THDC India Ltd.
New Delhi
Central Board of Irrigation & Power
INCOLD
Indian National Committee on Large Dams

Decision Support System:
Early Flood Warning System, Mapping & Risk Assessment

Theme: Dealing with Hazard and Risks

Sub Theme: Warning Systems, Exclusion Mapping, Evacuation Plans and Risk Assessment

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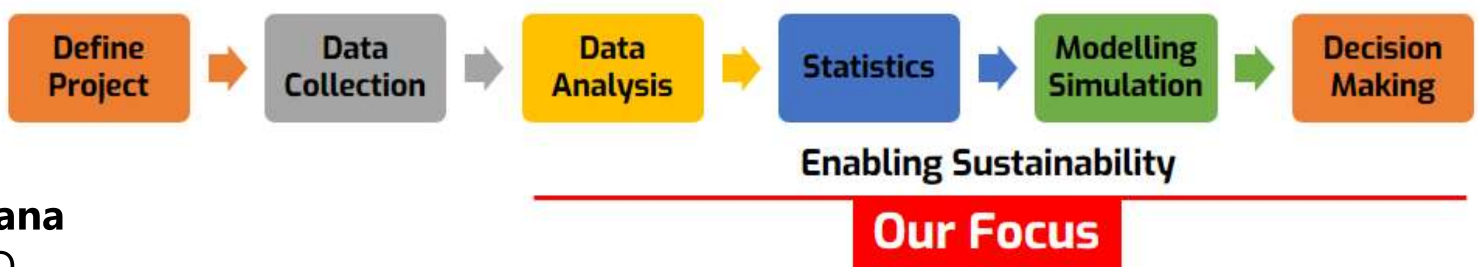
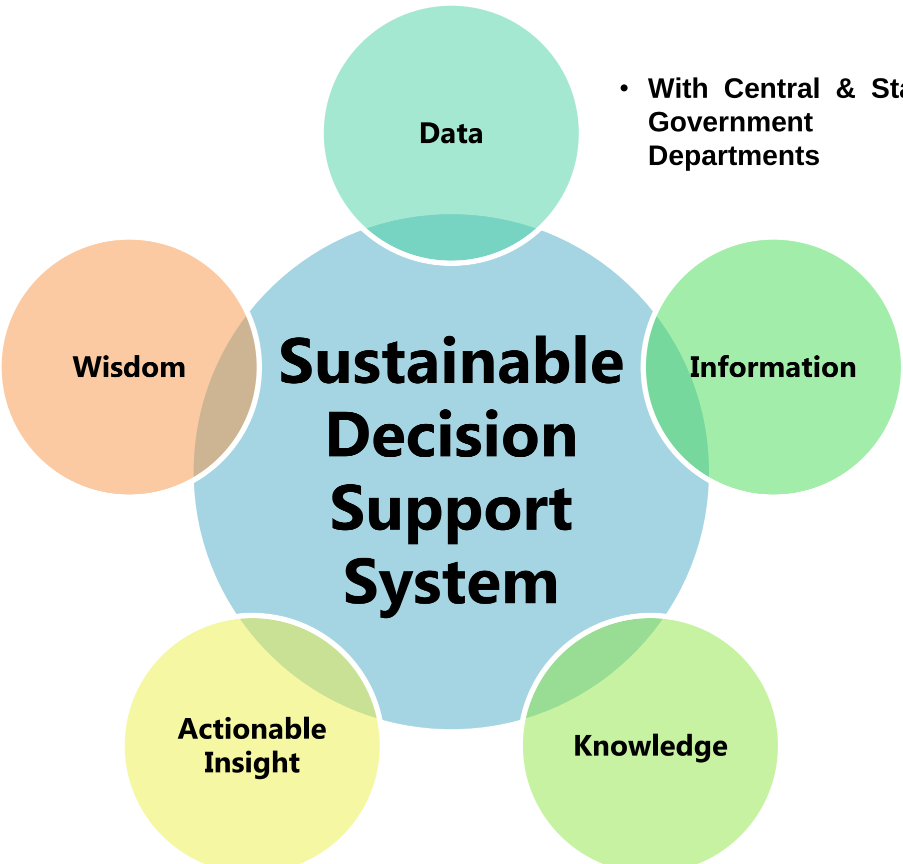
Forecasting | Analytics | Modelling | Simulation

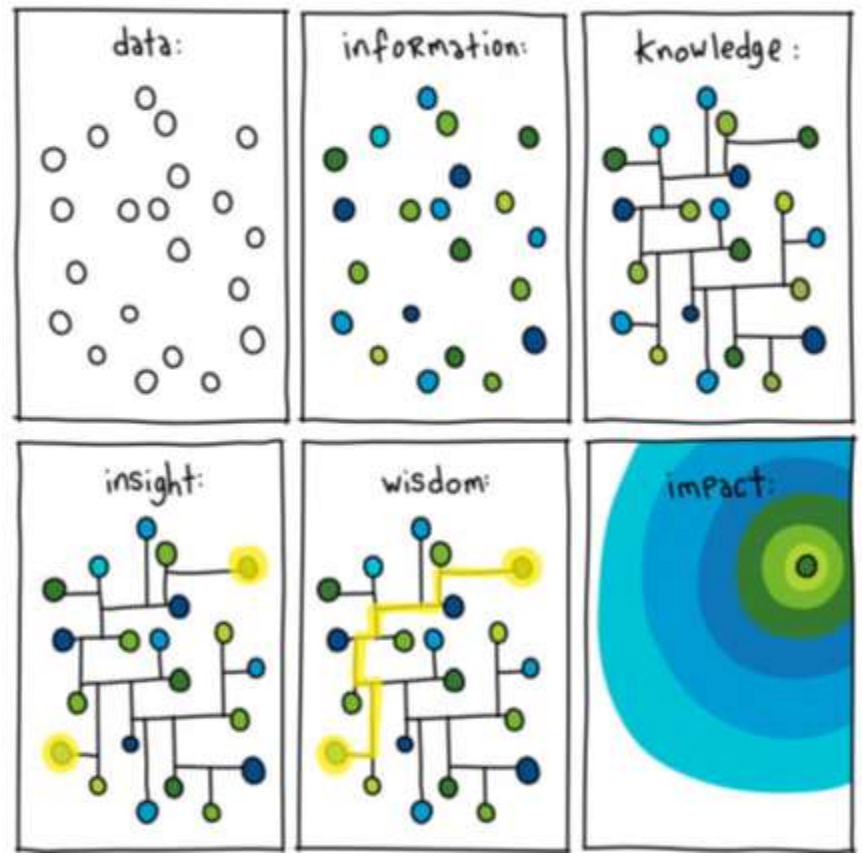


Presented by
Dr. Viraj Loliyana
Founder & CEO
FAMS Design Solution Pvt. Ltd.
INCOLD YEF Member
Email: ceo@famsds.com
Mob: +91 – 77790 90415

FAMS – Enabling Sustainability



- With Central & State Government Departments



FAMS Capability
- Domain Expertise
- Domain Services
- Domain Experts
- Domain Consultants

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Business Schematics

Dam Safety

Early Warning Systems

Climate Risk

Energy Risk

Flood Risk

Drought Risk

Sustainable Water Management

Irrigation & Drainage

River Morphology & Hydrology

Smart Water Utilities

Geo-spatial AI

Expert Services & Capacity Building

We enable sustainability through our services

Modelling, Simulation and Analytics

Evaluation and Monitoring

Spatio-Temporal Mapping, GIS and Remote Sensing

Client Support through Project Management

Technical Studies and Assessment of Implications

Technical Aid and Autonomous Expert Advice

Comprehensive Support & Development

Knowledge Sharing, Capacity Building and Training

Perceiving: Quality, Growth and Possibilities

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The Challenges

- Population outburst & water demand
- Water Governance Crisis
- Country faces heavy Floods in some parts & simultaneously drought in other part
- Erratic behavior of climate causing flash floods
- Resource Management under pressure
- Non-availability of reliable, real time and forecasted information from the water infrastructure
- Lapses in efficient water resources management
- Unequal distribution of water in command areas

Water Security

Water Scarcity

Unequal Distribution

Flash Flood

Opportunity

The Problem

- Technology is led and provided by **governmental agencies**
- 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

Existing Providers

- Repackage Models; Simulations; forecasts; – **lack of accuracy, resolution, and limited**
- **Could not overcome** the multi vertical complexity of extreme events impact
- Provide services **(not sustainable solutions oriented services)**
- Provide solutions based on raw data and **not actionable/decision making business insights**

The Facts

- ✓ **90% of businesses** cannot understand what water, crop, extreme weather events like, flood & drought data means for them
- ✓ **85% of the globe** doesn't have reliable real time and forecast weather & hydrological data

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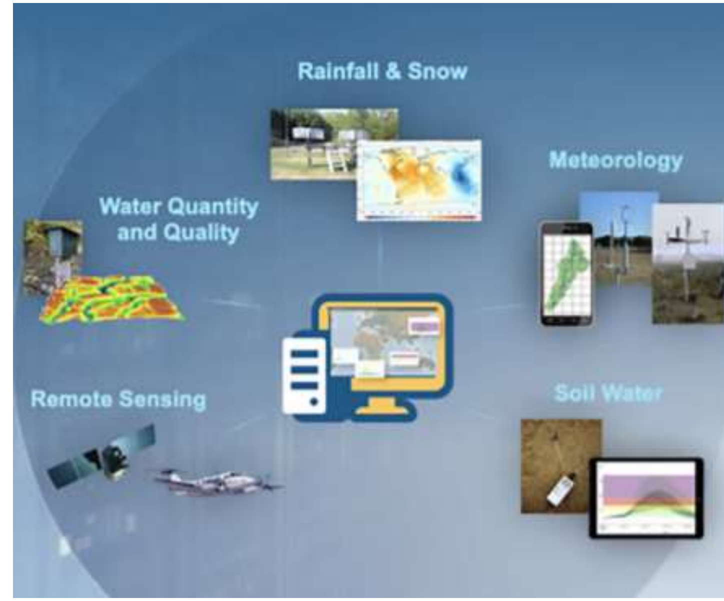
Cyberinfrastructure Requirements for Climate and Hydrologic Information Development

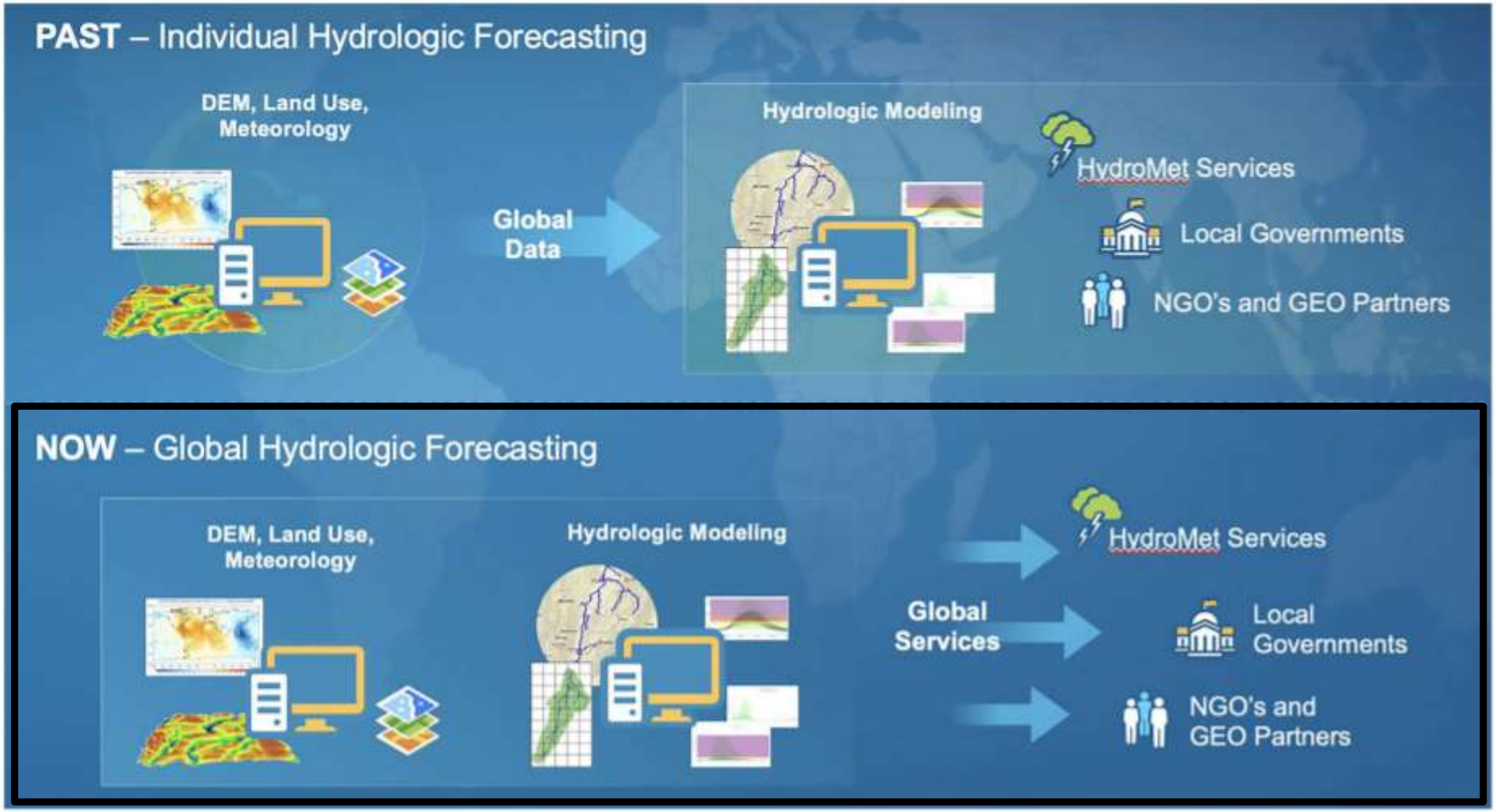
Dashboard Platform present the data in intuitive/compelling ways

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



Source: ESRI

Our Disruptive Technologies for Climate & Hydrologic Information Delivery



Source: ECMWF

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DSS: Extended Hydrological Predictions

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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

FAMS vision for the 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

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ESTD. 1927 New Delhi

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

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Data Modelling & Integration

We are setting datasets according to model and objective requirement, then run models using a robust data assimilation process.

Simulating Models with Scenario Analysis

The setting up thresholds are then used to train different scenarios to improve dynamic, forecasts and automated models.

Software as a Service (SaaS)

FAMS provides an accessible Software as a Service (SaaS) to leverage the power of big data, ML and fast AI simulations on cloud.

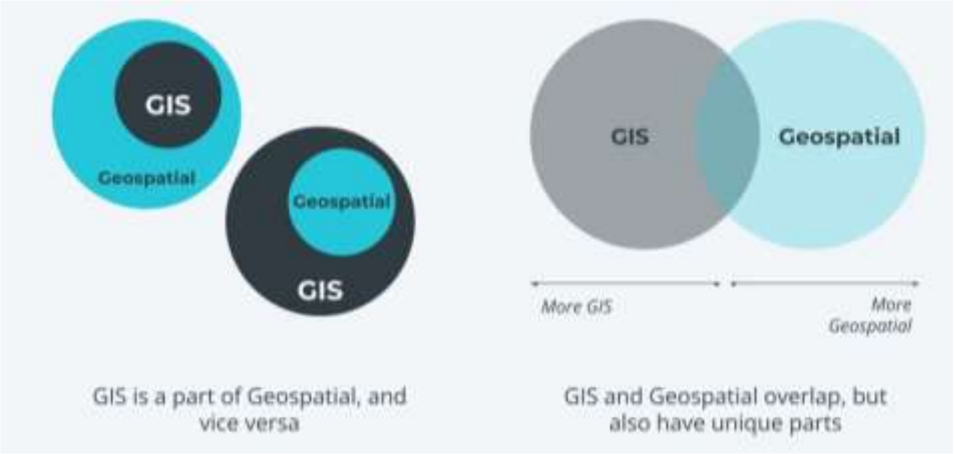
Enhanced Dynamic Analytics

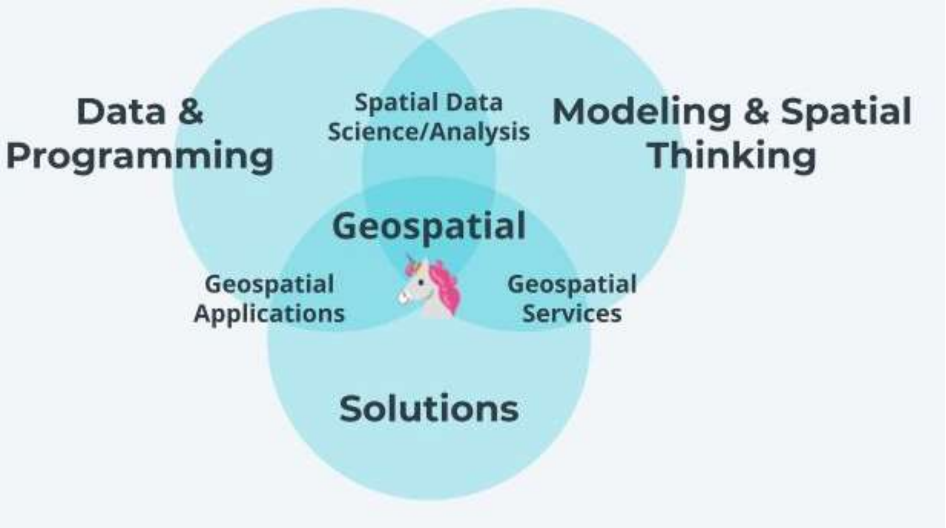
Exposure Spatio-Temporal Mapping

Carbon Emission & Portfolio Footprint

Integrating Technology

Geospatial and GIS





Geospatial Venn Diagram

Integrating Technology

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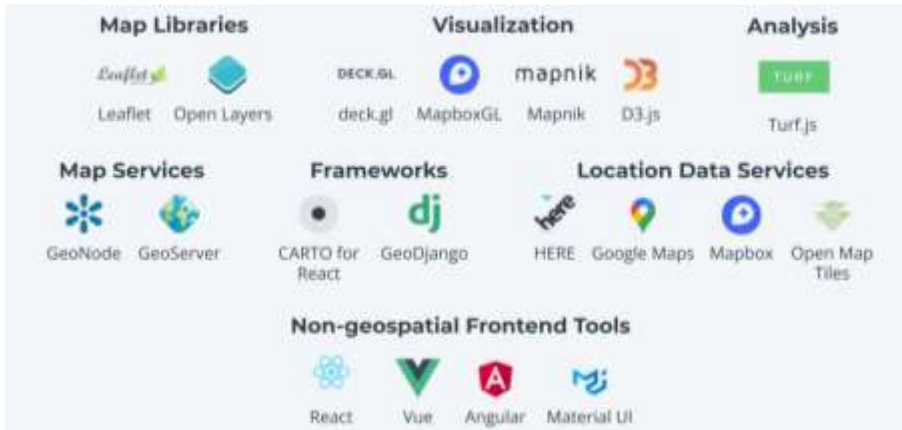
Geospatial Application Development Ecosystem

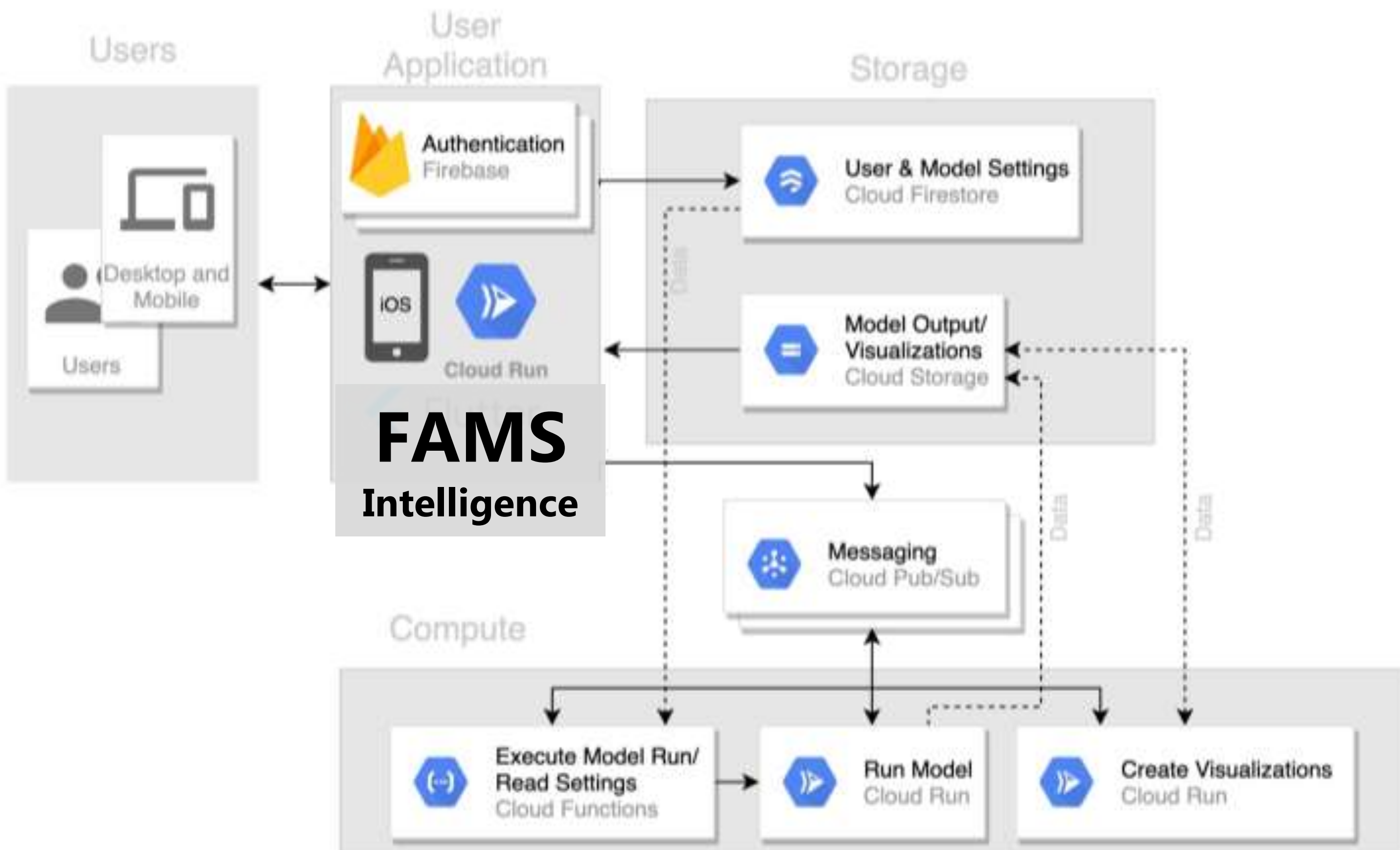


Geospatial Python/ Spatial Data Science Ecosystem

Geospatial Data Tools Ecosystem

Integrating Technology

Atmospheric/Hydrological Model & User Application



Early Warning to Early Action

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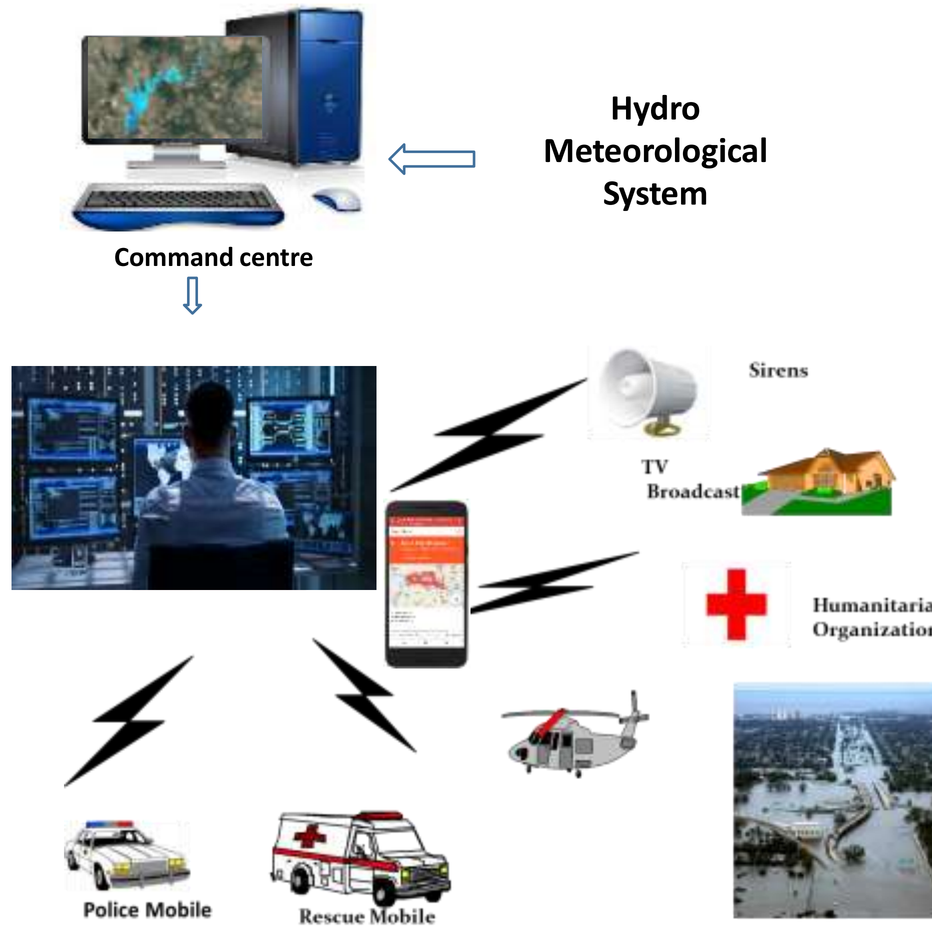
Key Features

- 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



Solution: Extended Hydrological Prediction

Real Time Data Acquisition → Hydrological Model → Inflow Prediction → Reservoir Operation → Flood Inundation Model → Flood Hazard Mapping → Flood Risk Assessment

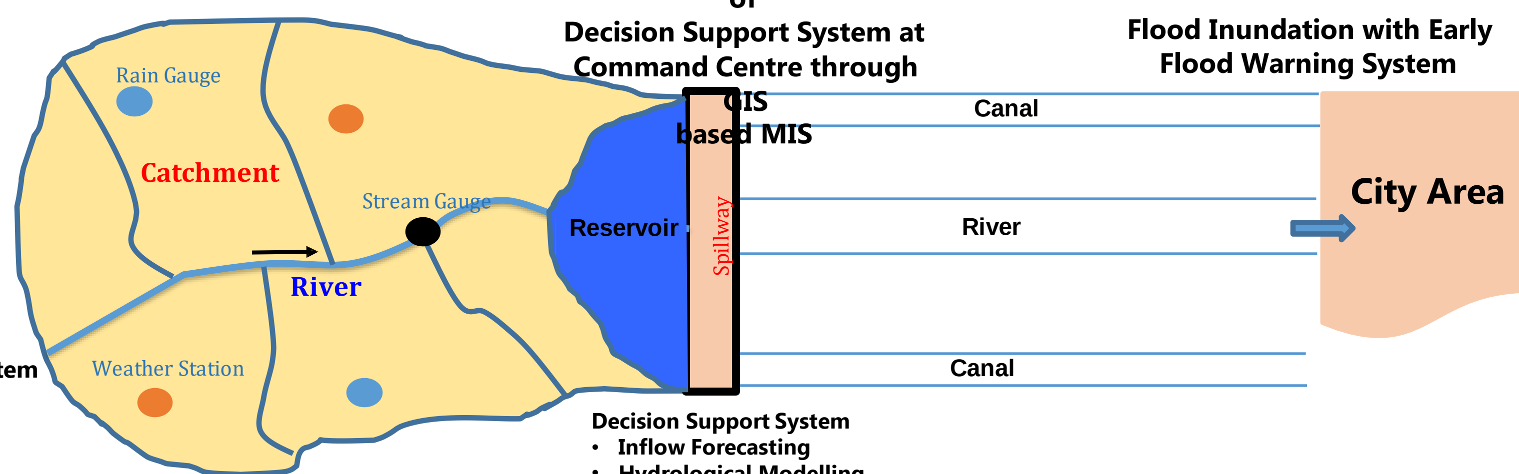
Rainfall Data
Weather Data

Forecasted Data ↑ (to Real Time Data Acquisition → Hydrological Model)

Stream Flow & Water Level Data ↑ (to Hydrological Model → Inflow Prediction)

Controlling & Monitoring of Decision Support System at Command Centre through GIS based MIS

Flood Inundation with Early Flood Warning System



Real Time Data Acquisition System
- Rain Gauge
- Weather Station
- Stream Gauging &
- Discharge
  Reservoir Water Level

Decision Support System
- Inflow Forecasting
- Hydrological Modelling
- Multi week Forecast
- Emergency Action Plan

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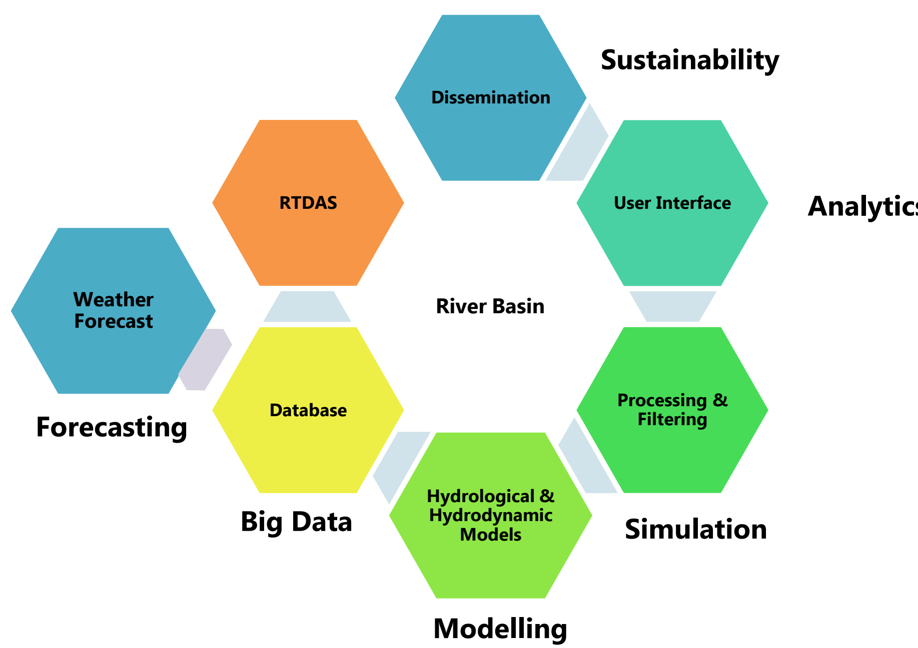
DSS: Objectives and Components

- 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

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

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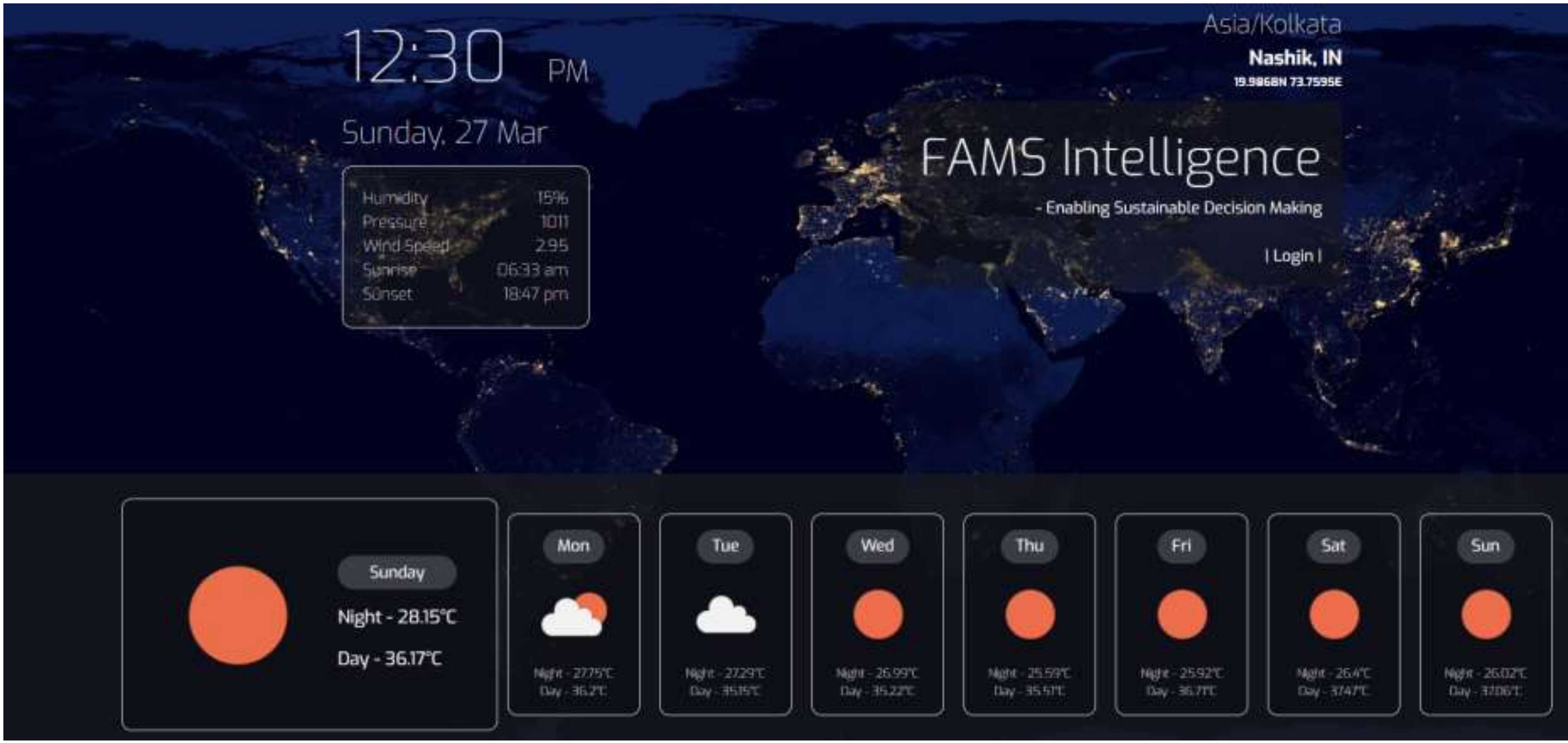
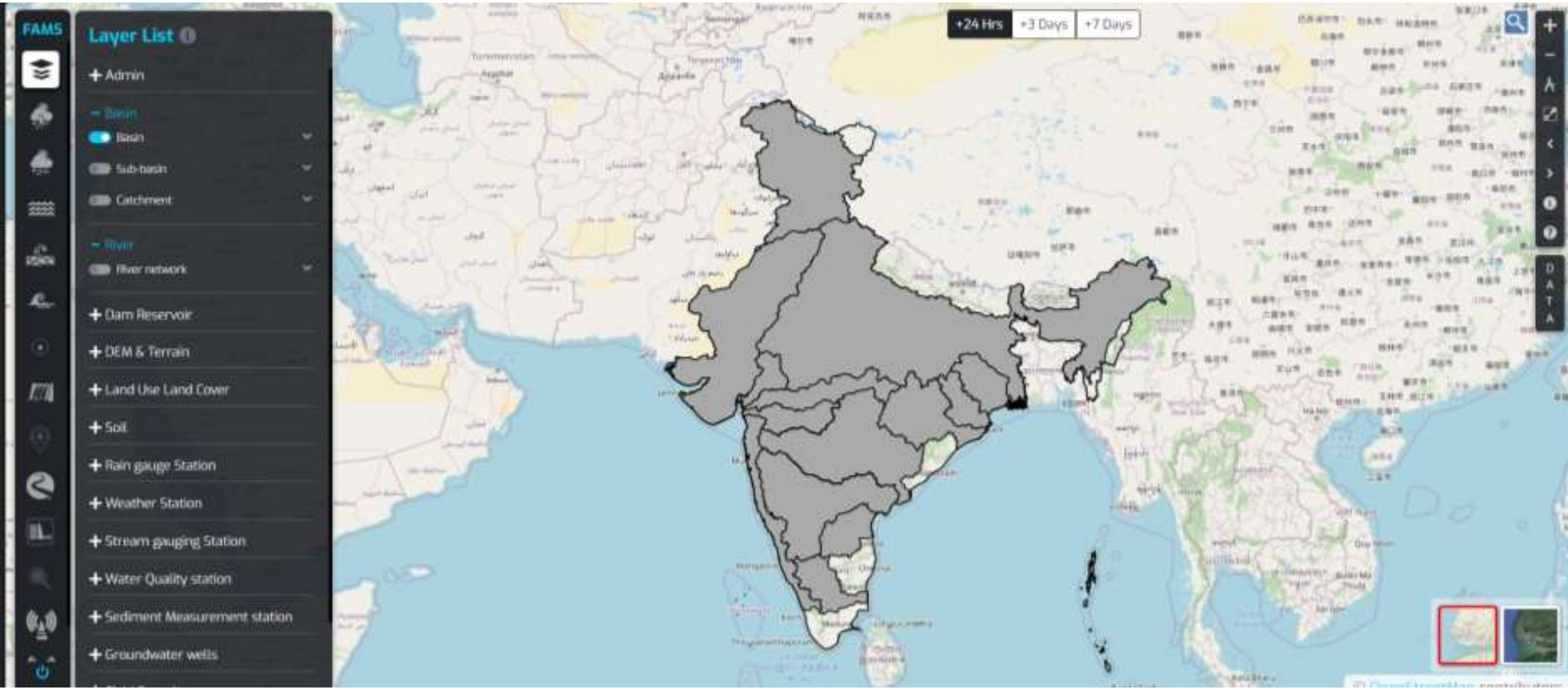
FAMS Intelligence: Decision Support System Portal

gis.famsds.com



FAMS Intelligence: Decision Support System Portal



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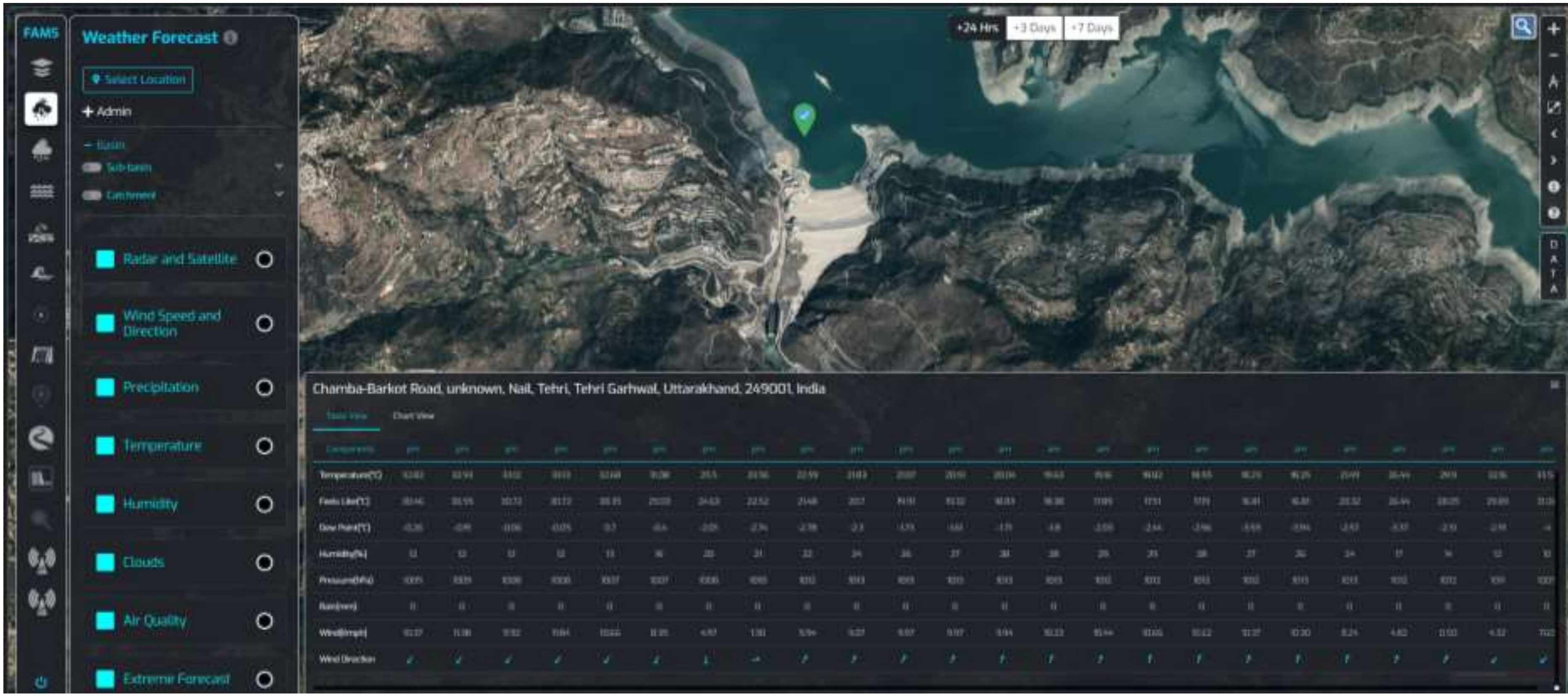
Weather Forecast at Particular Location



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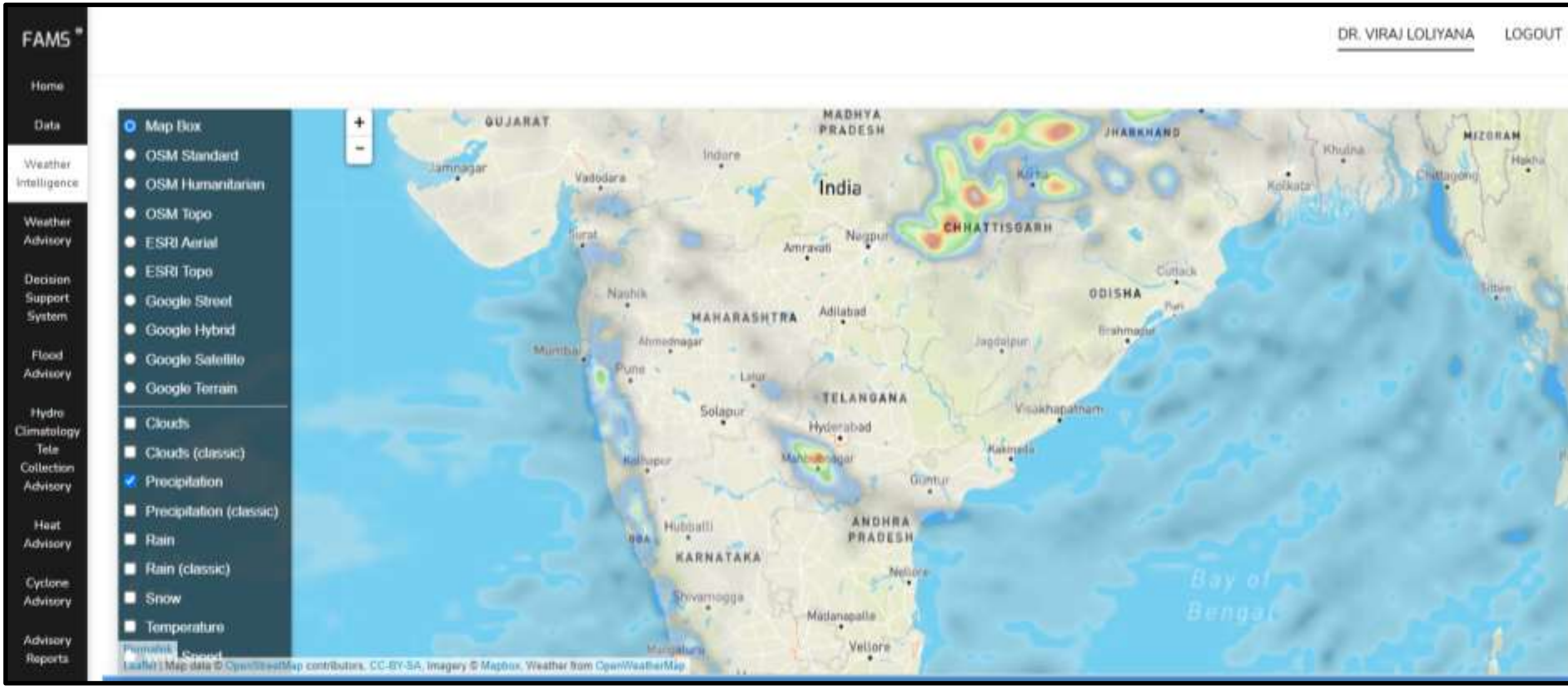
Weather Forecast



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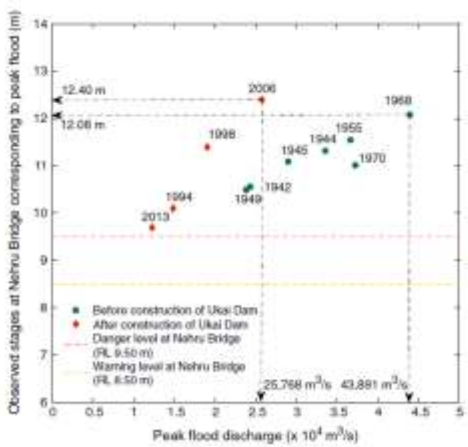
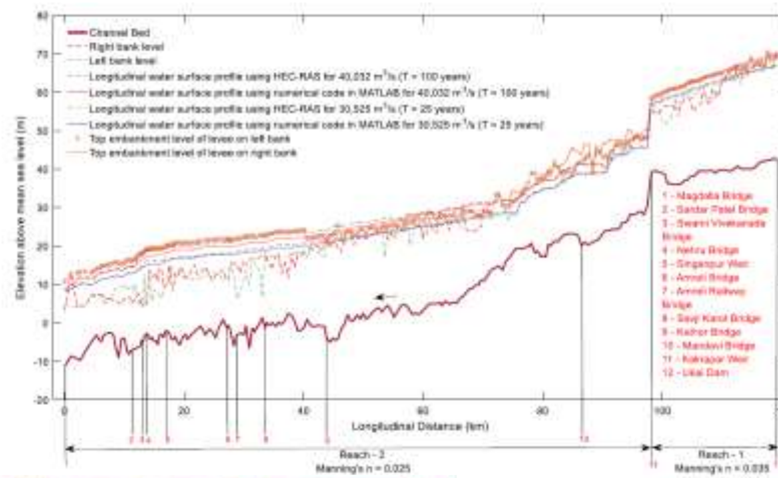
Flood Frequency and Flood Risk Assessment for Surat City

Table 1. Historic floods and corresponding water levels in Surat city

Serial number	Date	Peak flood discharge (m^3/s)	Corresponding water level at Nehru Bridge (m)
1	August 7, 1942	24,355	10.56
2	August 18, 1944	33,527	11.32
3	August 24, 1945	28,996	11.09
4	September 18, 1949	23,842	10.49
5	September 17, 1959	36,642	11.55
6	August 6, 1968	43,891	12.08
7	September 7, 1970	37,208	11.02
8	August 31, 1978	25,145 (12,459)[a]	8.59[a]
9	August 12, 1979	24,296 (9,345)[a]	8.22[a]
10	September 8, 1994	25,117 (14,866)[a]	10.10[a]
11	September 16, 1998	29,817 (19,057)[a]	11.40[a]
12	August 7, 2006	34,122 (25,768)[a]	12.40[a]
13	September 23, 2013	20,673 (12,257)[a]	9.70[a]

[a]Refers to peak discharge released from Ukai Dam and corresponding water level observed at Nehru Bridge.





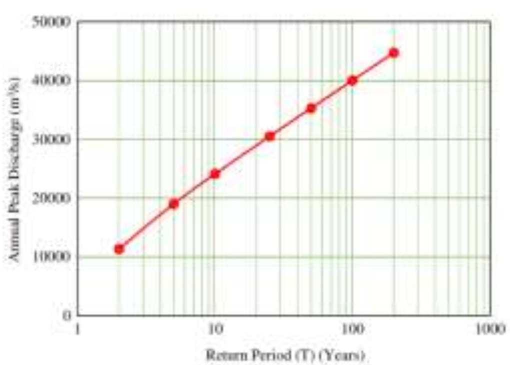


Fig. 4. Flood frequency analysis of annual peak discharge series of lower Tapi River observed at Kathor/Ukai from 1939 to 2013 using extreme value Type I distribution.

1) Vora, A., Sharma, P. J., Loliyana, V. D., Patel, P. L., & Timbadiya, P. V. (2018). "Assessment and prioritization of flood protection levees along Lower Tapi River, India." Natural Hazards Review (ASCE), 19(4), 05018009 1-11.

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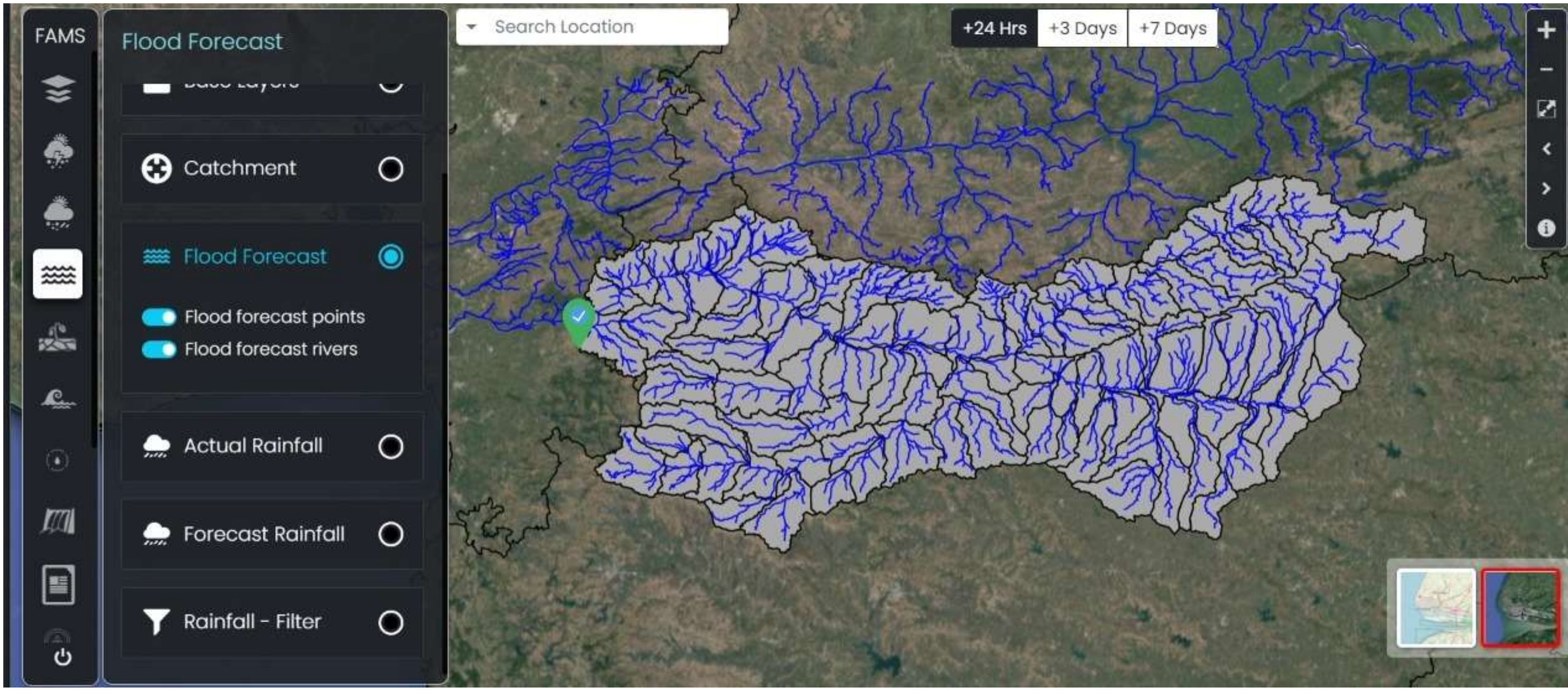
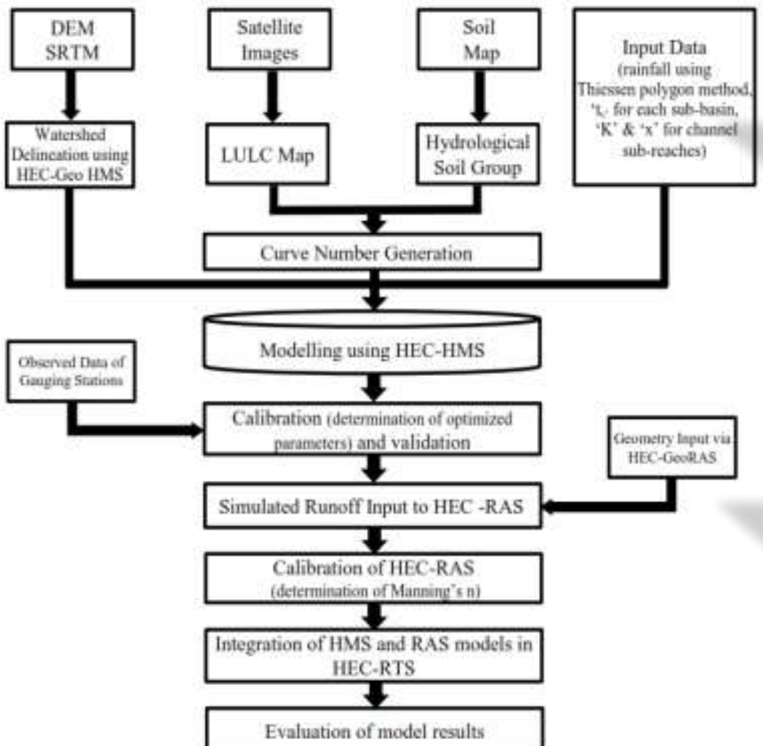
Web-based Flood Forecasting System



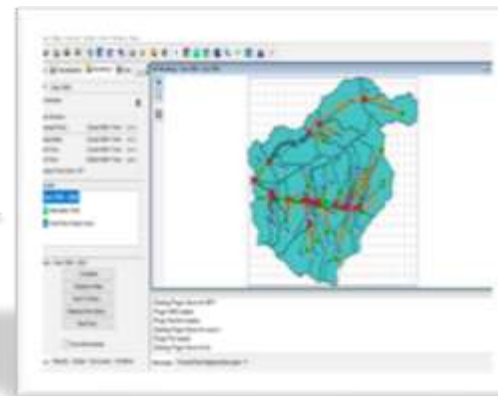
Solution: Inflow Predictions at Hathnur Reservoir, Tapi Basin using HEC-RTS



Methodology

HEC-HMS : Hydrological Model

HEC-RAS : Hydraulic Model



HEC – RTS:
Integrated Hydrological
and
Hydraulic model in
RTS to predict and forecast stream flows

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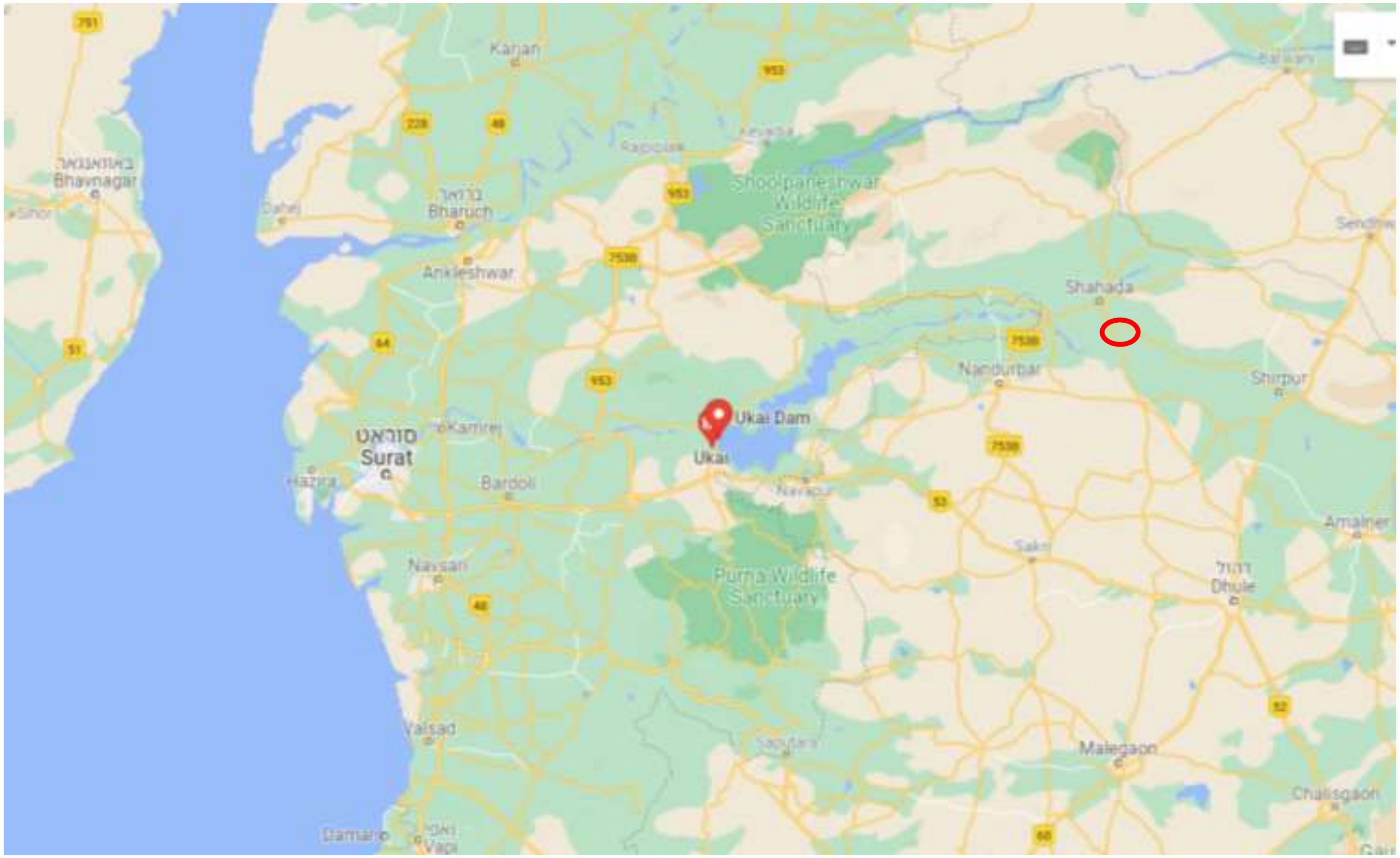
Deterministic and populistic forecast for the Tapi River: Hatnur and Ukai Dams



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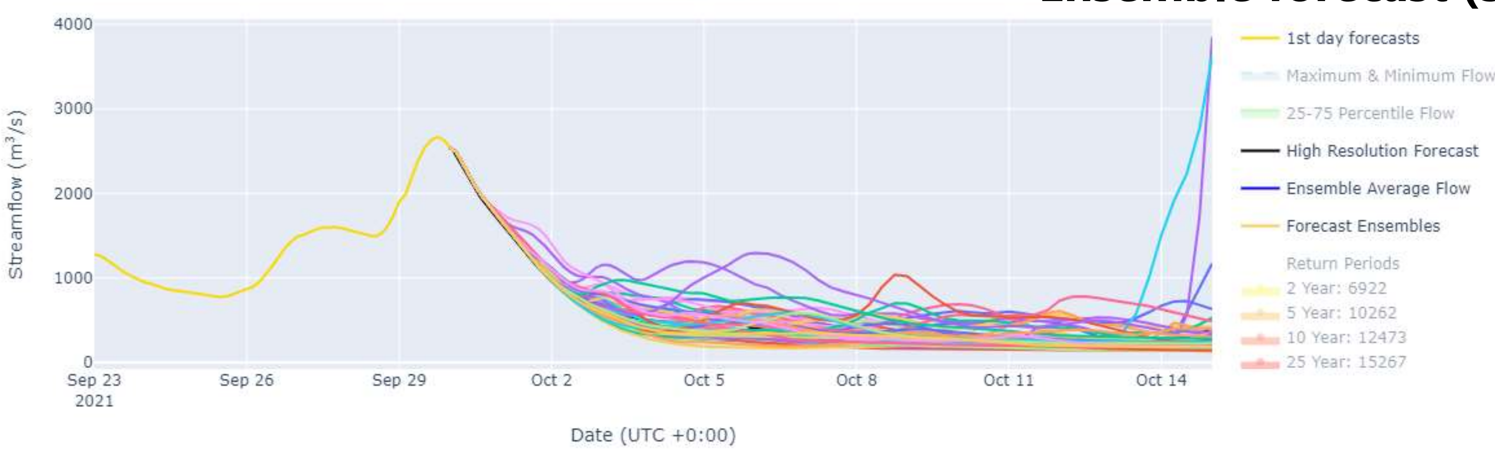
Tapi River at Hatnur dam:
High resolution deterministic forecast (in black) and the ensemble mean (blue)

Ensemble forecast (51 members)



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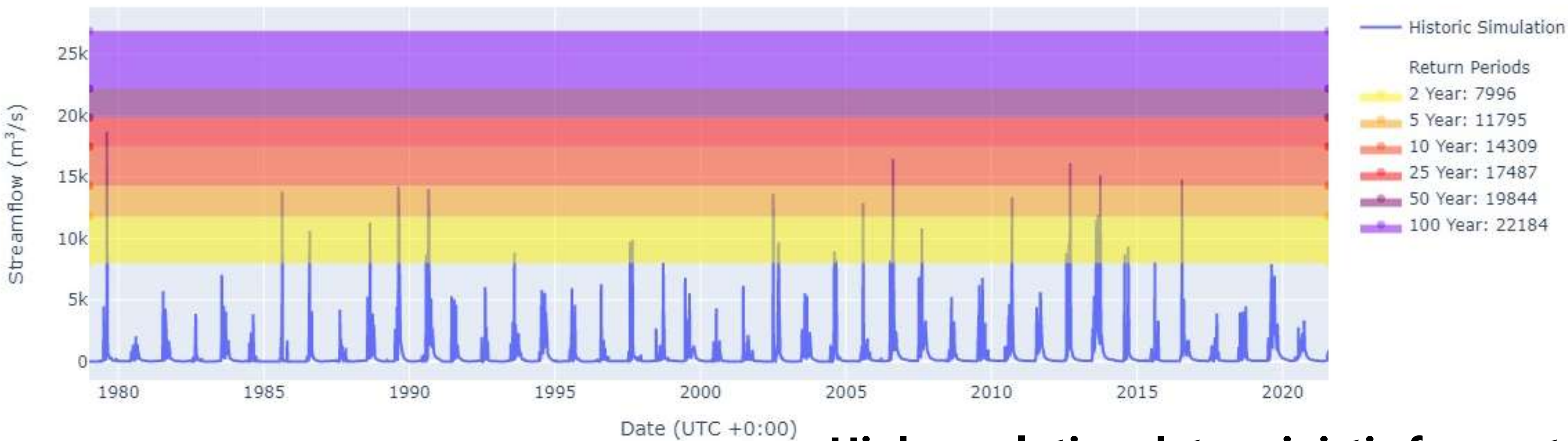
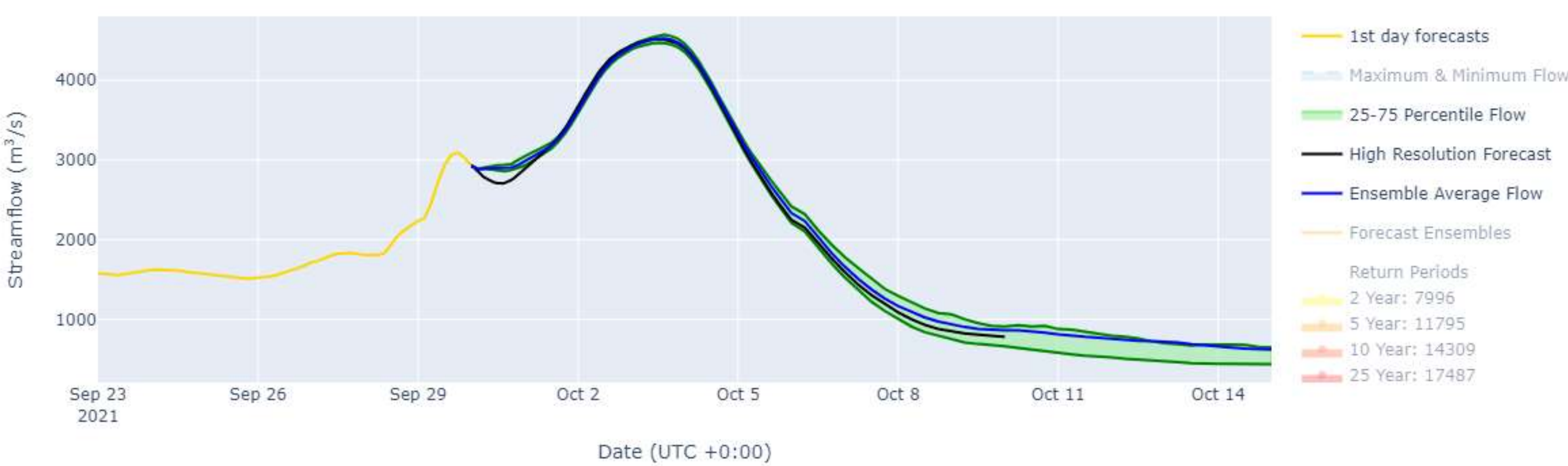
Tapi River at Hatnur dam: Historical Simulation



High resolution deterministic forecast (in black) and the ensemble mean (blue)



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Flood Forecast Model

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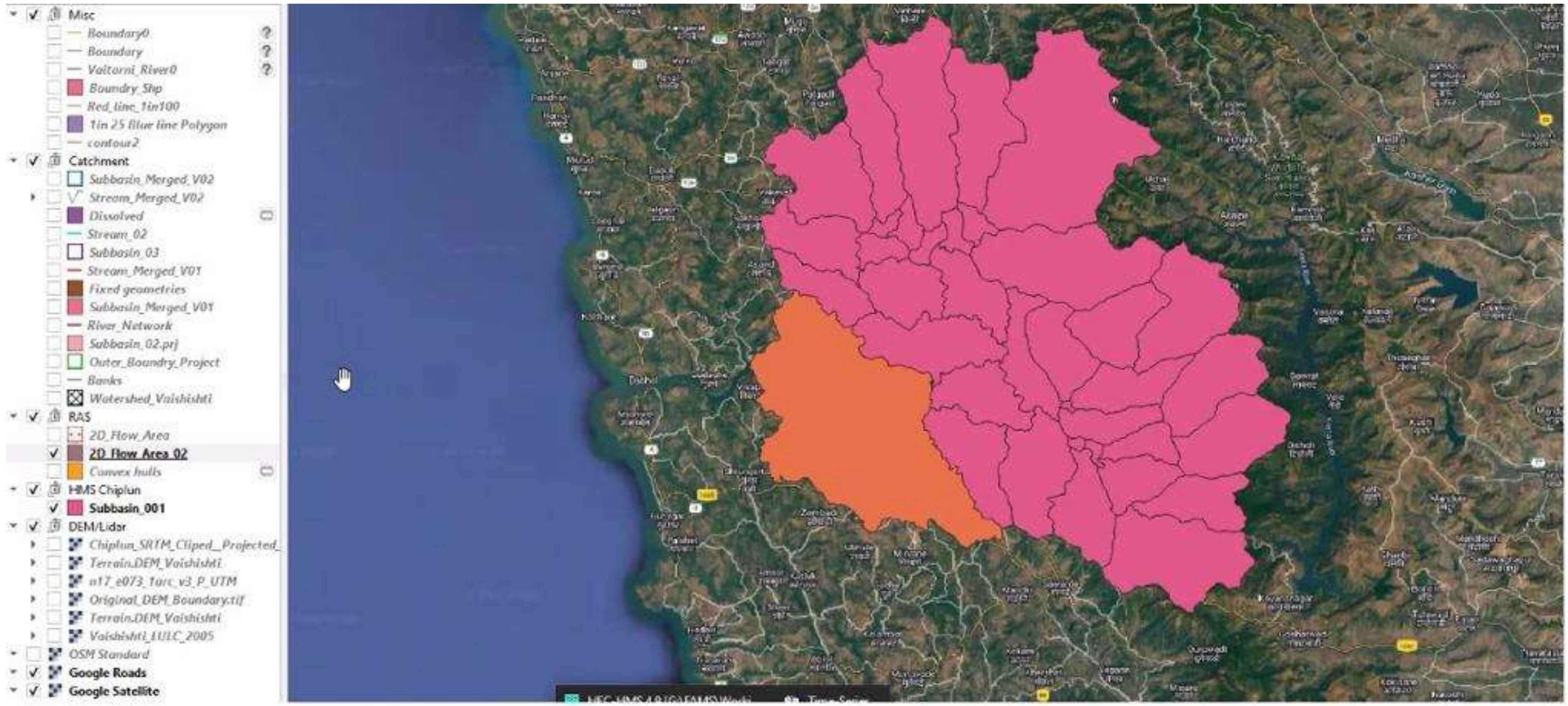
Flood Forecast Model



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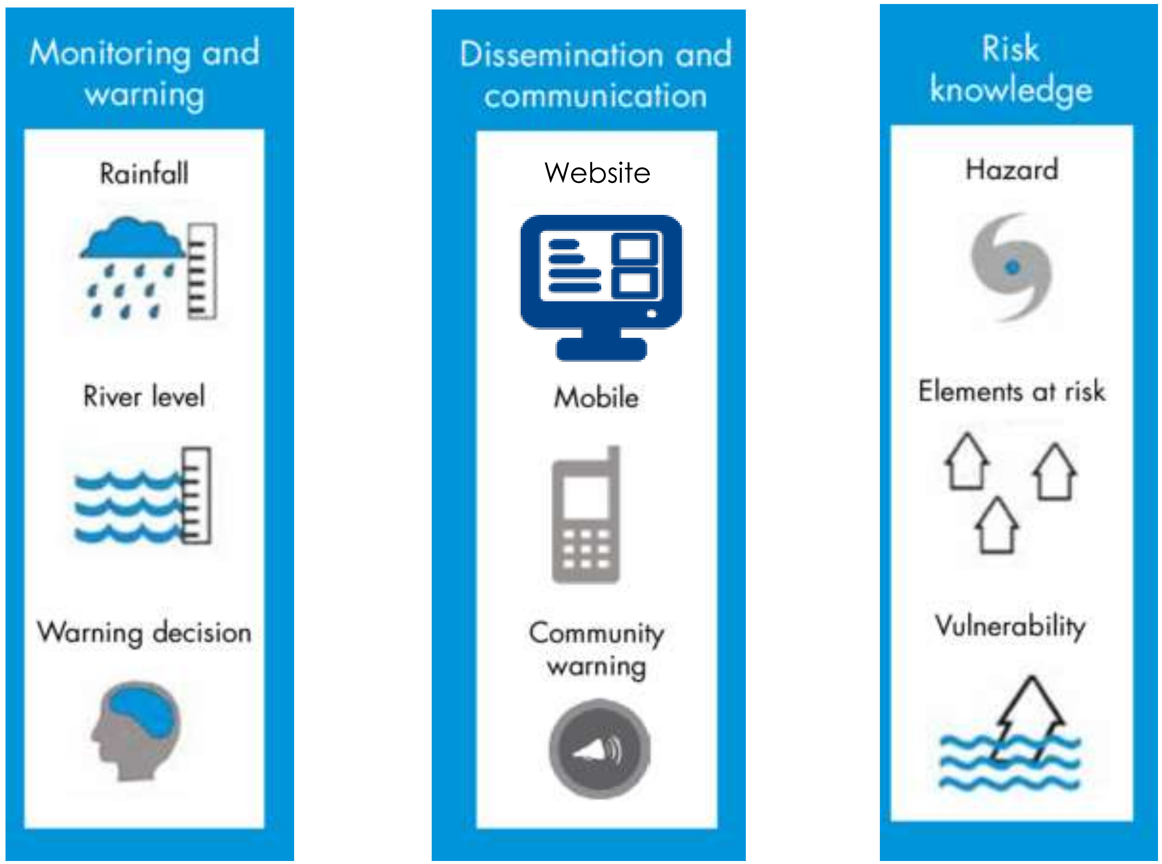
Dashboard: Early Flood Warning System

Home

Flood Forecast

Weather Forecast

Observed Weather



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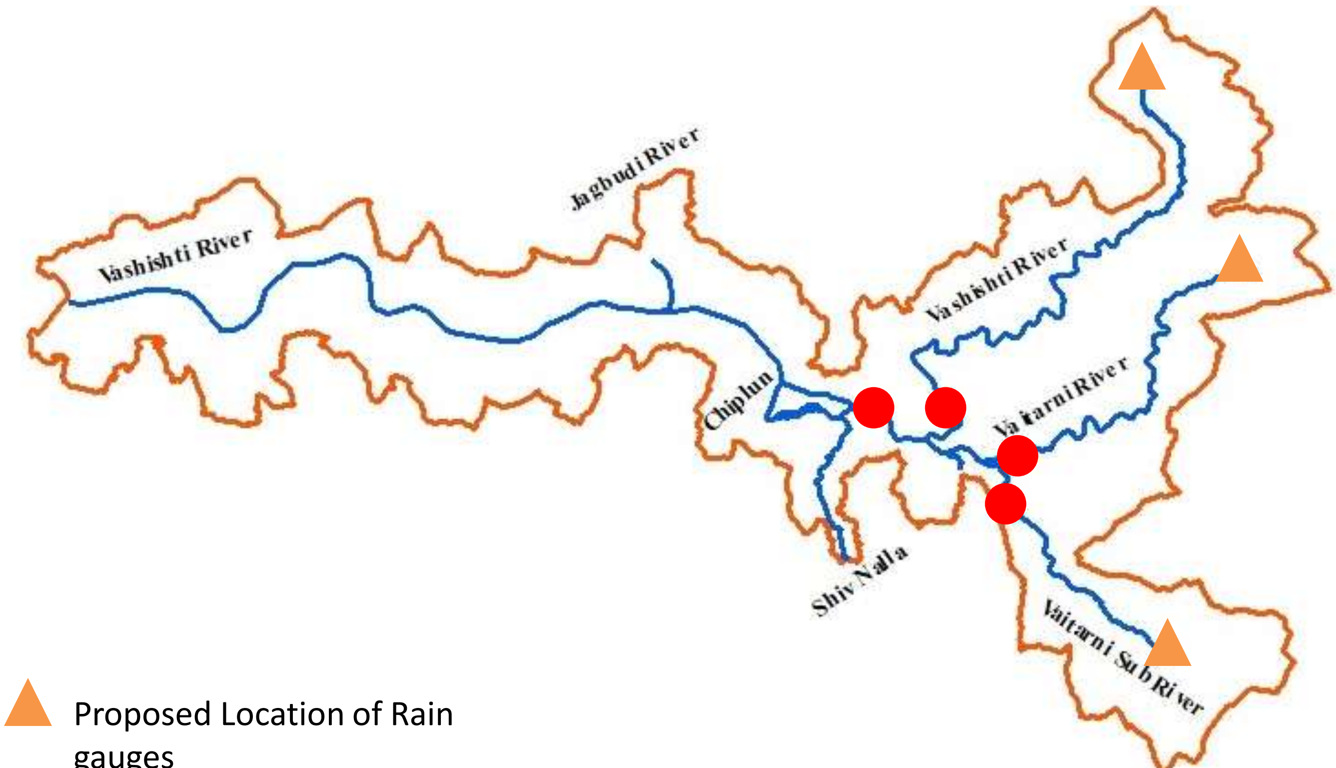
Dashboard: Home Module

- Home
- Flood Forecast
- Weather Forecast
- Observed Weather



Proposed Location of Rain gauges

Proposed Location of River gauges

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Dashboard: Flood Forecast Module

Home

Flood Forecast

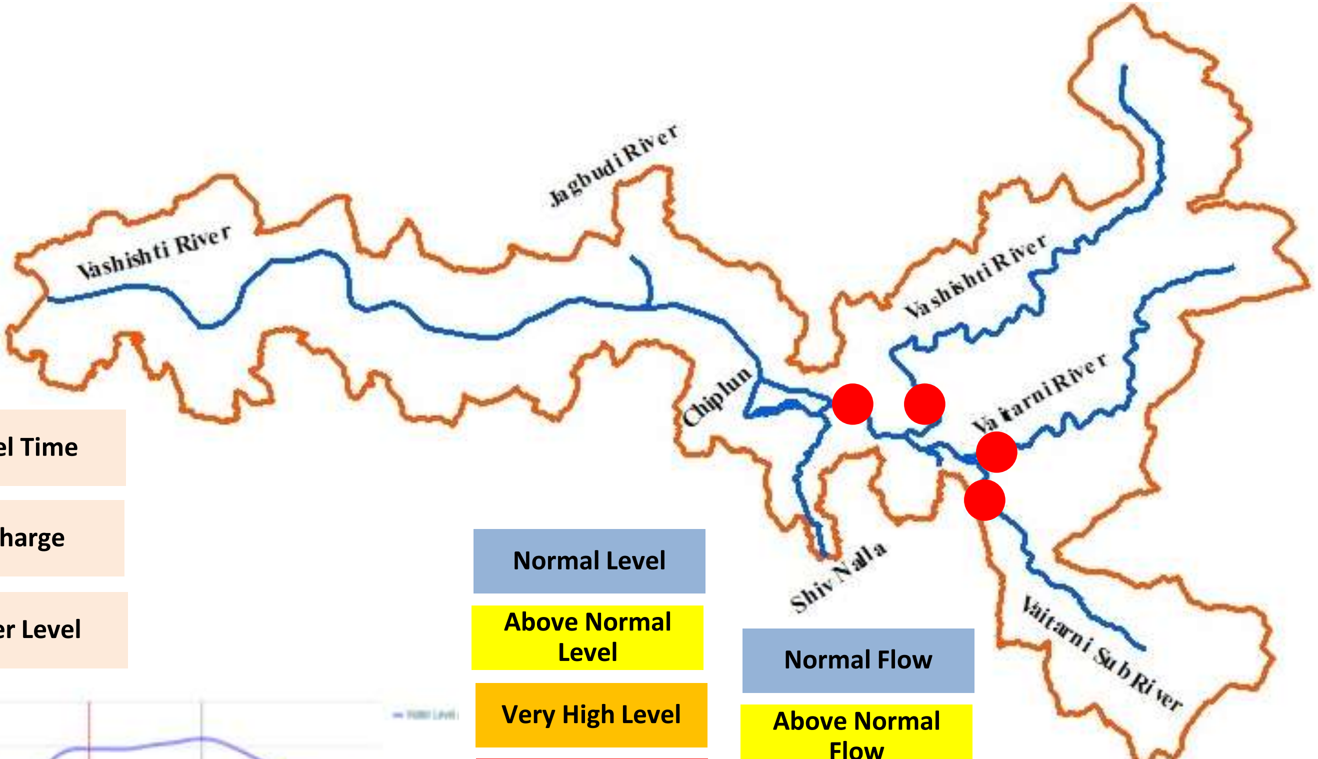
Weather Forecast

Observed Weather

Travel Time

Discharge

Water Level



Normal Level

Above Normal Level

Very High Level

Extremely High Level

Normal Flow

Above Normal Flow

Very High Flow

Extremely High Flow

Proposed Location of River gauges

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Dashboard: Weather Forecast Module

- Home
- Flood Forecast
- **Weather Forecast**
- Observed Weather

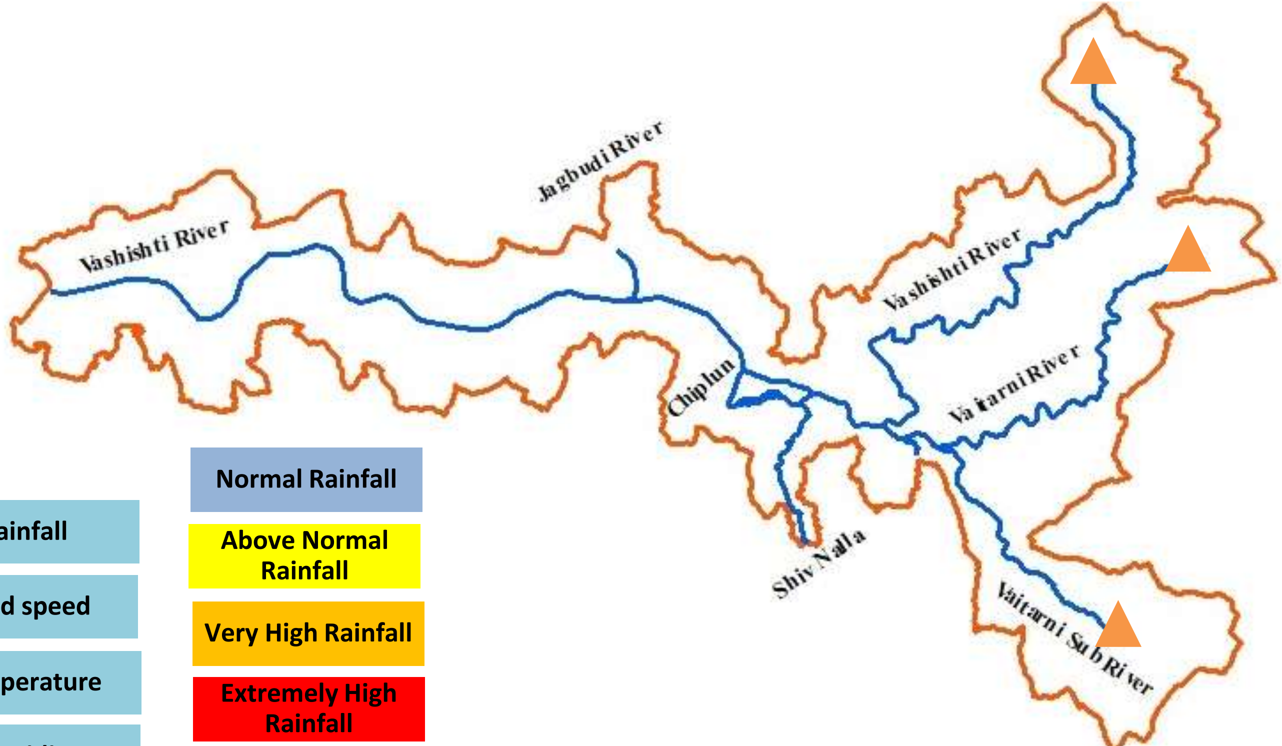
- Rainfall
- Wind speed
- Temperature
- Humidity
- Pressure
- Wind direction

Normal Rainfall

Above Normal Rainfall

Very High Rainfall

Extremely High Rainfall



Time	[illegible]
Temperature (°C)	[illegible]
Humidity (%)	[illegible]
Pressure (hPa)	[illegible]
Wind Speed	[illegible]
Wind Direction	[illegible]
Weather	[illegible]

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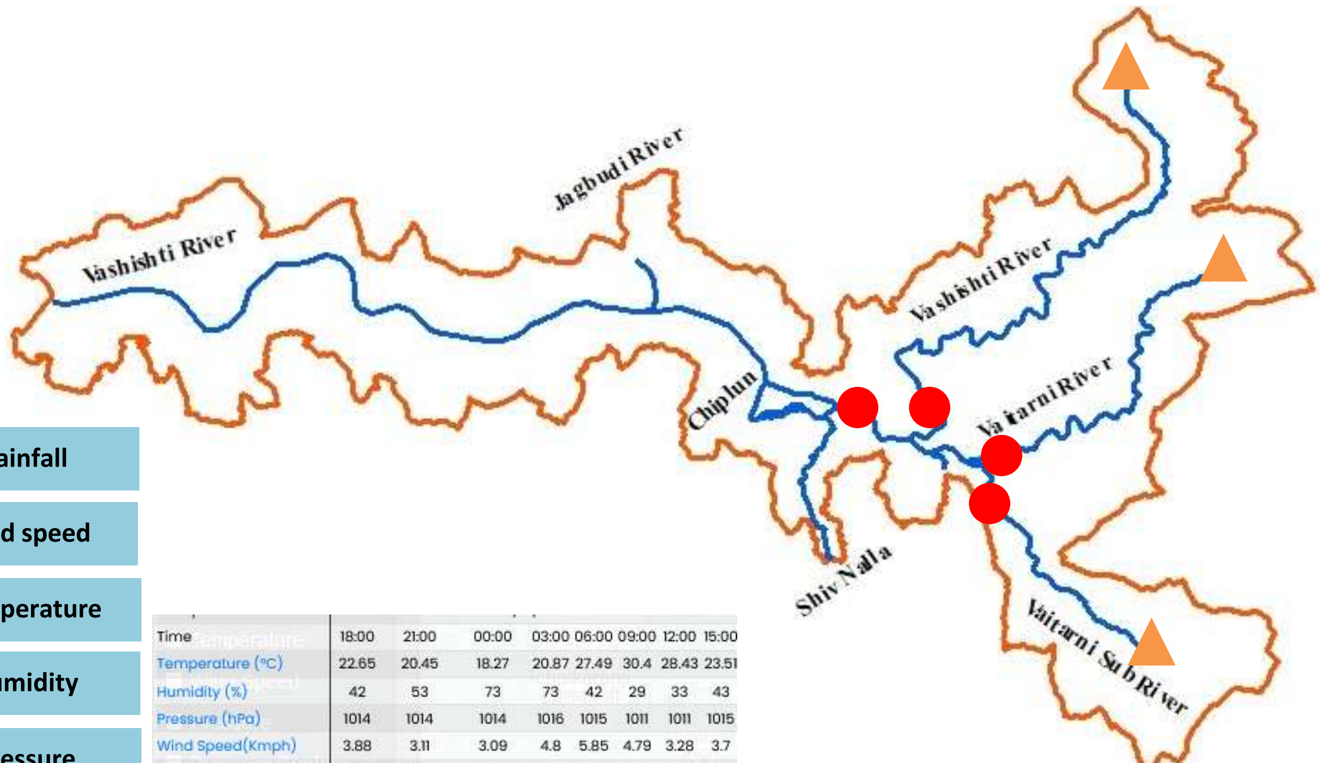
Dashboard: Observed Weather Module

- Home
- Flood Forecast
- Weather Forecast
- **Observed Weather**

- Rainfall
- Wind speed
- Temperature
- Humidity
- Pressure
- Wind direction



Time	18:00	21:00	00:00	03:00	06:00	09:00	12:00	15:00
Temperature (°C)	22.65	20.45	18.27	20.87	27.49	30.4	28.43	23.51
Humidity (%)	42	53	73	73	42	29	33	43
Pressure (hPa)	1014	1014	1014	1016	1015	1011	1011	1015
Wind Speed(Kmph)	3.88	3.11	3.09	4.8	5.85	4.79	3.28	3.7
Wind Direction	113	122	111	120	106	99	101	89
Weather	few clouds	scattered clouds	scattered clouds	clear sky	clear sky	clear sky	clear sky	clear sky

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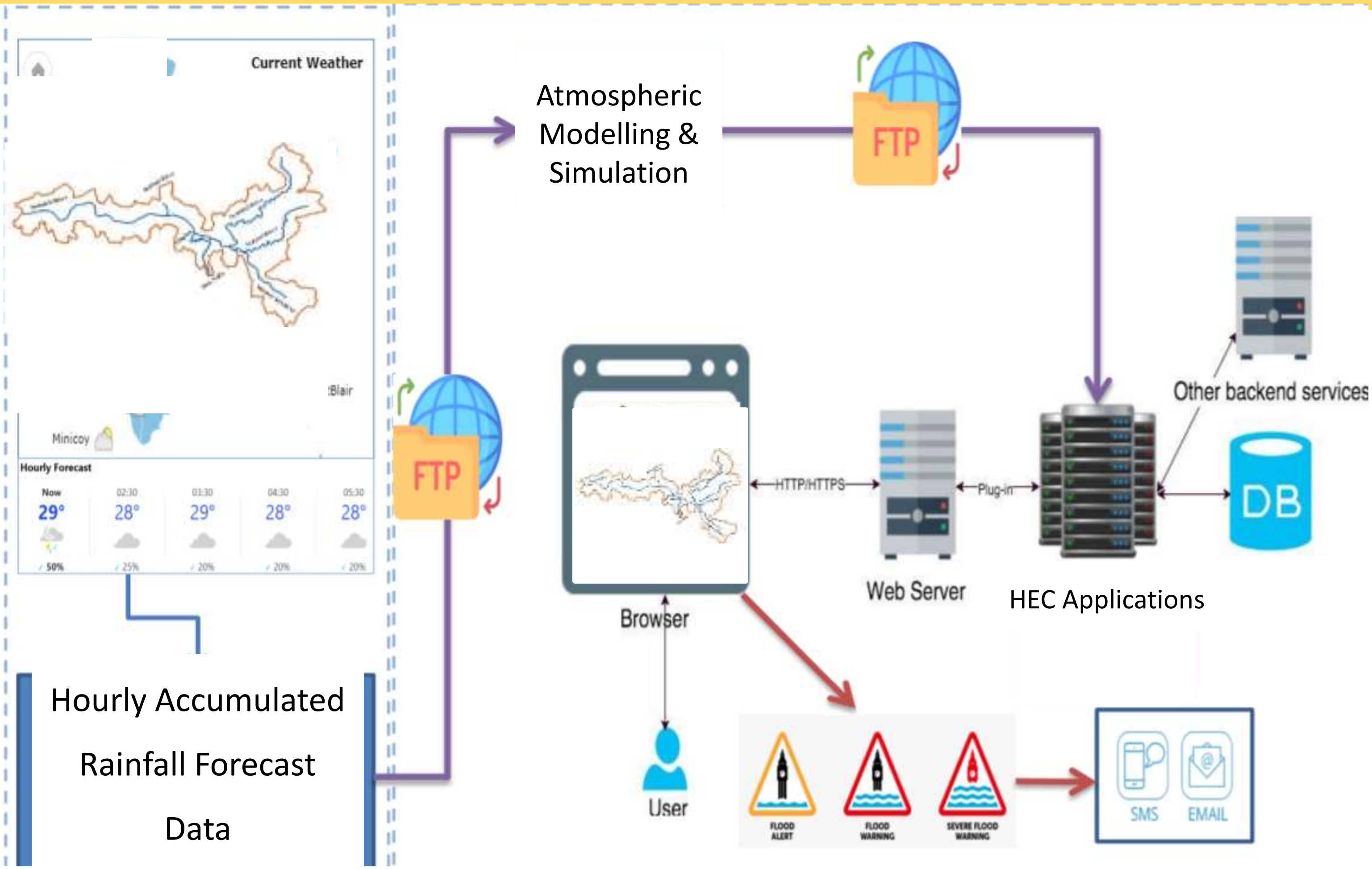
Flood Warning System Work Flow



Salient Features of the 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

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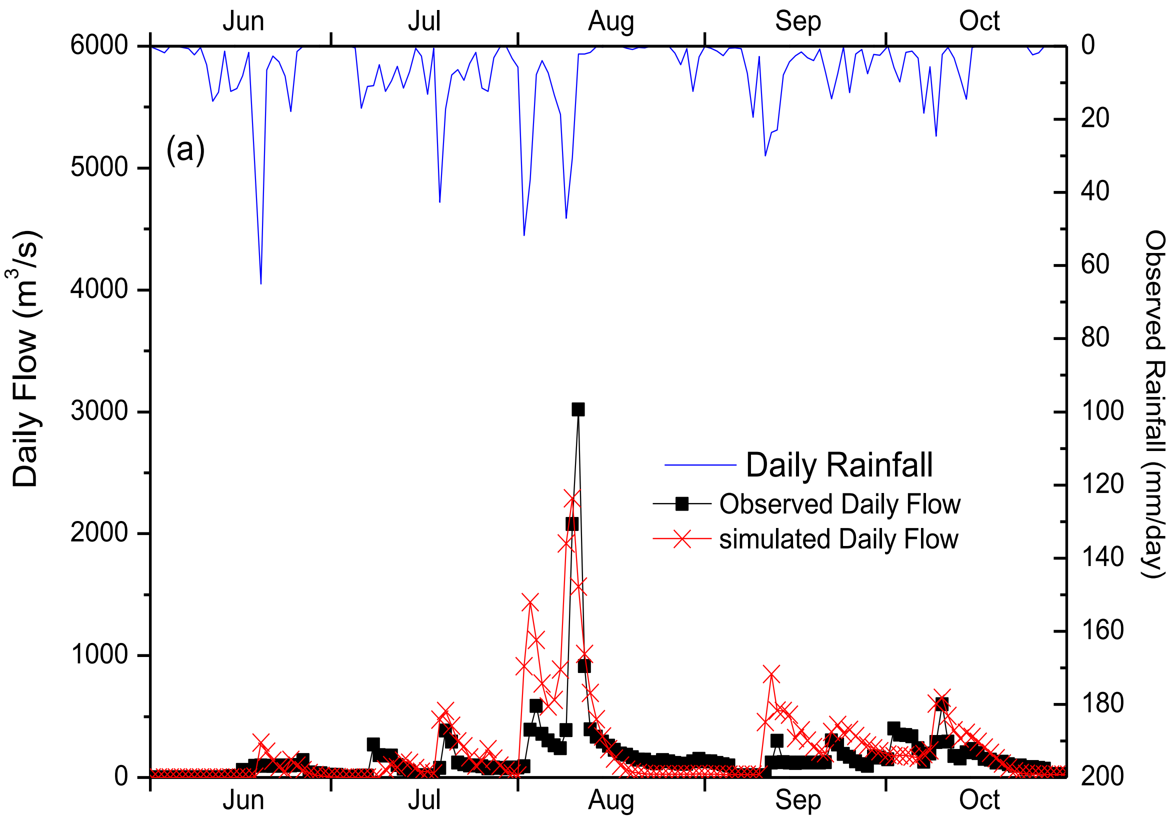
Output Parameters of Extended Hydrological Model

- Real time data acquisition of Rainfall, Weather Parameters, Stream flow and water level
- Discharge
- Water level
- Inflow into Reservoir
- Outflow from Reservoir
- Overland flow
- Multi week Forecast of all parameters



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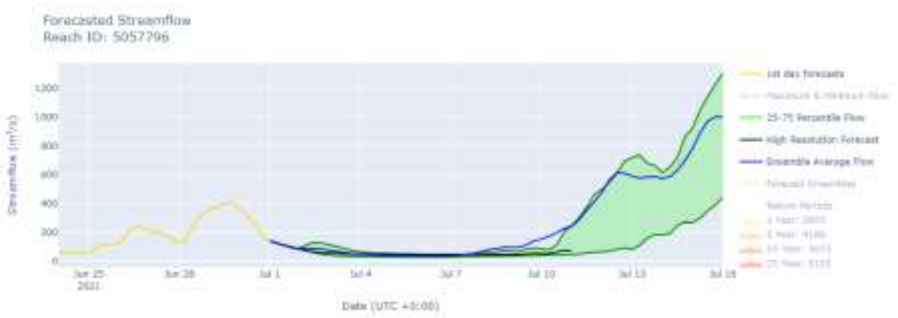
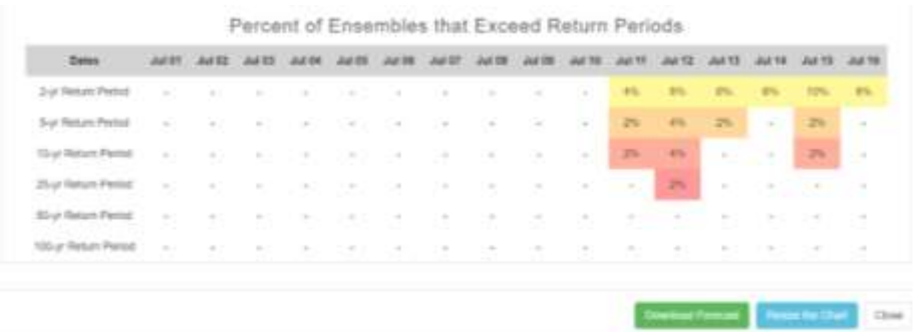
Case Study Ongoing : 15 days flow forecast for the Ulhas River, Maharashtra based on ECMWF Data

- 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.





Risk Assessment: Energy Risk; Flood Risk; Drought Risk

Energy Risk

- Integration of Numerical Weather Predictions
- Potential site selection, wind, solar, storage, hydro resource modelling & preliminary energy yield estimates
- Renewable energy yield due diligence
- Energy audit
- Feasibility studies & site Assessment
- Life extensions & re-powering
- Energy associated risk assessment
- Predictive maintenance strategy

Flood Risk

- Integration of Numerical Weather Predictions
- Assessment of Risk
- Risk Identification
- Hazard Identification
- Consequence Identification
- Risk Quantification
- Consequence Magnitude Estimation
- Failure Hydrographs
- Population at Risk
- Potential Loss of Life
- Economic Losses
- Risk Resilience
- Integrated Risk Management Strategy

Drought Risk

- Integration of Numerical Weather Predictions
- Heatwave identification
- Drought hazard & risk Classification
- Vulnerability to drought
- Exposure to drought
- Modelling tools and resources for drought assessment
- Drought Contingency Plans
- Drinking water stress
- Ground water depletion studies
- Crop soil moisture stress advisory
- Crop acreage estimation

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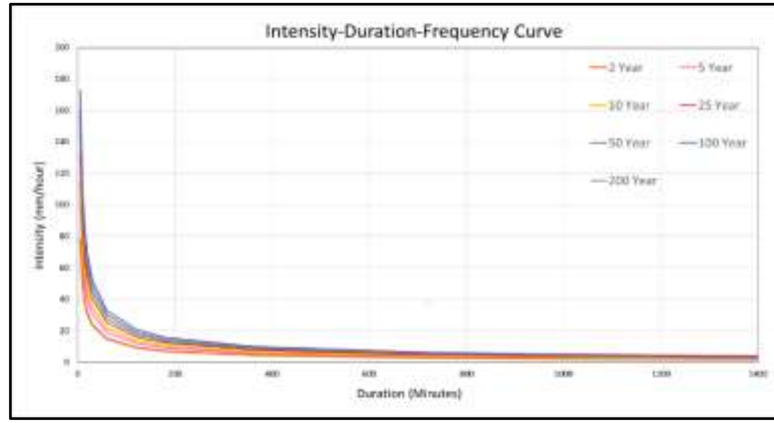
Climate & Flood Risk Assessment: Solar Power Project, Spain

- **Data Collection from various sources (Data cleaning and bias correction)**
- **Trend Anamalies of Rainfall for Historical and Future RCP 4.5 & 8.5**
- **Frequency Analysis for Estimation of Intensity-Duration-Frequency Curve for various Return Period**
- **Hydrological model HEC-HMS simulations for obtaining inflow, lag time, travel time at the site**
- **HEC-RAS 2D model simulations for obtaining Flood Inundation Depth, Flood Arrival time, Flood Depth at location for various return periods (Historical and Future)**



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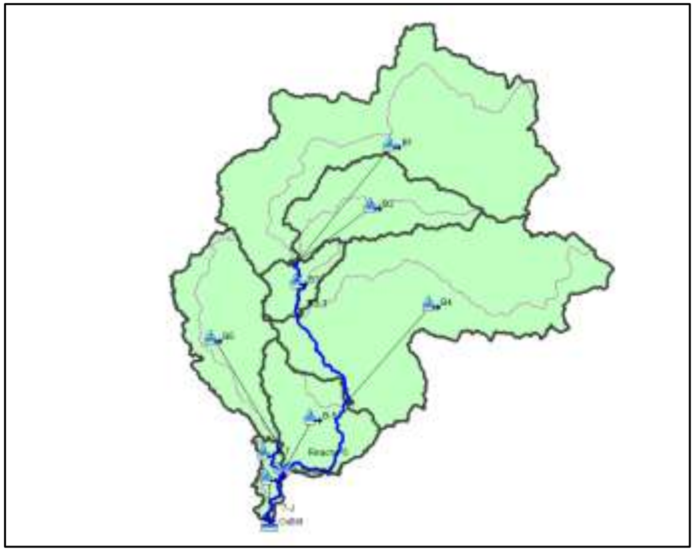
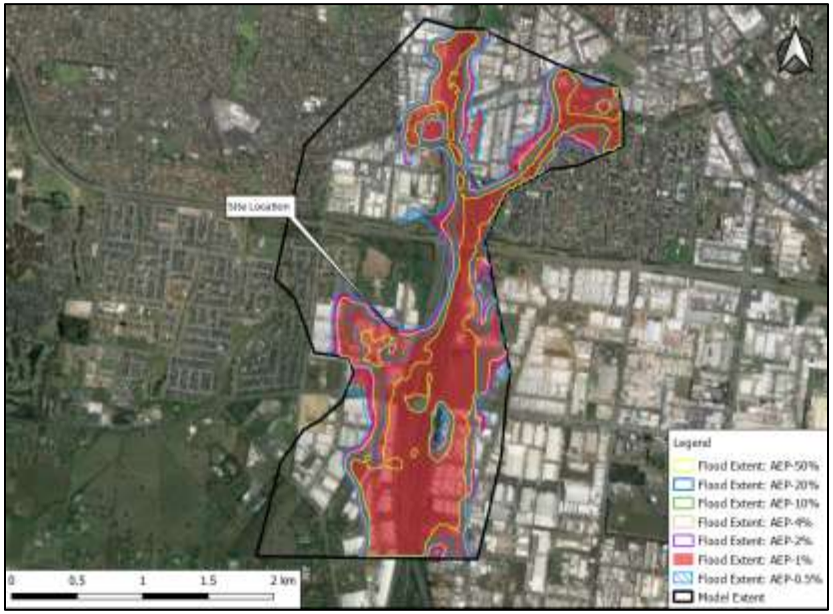
Climate & Flood Risk Assessment: Solar Power Project, Spain

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)	Lfslope	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





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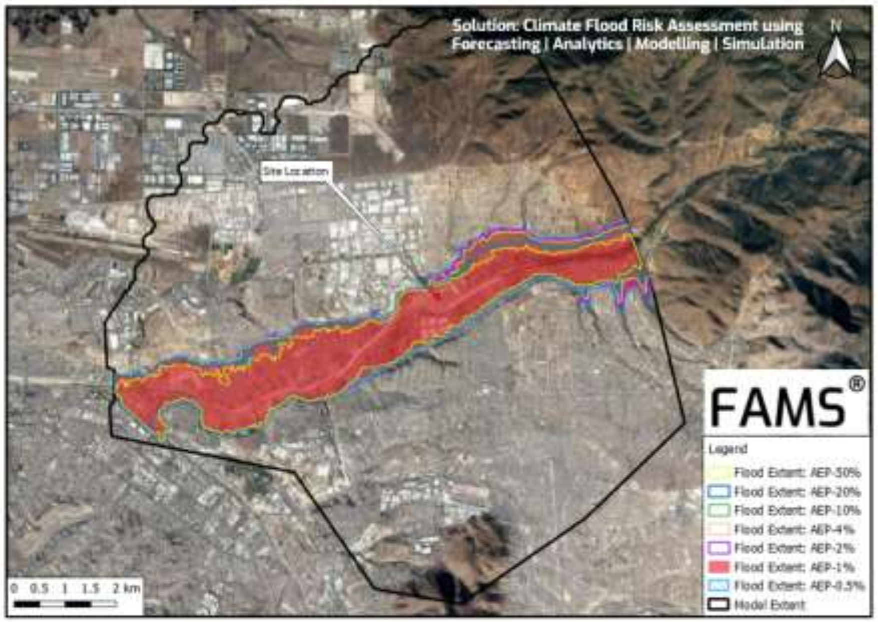
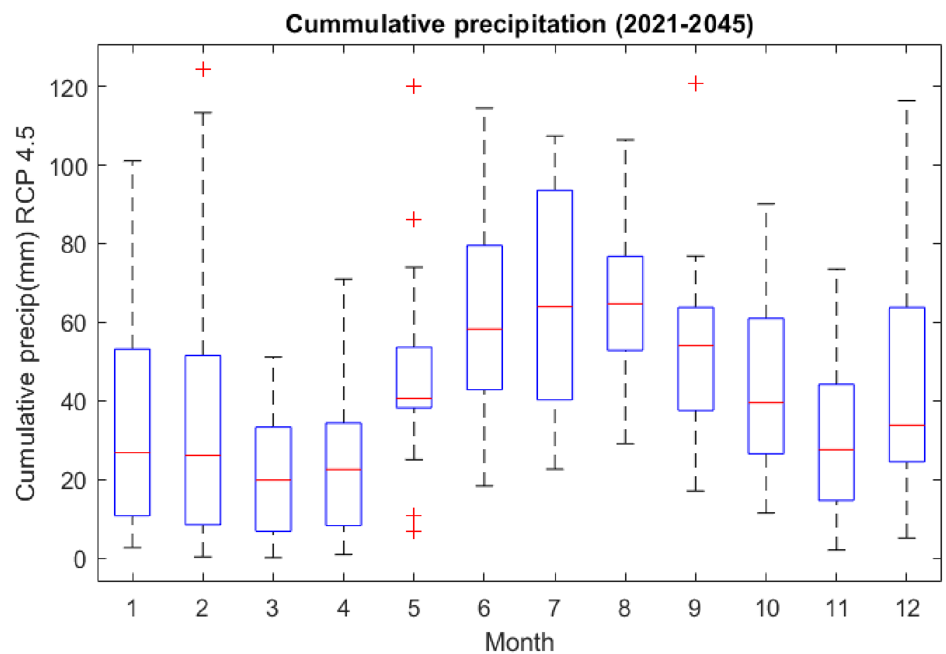
Climate & Flood Risk Assessment: Solar Power Project, Mexico

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





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Methodology Framework

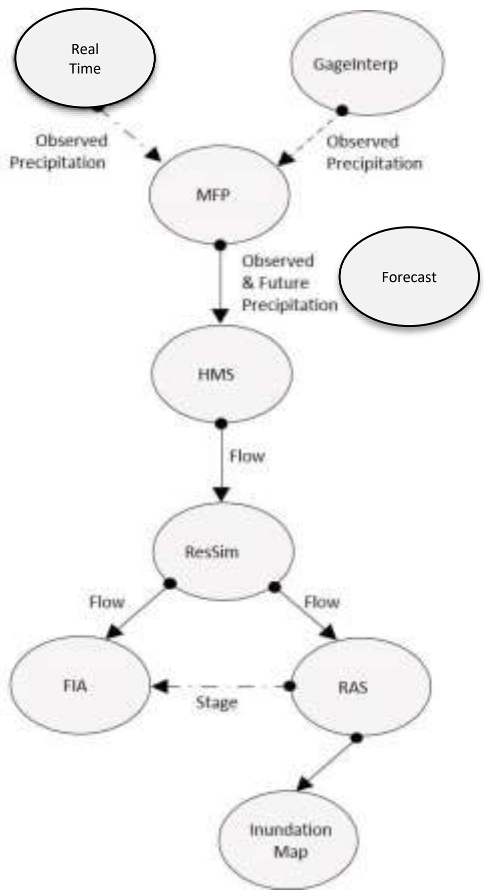
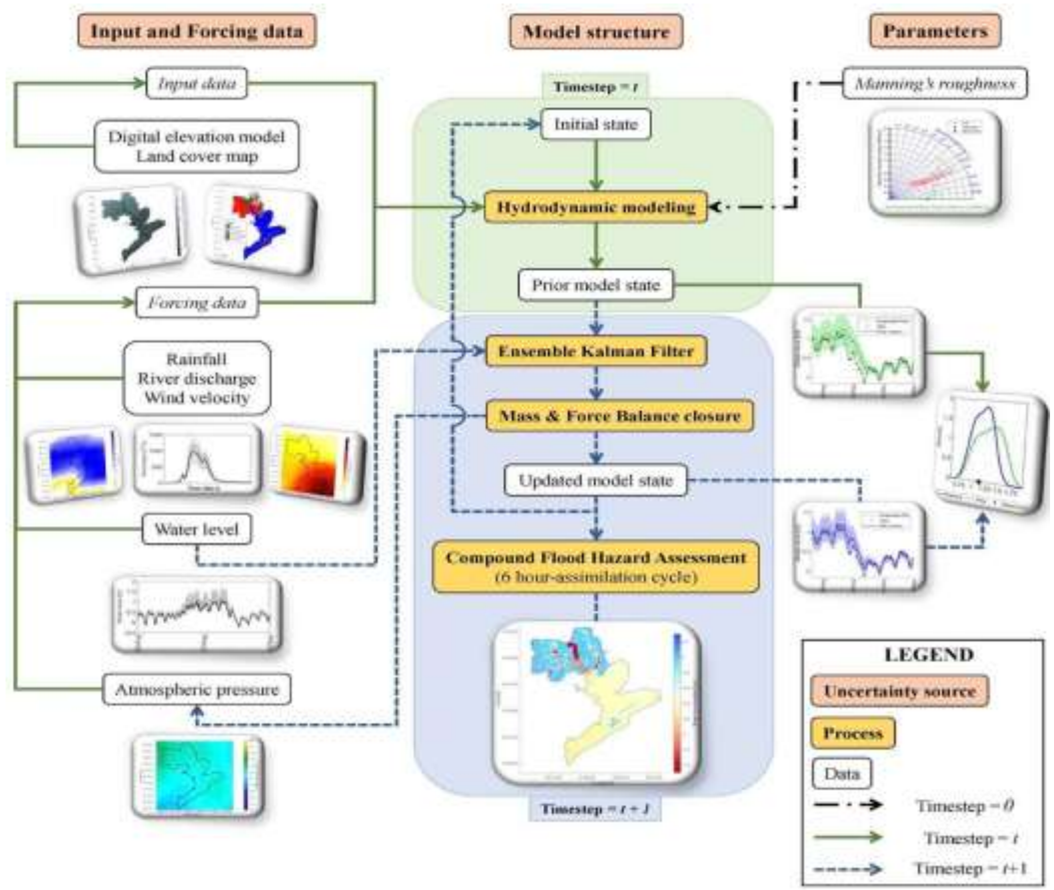


Image Source: US Army Corps of Engineers, https://www.hec.usace.army.mil/software/hec-rts/images/workflow.jpg



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Required Data, Tools and Mapping Results

- **Modelling Tools**
- ➢ HEC-HMS: Inflow Prediction Model
- ➢ HEC-ResSim: Reservoir Operation Model
- ➢ **HEC-RAS 1D and 2D: Flood Inundation Model**
- ➢ HEC-RTS: Real Time Simulation

- **Data we used:**
- ➢ River Geometry Data (cross-sections, Hydraulic Structures, Bridges, etc.)
- ➢ Catchment area shape file
- ➢ River channel & its tributaries shape file
- ➢ Discharge Gauging Stations shape file within sub-catchment
- ➢ Water Level Gauging Stations shape file within sub-catchment
- ➢ Rainfall and weather stations shape file within sub-catchment
- ➢ Rainfall and weather data for a period of 30 years
- ➢ Water Levels for a period of 30 years
- ➢ Discharge for a period of 30 years
- ➢ Dam reservoir sites within the sub-catchment
- ➢ Land use data of sub-catchment if available

2D Flood Inundation Modelling using HEC-RAS 2D

Emergency Action Plan; Flood Forecast, Dam Break Analysis

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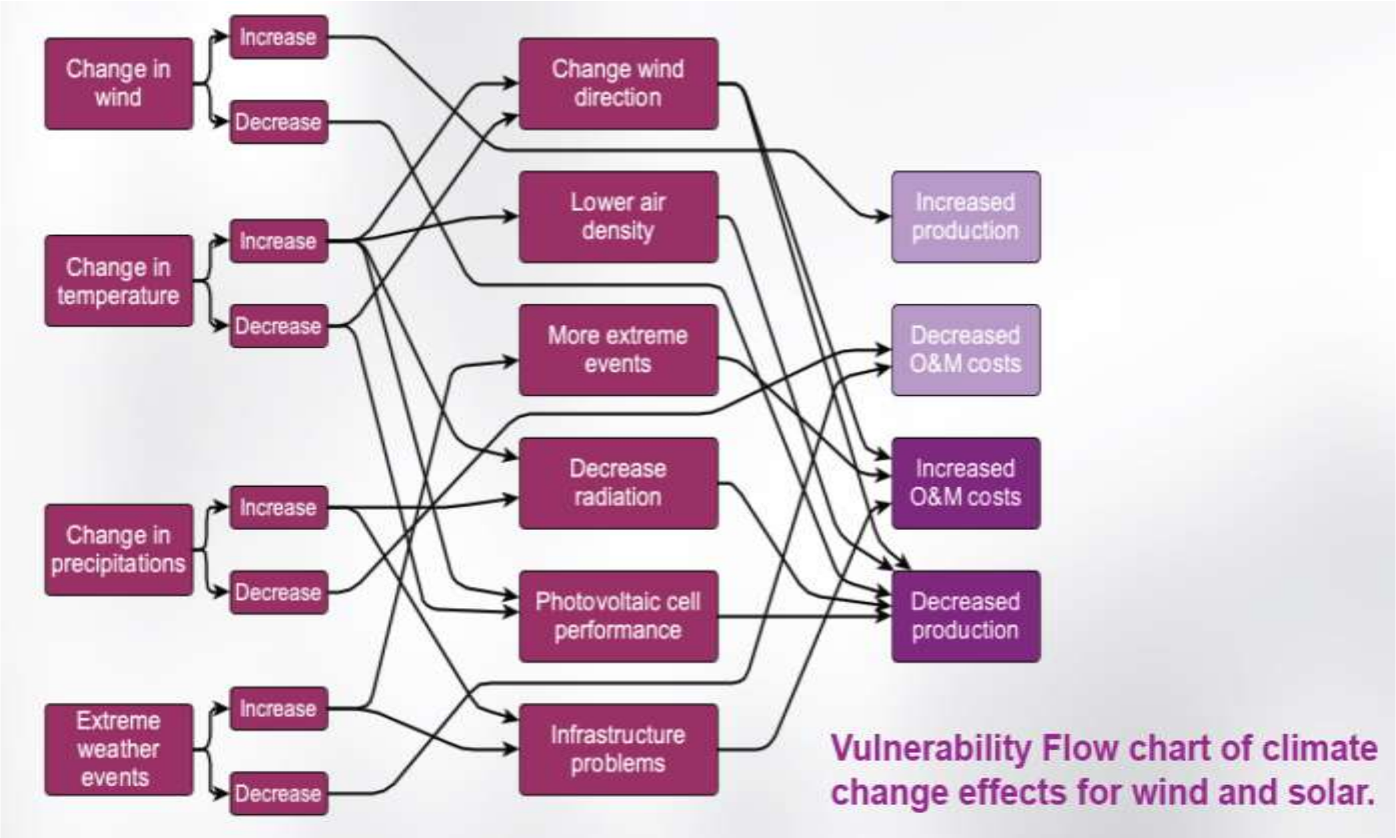
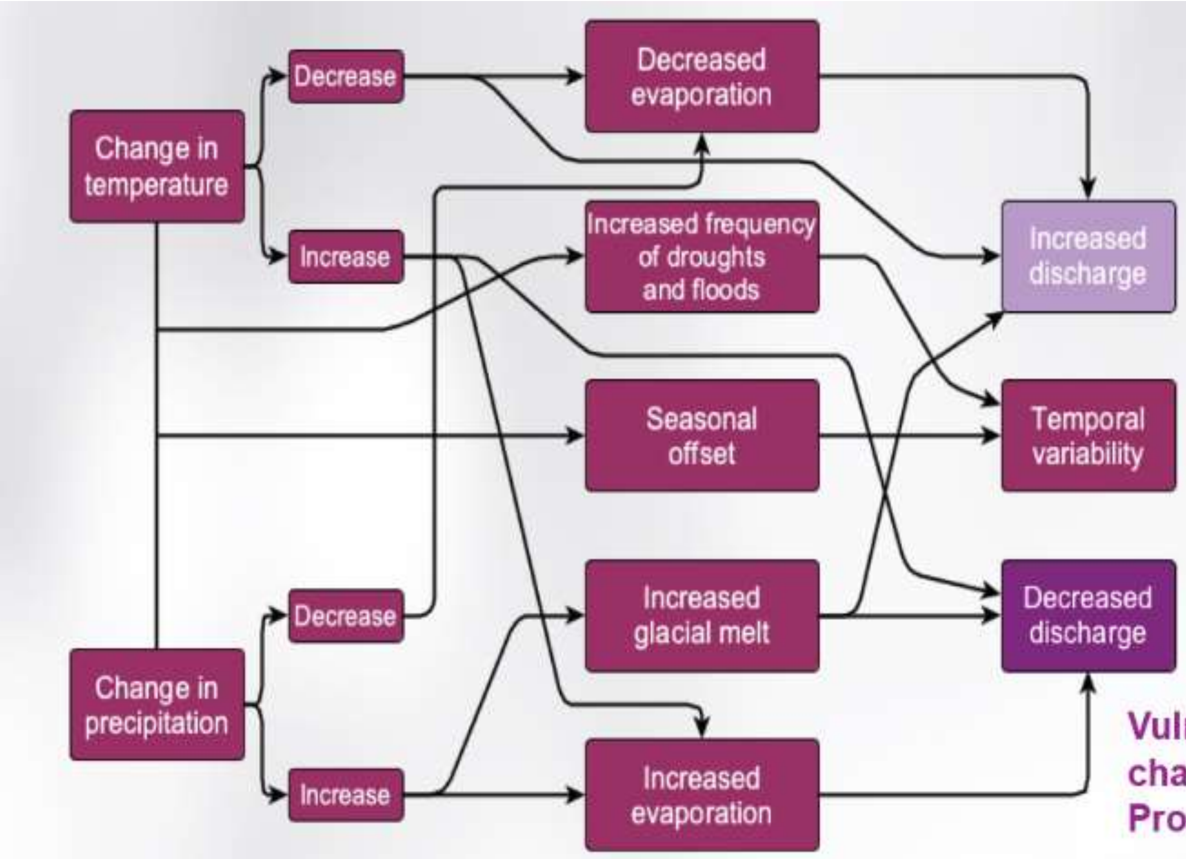
Case Study 1: Vulnerability assessment for quantification of climate change impact on renewable energy



Case Study 1: Vulnerability assessment for quantification of climate change impact on renewable energy



Vulnerability Flow chart of climate change effects for Hydropower Production.

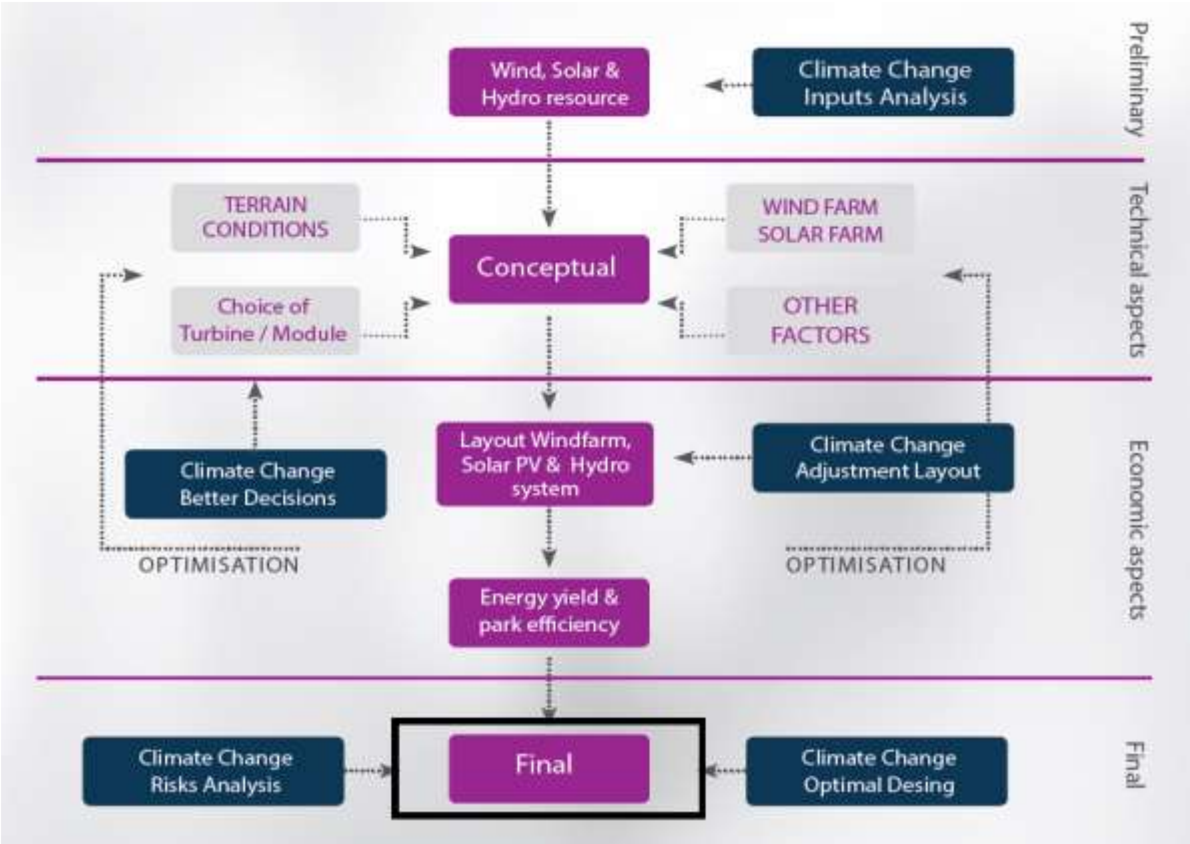
Case Study 2: Forecasting, Analytics, Modelling and Simulation

Betters Data,
Models & Tools

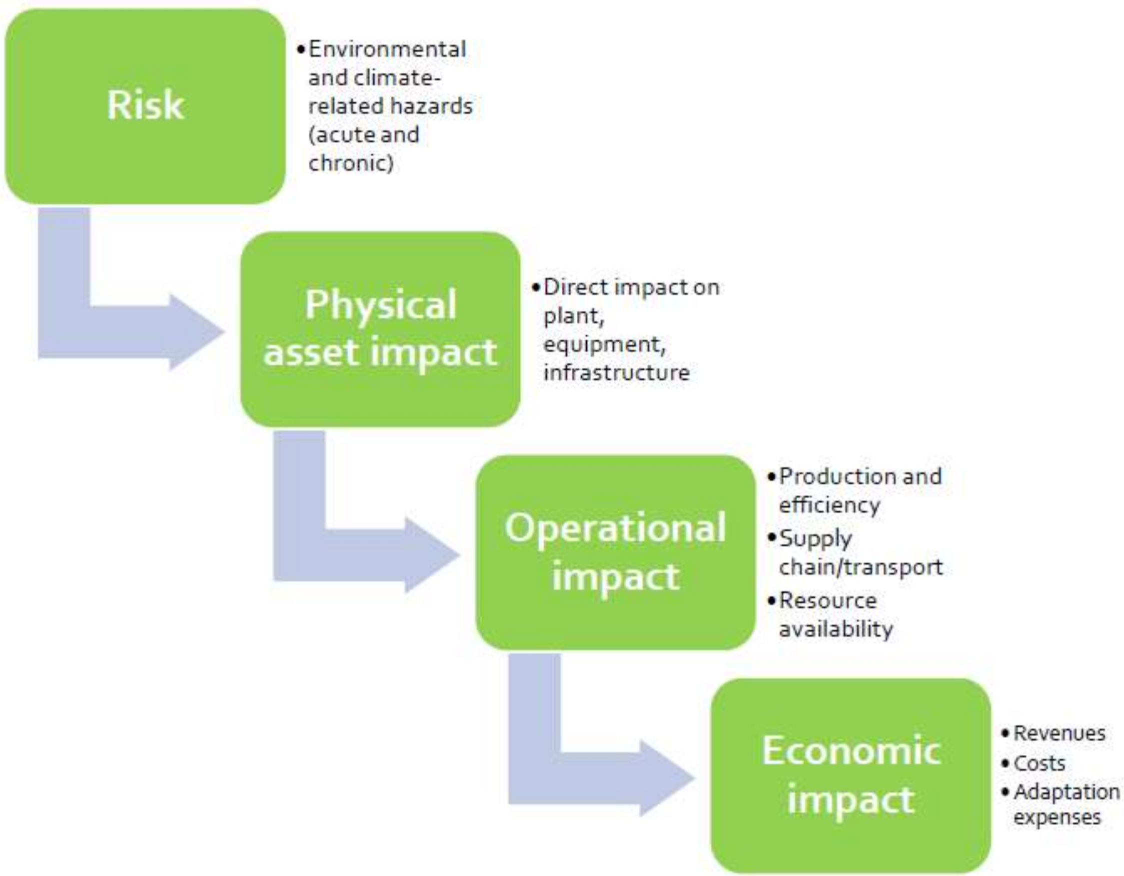
AMONG THE SOURCES OF INFORMATION TO USE FOR THE DEVELOPMENT OF OUR WORK ARE AMONG OTHERS:

- Wind Reanalysis Data:
  - CFSR 30 years, ERA5 18 years,
  - MERRA2 20 years, ERA-Interim, ECMWF (European Center), others.
- High-resolution weather and marine model:
  - WRF 4.3, ROMS, SWAN
  - CFD-OpenFoam models
- Wind, Solar, and Hydro analysis tools:
  - Furow, OpenWind, WAsP, archelios CALC
  - OpenFlows, Flow-3D, ETAP
- IPCC AR5/AR6 Climate Change Scenarios:
  - ECHAM6 (Max Planck Institute, IPM, Germany).
  - CESM (National Center for Atmospheric Research, NCAR, Colorado).
- Digital Terrain Model: Global Digital Elevation Model (GDEM V2) of the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) of NASA and Japan's METI.
- Bathymetry: Multibeam Bathymetry Database of NOAA.
- Hydrological parameterization:
  - Soils: Harmonized World Soil Database (FAO, IIASA, ISRIC, ISSCAS, JRC).
  - Land Uses: GlobCover 2009 land cover map, National Land Cover Database 2006.
  - Temperature and Precipitation: ERA5 Reanalysis.
  - Precipitation Frequency Data Server (PFDS) del Hydrometeorological Design Studies Center de la NOAA's National Weather Service.

Assessment of operating assets to determine the performance of the project



Case Study 3: Climate and Flood Risk assessment for water security and energy projects



Case Study 3: Climate and Flood Risk assessment for water security and energy projects

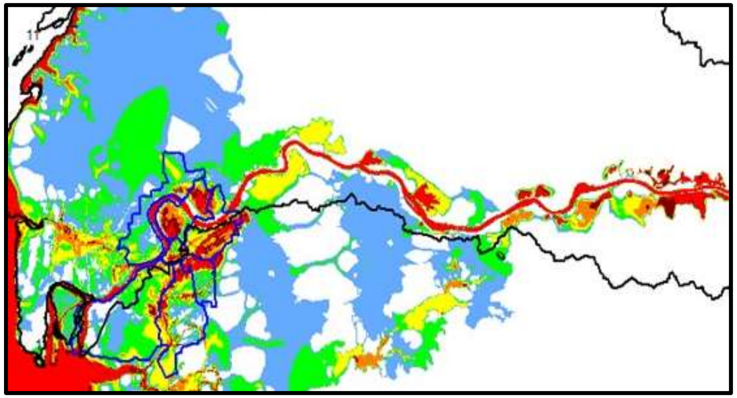
Hazard	Physical asset impact	Operational impact	Economic impact
Water scarcity			
Reduced river flow (chronic)	Reduced cooling water intake over long term	Production, efficiency; resource availability	Adaptation expenses – improved water extraction, changing pump location
Drought (acute)	Temporary loss of cooling water; more frequent reliance on emergency water supply	Production, efficiency; resource availability	Revenues – reduced power output
Heat stress			
Increased river temperature (chronic, acute)	Higher temperature of cooling water may reduce long-term condenser efficiency	Production, efficiency - slower condensation	Revenues – long term output reduction
	Used cooling water discharge stalled under obligation to protect river temperatures	Production, efficiency; shutdown	Adaptation expenses – increase used water storage capacity
Increased air temperature (chronic)	Higher temperatures may reduce long-term condenser efficiency	Production, efficiency - slower condensation	Revenues – output reductions
Heat wave (acute)	Used cooling water discharge stalled under obligation to protect river temperatures	Production, efficiency; shutdown	Adaptation expenses – increase used water storage capacity
	Higher temperature of cooling water may reduce condenser efficiency	Production, efficiency - slower condensation	Revenues – output reductions

Output Parameters from Flood Inundation Model

- Depth of inundation
- Water surface elevation
- Velocity of water flow
- Inundation boundary
- Shear stress
- Depth x Velocity
- Depth x Velocity^2
- Flood arrival time
- Time of flood recession
- Duration of flooding
- Percent time inundated
- Stream power
- Multi week Forecast of all parameters

GIS based Flood Hazard Mapping

- Map Projection
- Map Elements
- Map Design
- Flood Hazard Classes
- Hazard to People
- Hazard to Vehicle
- Hazard to Buildings
- Combined General Flood Hazard Classification
- Use of Flood Inundation Maps
- Inundation Mapping



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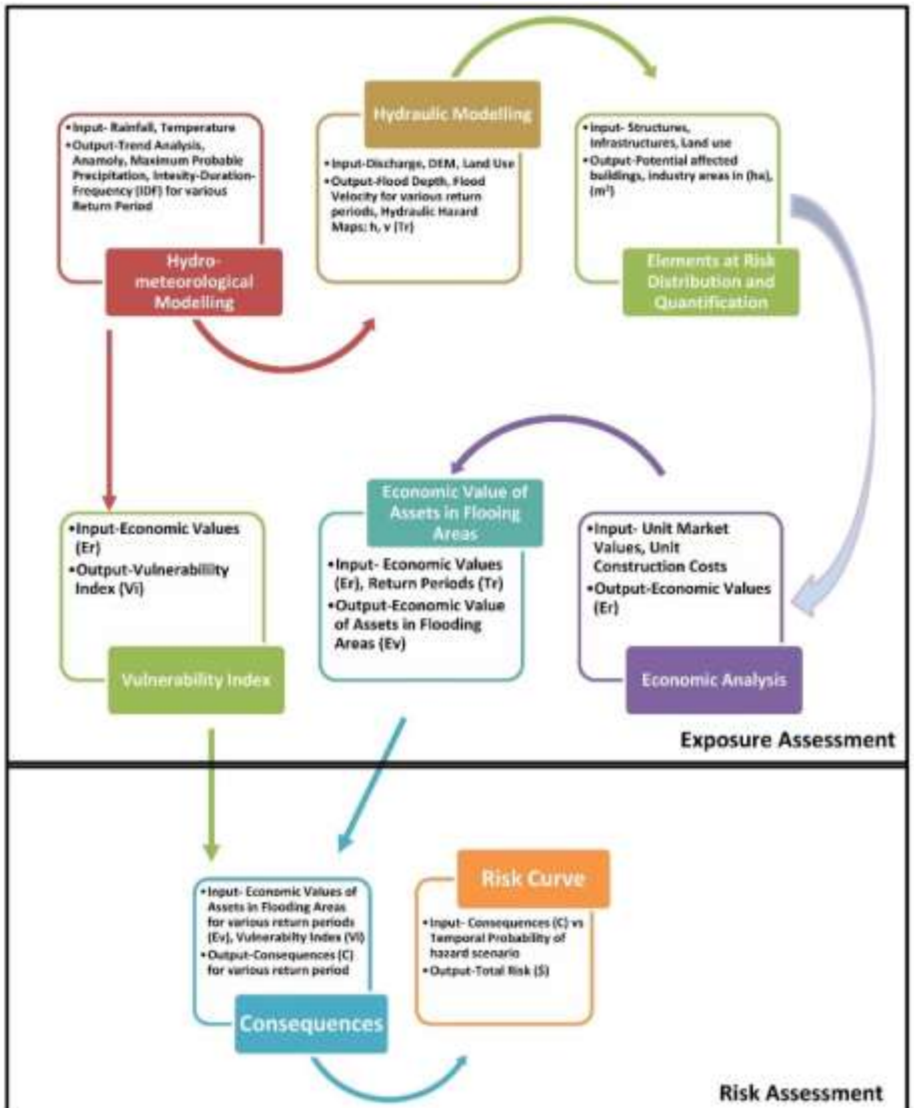
Climate Risk Assessment: Energy Projects



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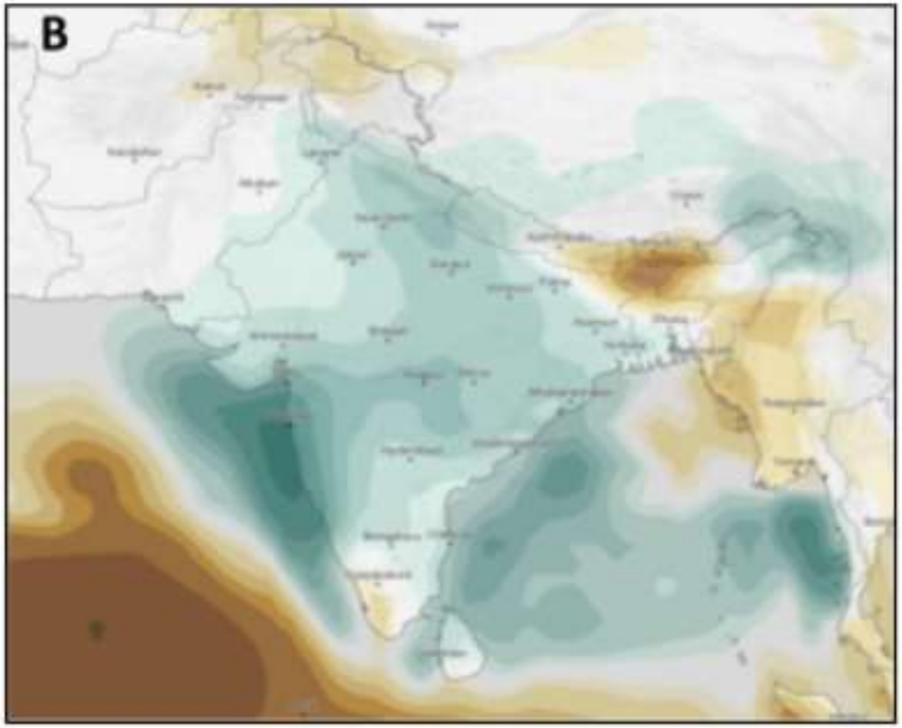
Case Study Ongoing: Precipitation Forecast Anomaly



Forecast for the anomaly of precipitation (B) for June issued in May based on ensemble for 6 different climate models (ECMWF, NCEP. Meteo France, UKMet, DWD, CMCC, JMA).

- Based on the different model's performance and the hindcast analysis from the previous years, we will choose the best model or combination of models for the different parts in India.
- We can **produce 3 to 6 months precipitation anomaly forecast** for India on a state level.
- The forecast will include the following:
- Three months expected precipitation in respect to the average (the last 30 years average), For example, the expected anomaly for June-July August in respect to its averages.
- Probability of exceeding to the median precipitation (normal, average conditions), the lowest 20% (dry conditions) and the highest 20% (wet conditions), the probability for being in the lower and the upper tercile categories (lower tercile means beaning at the 33% percentile and lower and upper tercile means been on at the 66% percentile and upper).
- The probabilities are estimated by comparing the forecast probability density function with the corresponding model climate probability density function, estimated from the hindcast set.

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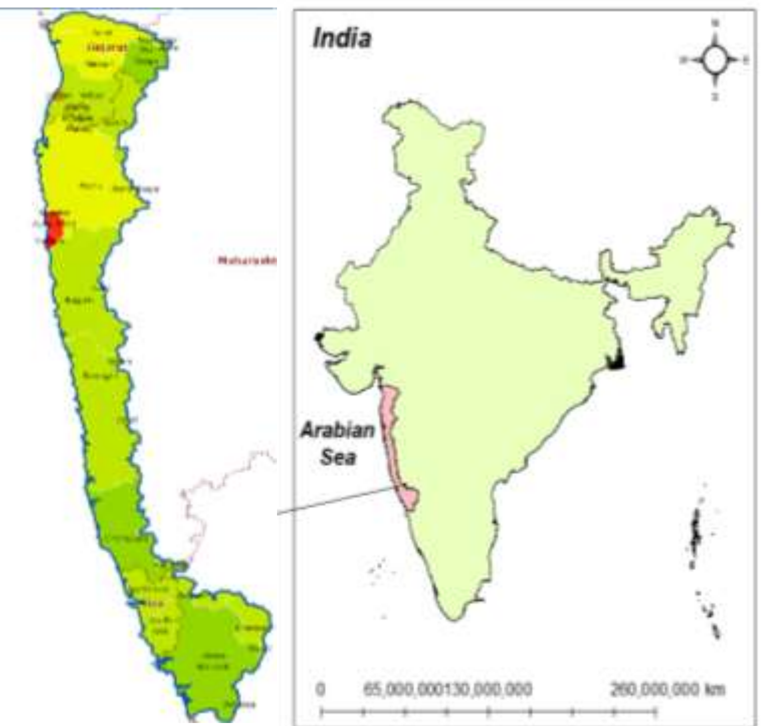
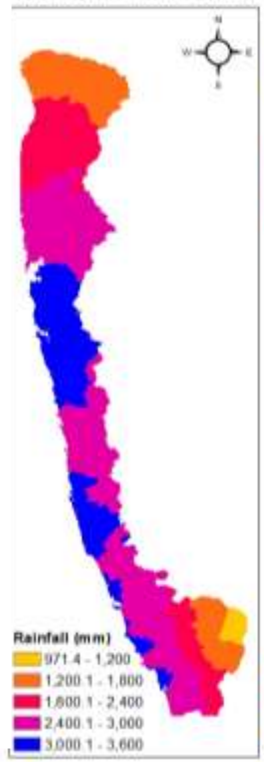
Variability of Rainfall, Temperature and Potential Evapotranspiration at Annual Time Scale over Tapi to Tadri River Basin, India

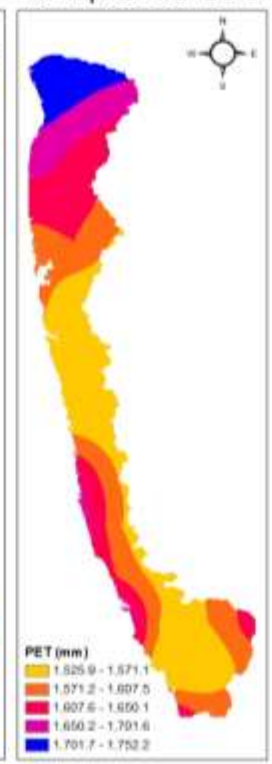
Tapi to Tadri River Basin, India



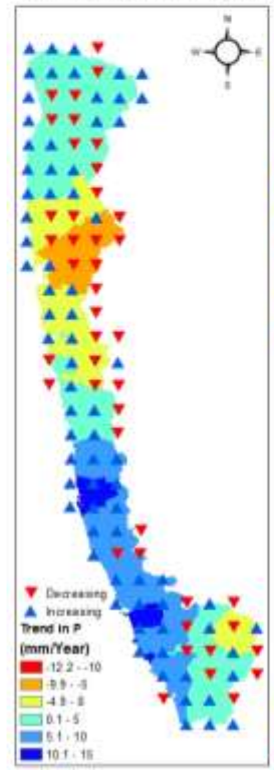
Average Annual Rainfall (1901-2016) for Tapi to Tadri Basin



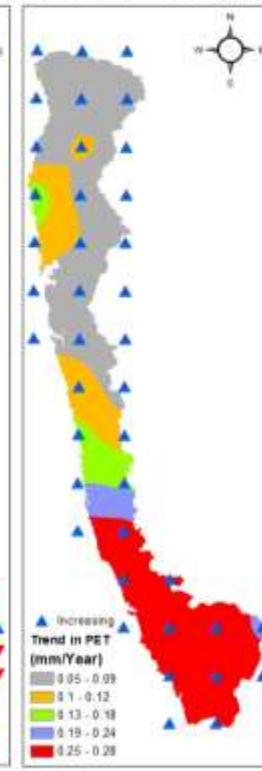
Average Annual PET (1901-2016) for Tapi to Tadri Basin



Trends in Average Annual Rainfall for Tapi to Tadri Basin



Trends in Average Annual PET for Tapi to Tadri Basin



1) Mahyavanshi et al. (2021). "Variability of Rainfall, Temperature and Potential Evapotranspiration at Annual Time Scale over Tapi to Tadri River Basin, India", Book Chapter, In: Jha R., Singh V. P., Singh V., Roy L. B., Thendiyath R. (Eds.) Climate Change Impacts on Water Resources (pp. 349-364). Springer, Cham.

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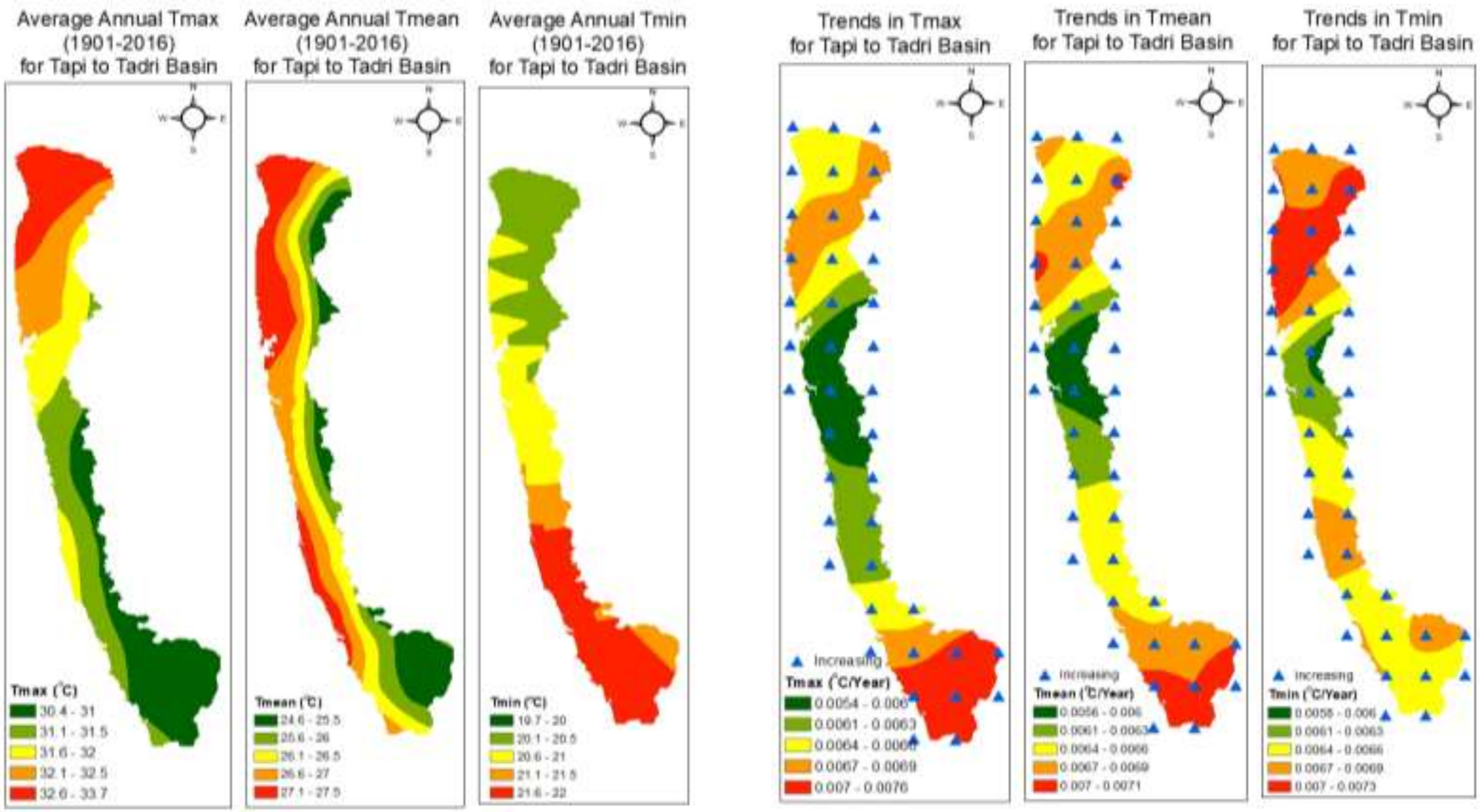
Variability of Rainfall, Temperature and Potential Evapotranspiration at Annual Time Scale over Tapi to Tadri River Basin, India



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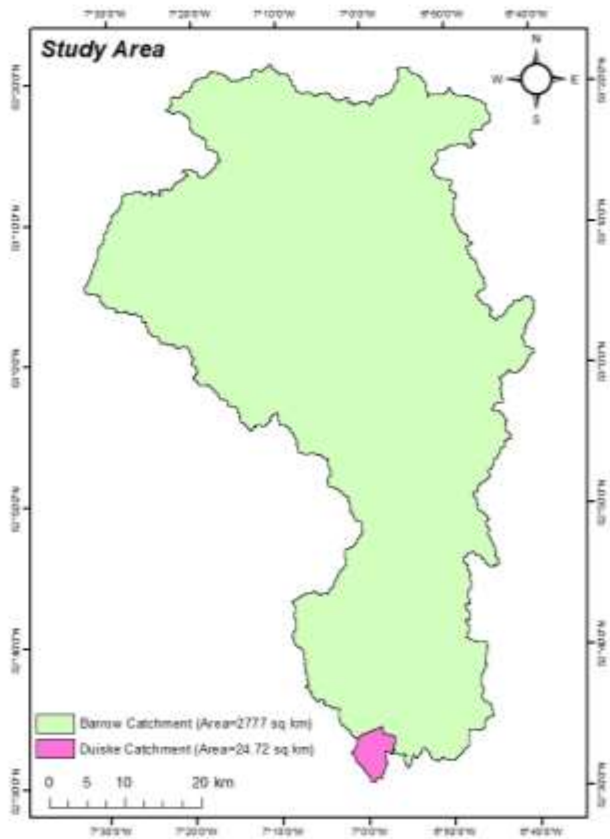
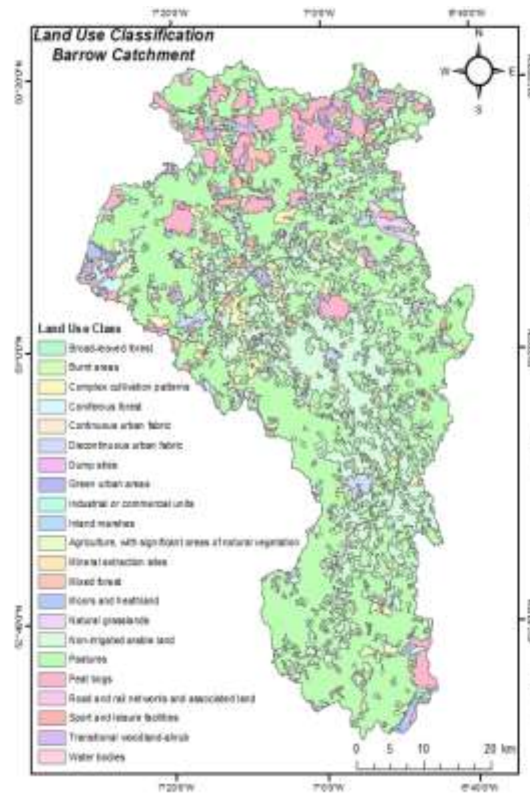
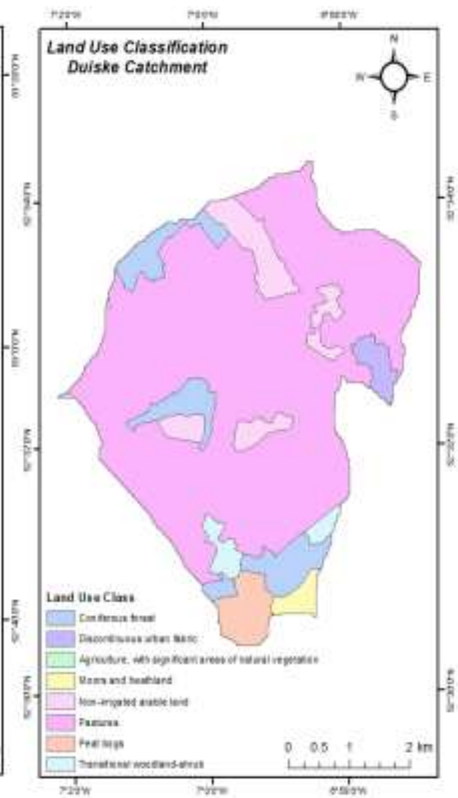
Case Study: GIS based Flood Plain Storages of Two Catchments of Ireland







Client: EPA, Ireland

Sensitivity of Land use change, soil and sedimentation for identification of flood plain storages using QGIS, HEC-RAS 2D and STREAM Models

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Case Study: GIS based Flood Plain Storages of Two Catchments of Ireland

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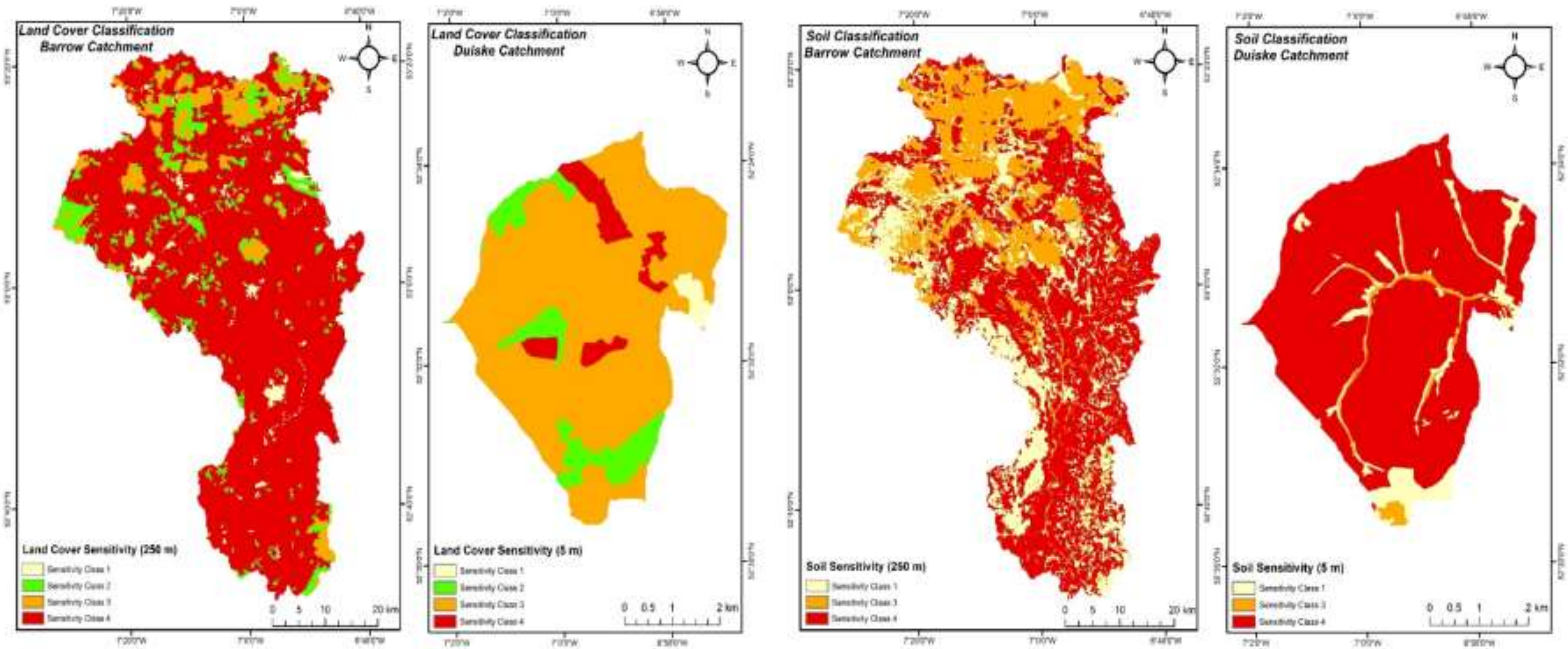
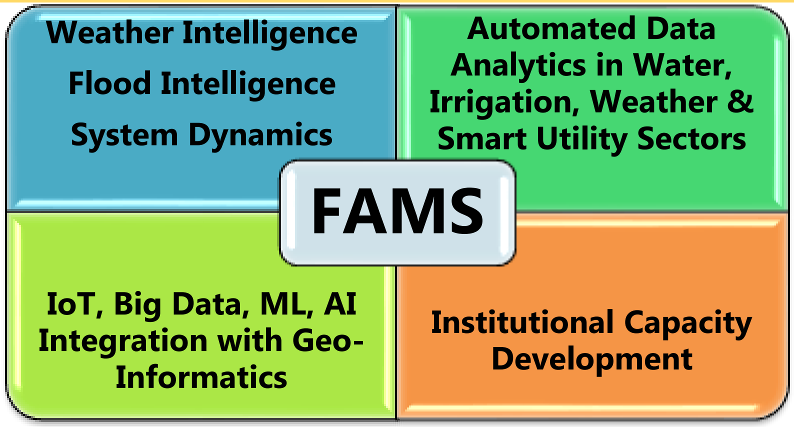
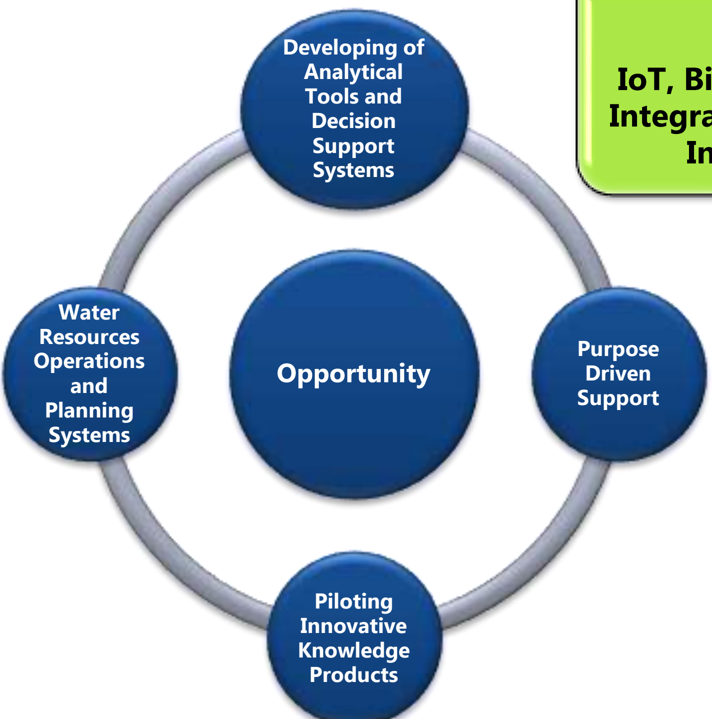
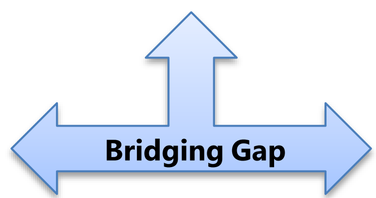


Client: EPA, Ireland

Bridging the Gap







- Central Government Departments
- State Government Departments
- Institutions & Private Companies
- Non-profit organisations

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Our vision for prospect collaboration with Institutions

Areas for Collaboration

- Dam Safety and Risk Assessment Studies
- Water Resources Intelligence
- Weather Intelligence
- Flood Intelligence
- Dam Safety Solutions: Hazard | Risk | Operation, Monitoring & Control
- Flood and Climate Risk Assessment
- Integration of Climatology Predictions
- Hydrological System Dynamics
- Irrigation Intelligence
- IoT, Big Data, ML, AI Integration with Geo-Informatics
- Institutional Capacity development

Collaborative Work Leads To

- **Developing of Analytical Tools and Decision Support Systems**
- **Integrating Advanced Technology in Water, Irrigation, Weather, Smart City projects**
- **Professional Development with Capacity Development of various stakeholders**
- **Project Management & Operational Support to Clients**
- **Research & Consultancy Projects**
- **Employment Generation & Developing Young Intellectual Community**

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Those who sees the invisible ➡ can do the impossible!!

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Thank you!!

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