351
50	2	0.055	80.45071	0	0	0	0	0	0
100	1	0.061	87.81561	0	0	0	0	0	0
200	0.5	0.068	95.15364	0	0	0	0	0	0

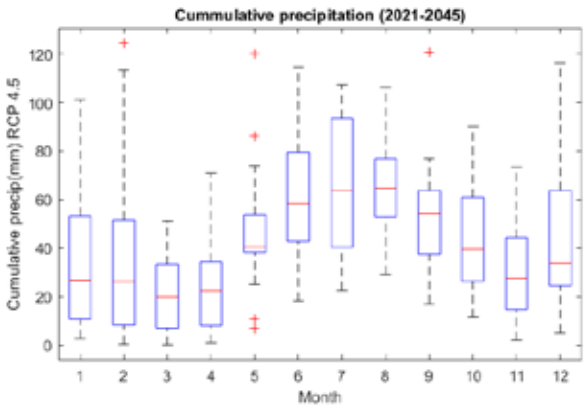


Fig. 11 : Methodology, Results: Climate Risk Assessment and Flood Risk Assessment

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- Prior to starting FAMS, he was Hydrology Expert in Mechatronics Systems Pvt. Ltd., Pune, Maharashtra, India during July 2019 – September 2020.
- He worked as Faculty and Course Coordinator, Department of Civil and Construction Engineering, Rustomjee Academy for Global Careers, Dahanu, Maharashtra, India in association with University of Wolverhampton (UK) during November 2017-February 2020.
- He did Bachelor in Civil Engineering from Shantilal Shah Government Engineering College of Bhavnagar Univeristy, Bhavnagar, Gujarat, India
- Then, He pursued for M.Tech Degree and Doctoral Degree (under the guidance of Dr. Prem Lal Patel, Professor) subsequently with specialization in Water Resources Engineering from Department of Civil Engineering, Sardar Vallabhbhai National Institute of Technology (SVNIT), Surat, Gujarat, India.
- He was awarded Institute Gold Medal for securing first position in M. Tech. (WRE) for the batch 2009-2011.
- He has published more than 30 papers in peer-reviewed journals and conferences of repute.
- He worked as Research Scholar under a Centre of Excellence (CoE) on 'Water Resources & Flood Management' through research grant from World Bank sponsored TEQIP-II during 2013-2017 in the Department of Civil Engineering, SVNIT Surat.