Asia Water Forum 2022
8–11 August 2022 • Online

Focus Area: Water as a sustainable resource

Session Title: Innovative technologies for optimization and resilience

Presentation Title: River Basin Performance Optimization

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Schedule: [10 August 2022 (Wed) | 3:00 p.m. - 4:30 p.m. (GMT+08)]

ADB

INTRODUCTION: RIVER BASIN MANAGEMENT

Management of river systems and understand its dynamic nature to scale up optimal water governance.

Transboundary Water

Water Allocation Planning

Decision and conflicts

Transparent Governance

OBJECTIVES

MITIGATING CLIMATE CHANGE CRISIS

MINIMIZE FLOOD DAMAGES

MANAGING ENVIRONMENTAL FLOW DEFICITS

MINIMIZE IRRIGATION DEFICITS

MINIMIZE EVAPORATION LOSSES

CURBING UNNECESSARY RELEASES

Additionally, there are several constraints that must be satisfied, such as, relative deficit sharing across given irrigation blocks, reservoir storage constraints, evaporation constraints, canal outflow constraints, maximum canal and channel capacities and so on.

KEY TECHNOLOGIES

GEOSPATIAL DSS

Real-time visibility of river basin basin performance, location analytics, land use changes, yields, inflows and discharges

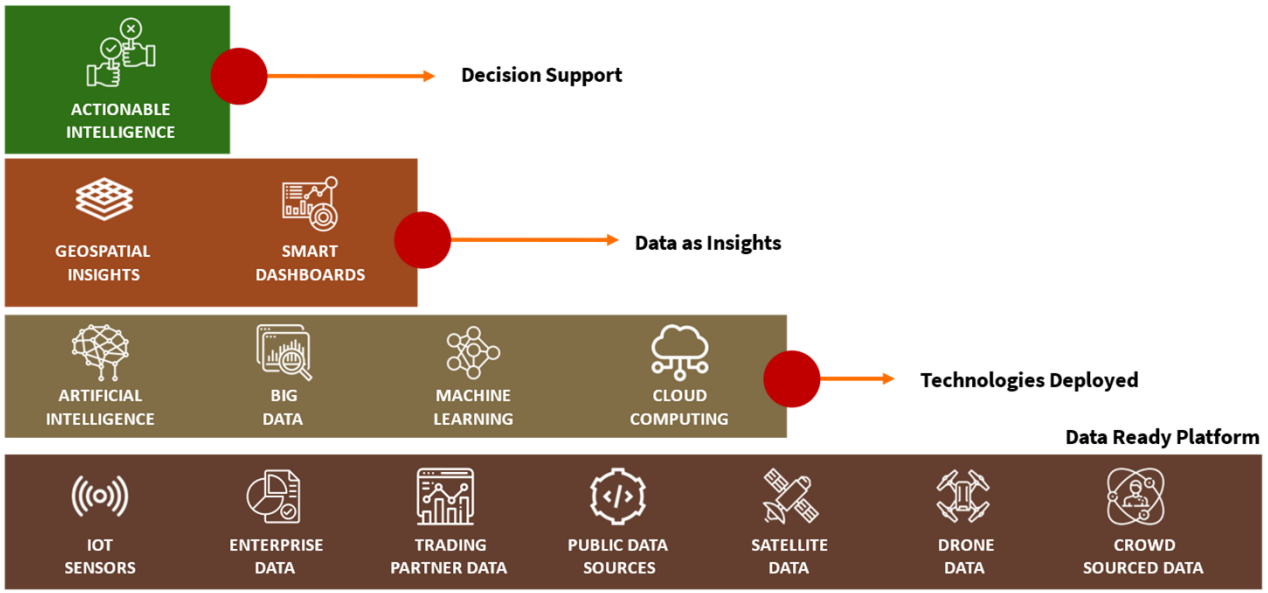
AI & ML MODELLING

Automating Hydrology(HEC-HMS), Hydraulic(HEC-RAS), model with dynamic data to provide real-time intelligence and prediction of inflows

INTERNET OF THINGS

Weather station automated AWS, level and flow sensors leverage operational insights along with rainfall data etc.

KEY TECHNOLOGIES: aquaWISE™ Platform



- Enable high performing business processes through actionable intelligence
- User centric smart dashboards that provide multi level business insights
- Deep expertise in the application of data science and big data modelling
- Able to ingest data from different sensors, machine and business systems

GEOSPATIAL DSS

AI & ML MODELLING

BIG DATA SOLUTIONS

IOT SYSTEMS

MOBILITY SOLUTIONS

Solution Highlights

Empowering sustainable water resource management for cohesive transboundary basin governance and leverage equitable distribution with multiple stakeholders.

Allocation & Accounting

Annual state wise water utilization insights along with flow details and withdrawals

Reservoir Planning & Operations

Storage details, information on water inflow and discharge

Intelligent Analytics

Visibility on water distribution across reservoirs and demand blocks

Realtime Monitoring

Insights on current water levels, utilization, real-time storage information

Flood Risk & Safety

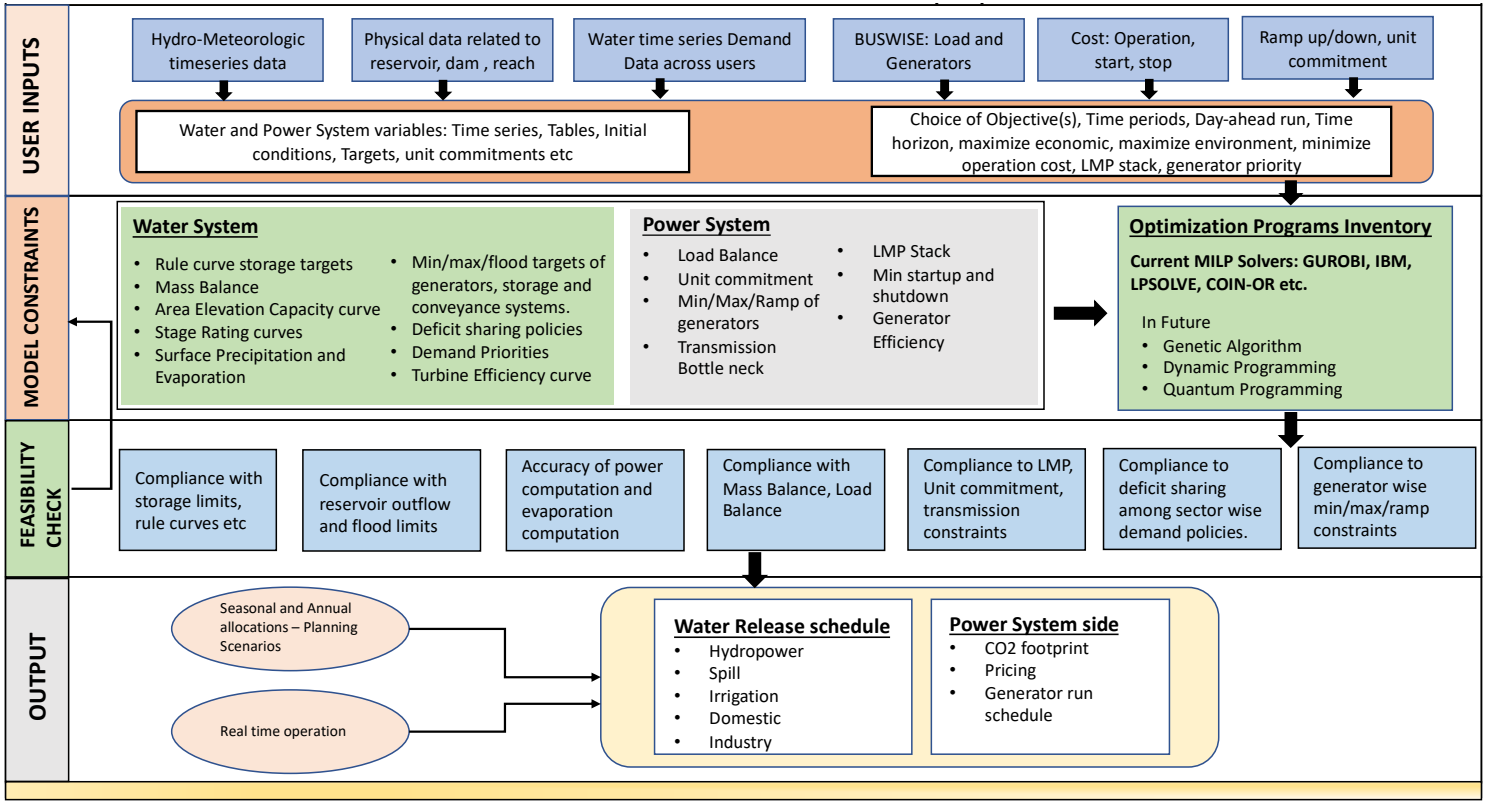
Early warnings on emergency situations, impact assessments and dam safety

Alerts and Advisories

Operational insights, alerts on basin performance leading to timely risk mitigation

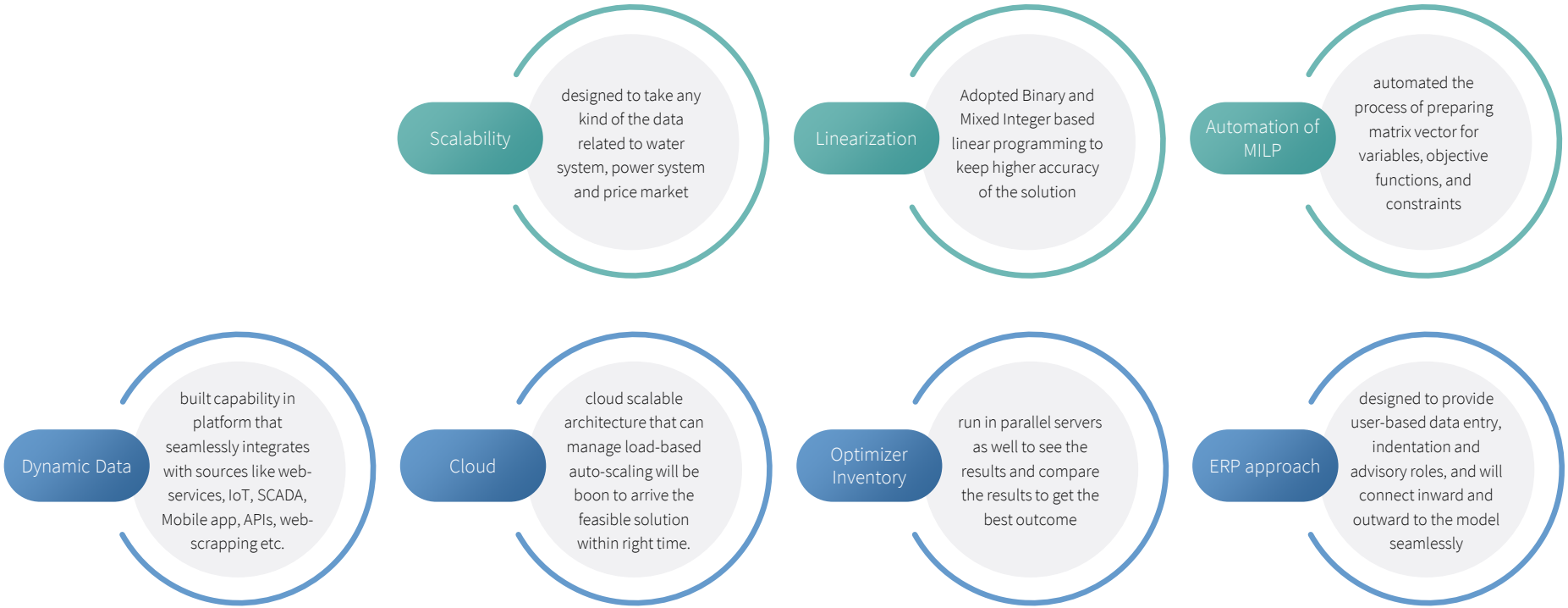
Technical Methodology

Current approach uses a mixed integer and binary linear programming-based optimization approach to replicate real water and power grid systems and provide optimized solutions for their operation based on their objectives



Solution Approach

Empowering sustainable water resource management for cohesive transboundary basin governance and leverage equitable distribution with multiple stakeholders.

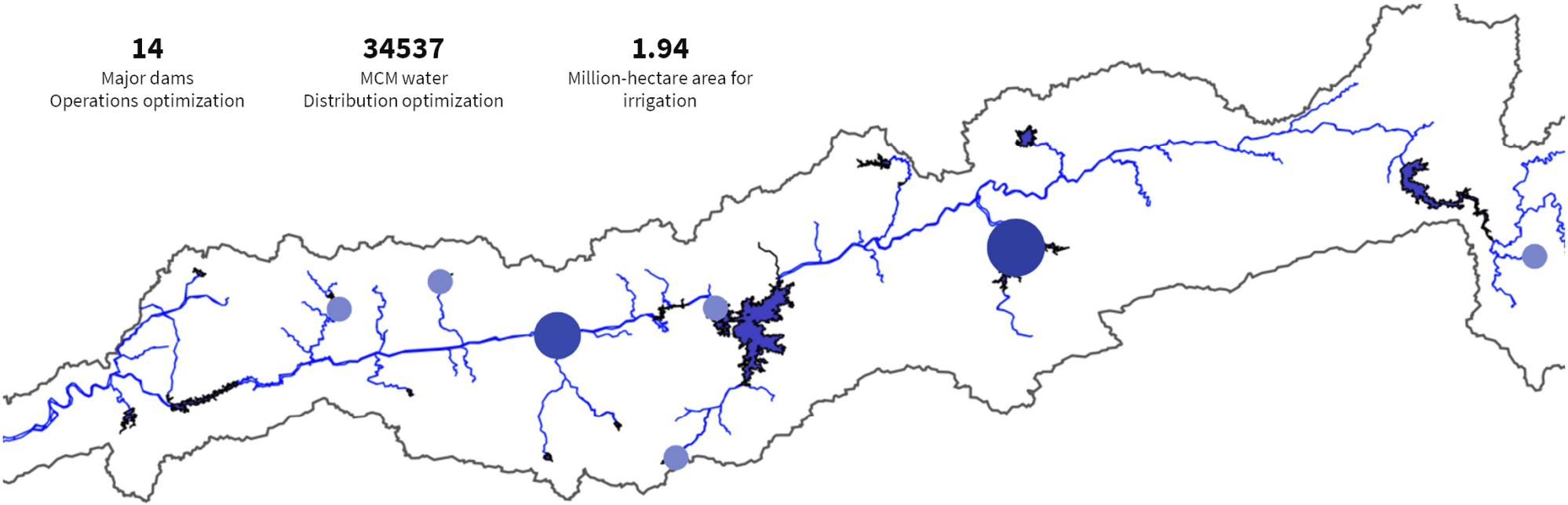


Case Study: Narmada River Basin Optimization

14
Major dams
Operations optimization

34537
MCM water
Distribution optimization

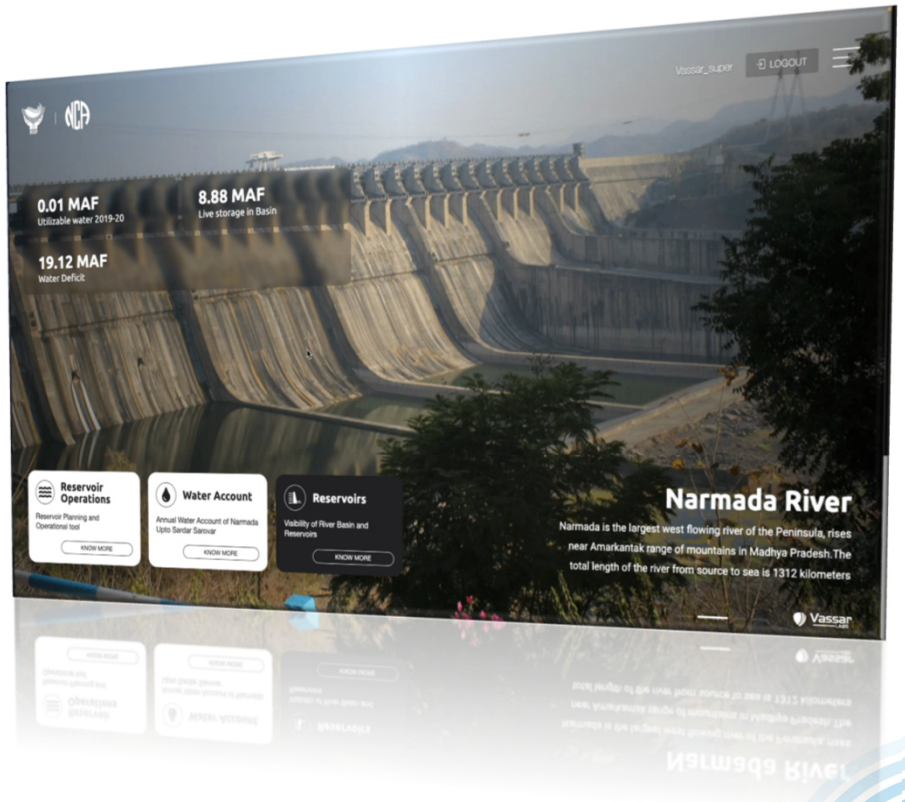
1.94
Million-hectare area for
irrigation



Case Study: Narmada River Basin Optimization

OBJECTIVE

- Avoid Flood Losses
- Equal Deficit Sharing
- Maintain Environmental Flows
- Reduce Demand Deficit



RESULT

- River basin planning for water allocation
- In season operation with release targets
- Automation of annual water accounting

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Optimization Model

The main challenge involves breaking of a non-linear and multi-objective problem statement into a linear and single objective model. The final linear model was implemented using LpSolve as the base solver for optimization, integrated with Java, which has been used as the main programming language.

- Linear Programming Techniques (Revised Simplex Method)
- Used LpSolve library, an open-source linear programming solver based on revised simplex method. And Java for other development purpose.
- Breaking of non-linear, multi-objective problem statement into a linearized, single objective problem.
- Simple user interface for defining river networks, time-steps, input data and control inputs.

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Optimization Model

OPERATIONAL CONSTRAINTS

Reservoir Storage

- Maximum Capacity of Reservoir
- Do not recede below dead storage
- Use Flood Storage only during '**inevitable**' floods
- Satisfy Elevation-Volume-Area curve relationships
- Meet minimum storage target at the end of the year

Canal Constraints

- Maximum Canal Capacity
- Do not supply more than the demand
- Maintain constant target flow in required canals
- Do not violate Elevation-Outflow curve for canal gates

Environmental & Mandatory Flows

- Should be of highest priority (after flood management)
- Maintain constant target flow in specified river reaches
- Avoid unnecessary releases from the reservoir to the reach

Irrigation Demand Constraints

- Do not supply more than the demand
- Equal Deficit Sharing Policy across time and space
- Second highest priority after environmental demand

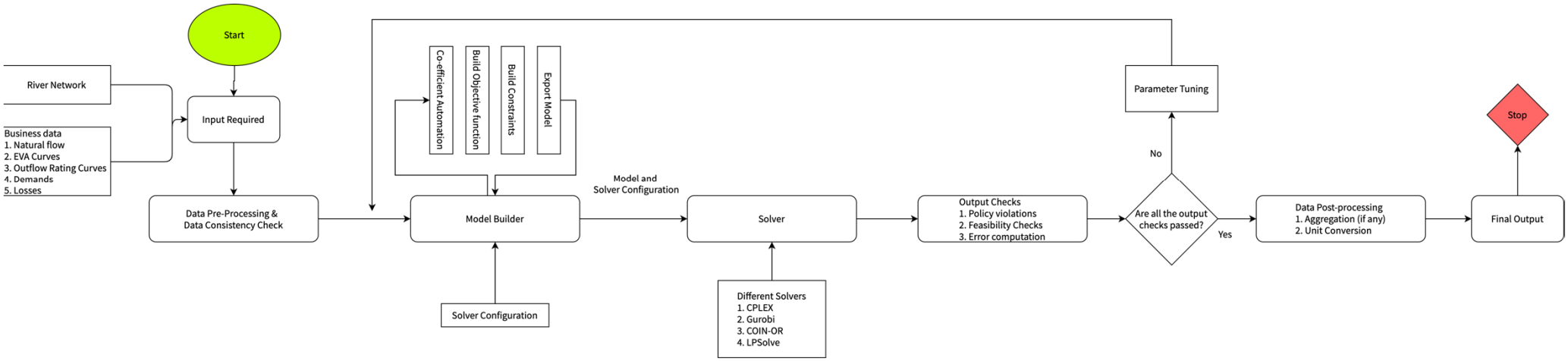
Flood Management Constraints

- Do not exceed River Reach Capacities
- Use 'Flood Storage' only during inevitable floods
- Pre-flood drawdowns in case of high inflow forecasts

Mass Balance Constraints

- Sum of all inflows and all outflows into a node are equal.
- For reservoir nodes, the balance equation must also include storage change and evaporation losses.

Model Illustration



User Friendly Model builder

Web Based Model, User can setup from any where in the world and collaborate with remote teams

Easy and intuitive interface which allows anyone to use effortlessly with no limit on models to run in background

Very easy to customize variables and objective functions for multiple objectives by changing priorities or operational constraints

Autonomous models running on cloud with ML, ingesting real-time weather and inflow data to provide optimal solutions in near real time

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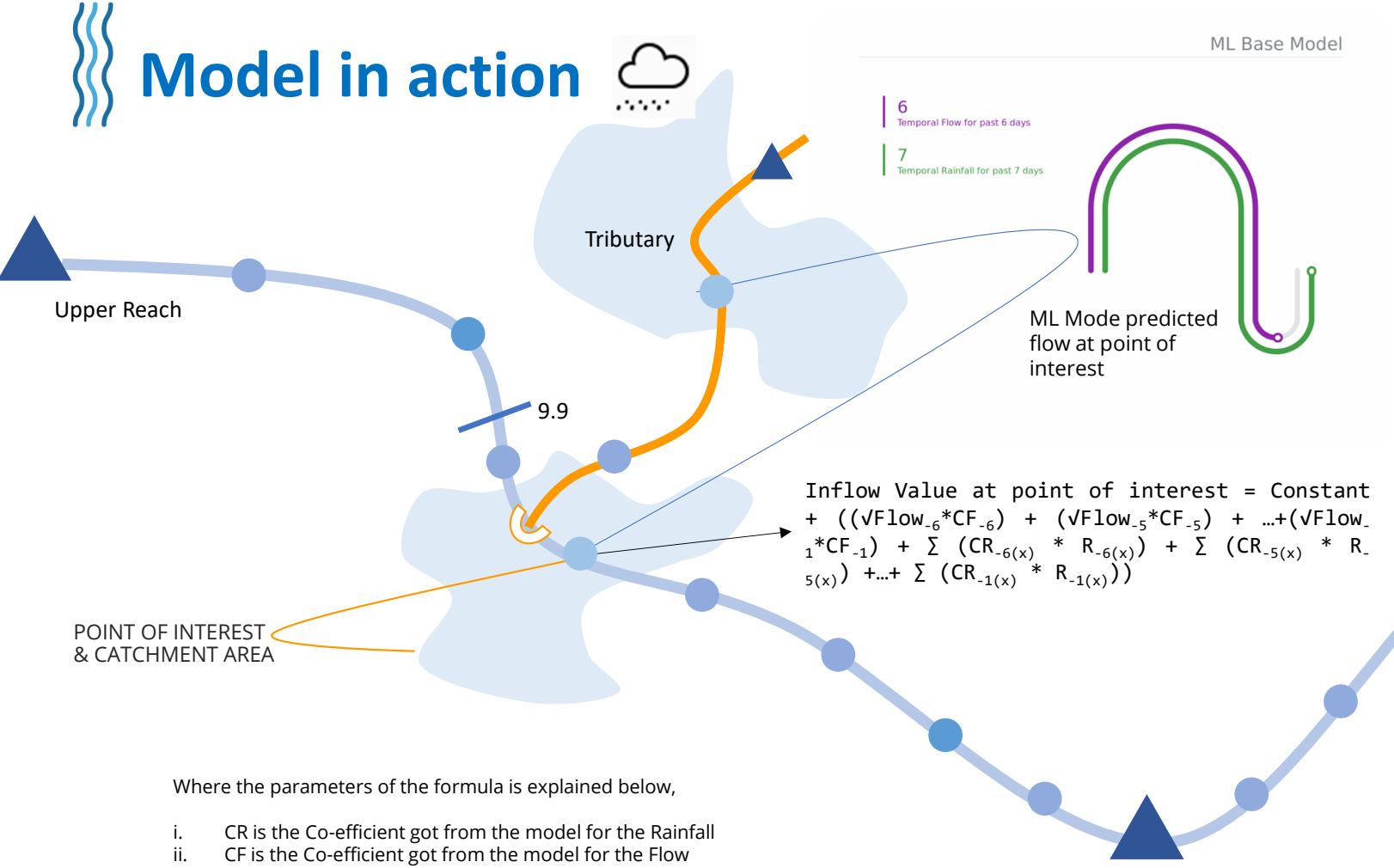
Model in action



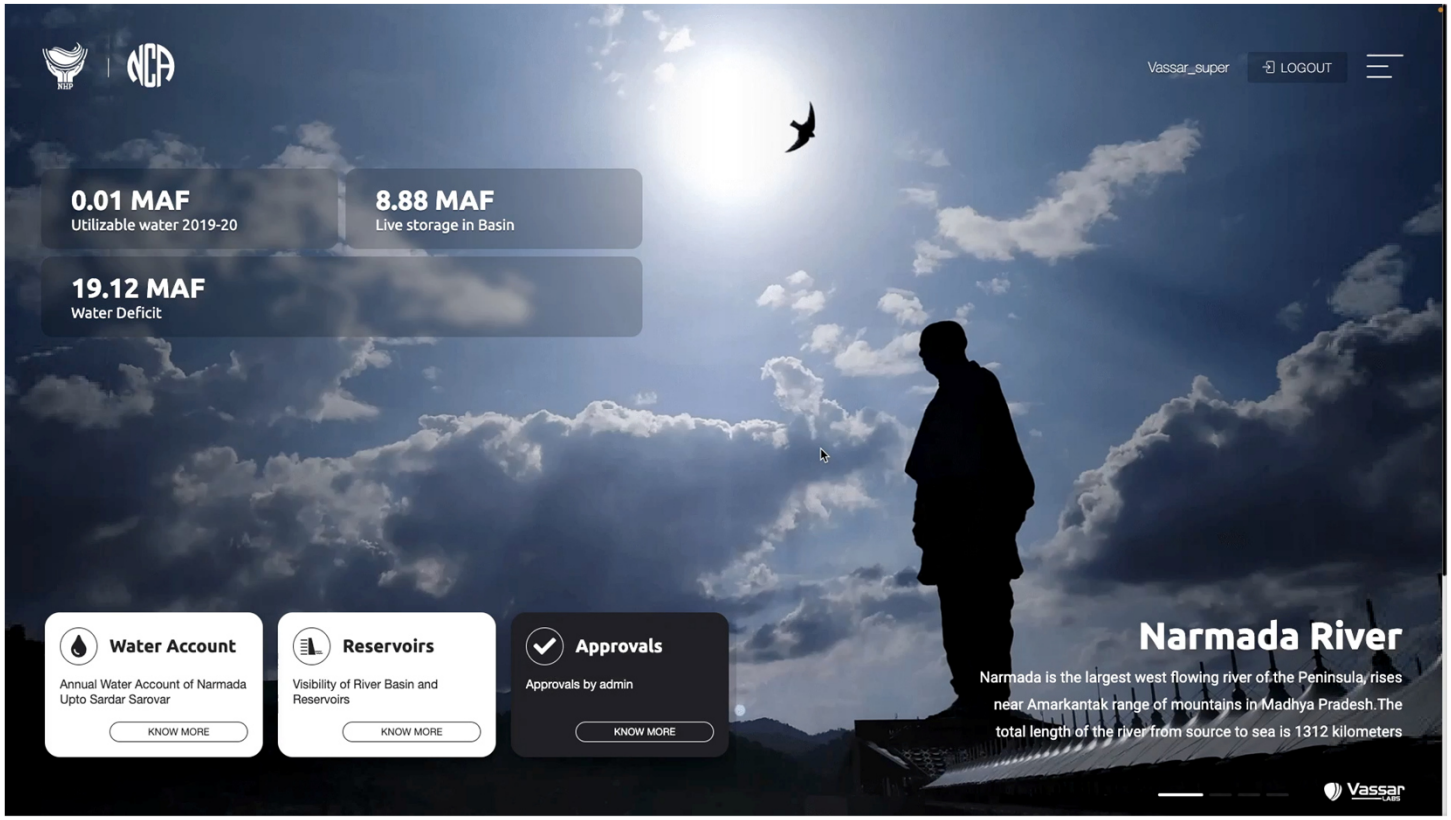
$$\text{Inflow Value at point of interest} = \text{Constant} + ((\sqrt{Flow}_{-6} * CF_{-6}) + (\sqrt{Flow}_{-5} * CF_{-5}) + \ldots + (\sqrt{Flow}_{-1} * CF_{-1}) + \sum (CR_{-6(x)} * R_{-6(x)}) + \sum (CR_{-5(x)} * R_{-5(x)}) + \ldots + \sum (CR_{-1(x)} * R_{-1(x)}))$$

- The Decision Support system uses Machine Learning (ML) Algorithms to predict the inflow
- the system leverages the last 30 years of historical data of Rainfall and Inflow into particular locations.

Where the parameters of the formula is explained below,

i. CR is the Co-efficient got from the model for the Rainfall
ii. CF is the Co-efficient got from the model for the Flow
iii. Flow is the flow at a particular point
iv. X represents the locations those are the strategic upstream points that affect a particular location. Hence these are are all cumulatively summed up for a particular location for each day
v. All the negative numbers are representation of days i.e, -1 represents 1-day before

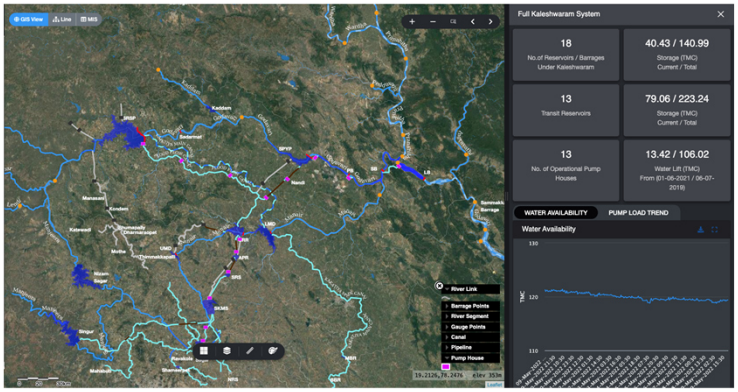
Model Demo


Vassar_super
LOGOUT
0.01 MAF
Utilizable water 2019-20
8.88 MAF
Live storage in Basin
19.12 MAF
Water Deficit
Water Account
Annual Water Account of Narmada Upto Sardar Sarovar
KNOW MORE
Reservoirs
Visibility of River Basin and Reservoirs
KNOW MORE
Approvals
Approvals by admin
KNOW MORE
Narmada River
Narmada is the largest west flowing river of the Peninsula, rises near Amarkantak range of mountains in Madhya Pradesh.The total length of the river from source to sea is 1312 kilometers
Vassar

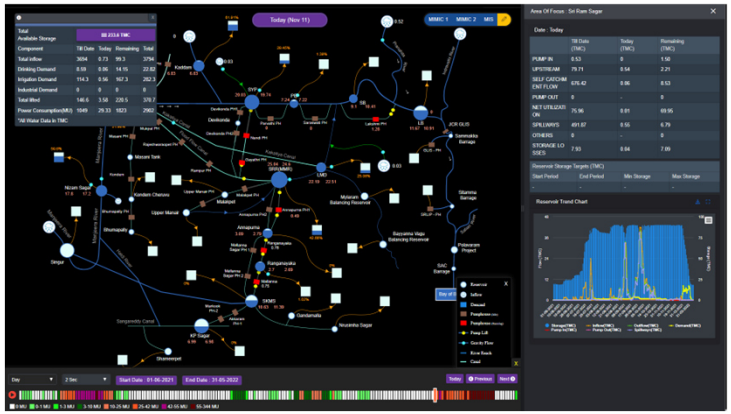
Immersive Visualization

Click to Watch Dashboard Visualisation https://youtu.be/Mk8RVKii0Pc

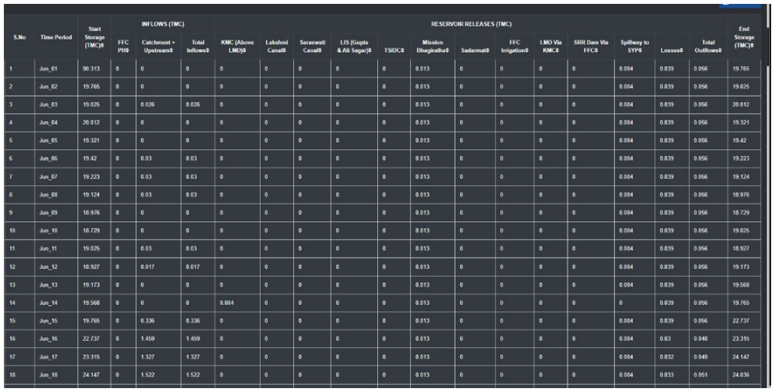
GIS



MIMIC/ Schematic View

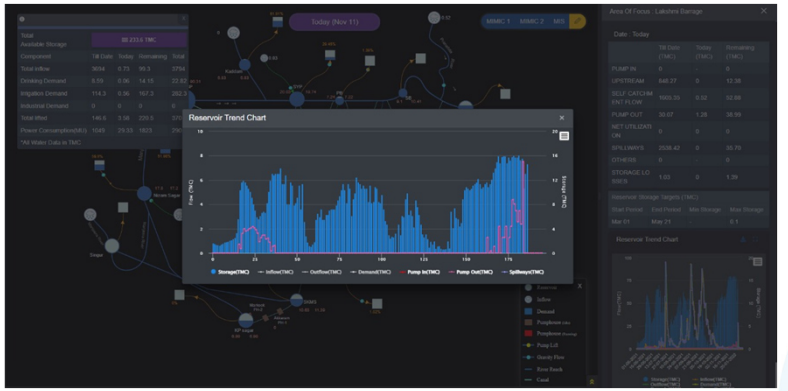


MIS



S.No	Time Period	Start Storage (TMC)0	INFLOWS (TMC)							RESERVOIR RELEASES (TMC)							End Storage (TMC)0
			FTC PSB	Catchment + Upstream0	Total Inflows0	KMC (Above LMD)0	Lakshmi Canal0	Saraswati Canal0	LIS (Gopla & Ali Sagar)0	TSDC0	Mission Bhagiratha0	Sadarmat0	FTC Irrigation0	LMD Via KMC0	SRR Dam Via FTC0	Spillway to SYP0	Losses0	Total Outflows0	
1	Jun_01	90.313	0	0	0	0	0	0	0	0	0.013	0	0	0	0	0.004	0.039	0.056	19.765
2	Jun_02	19.765	0	0	0	0	0	0	0	0	0.013	0	0	0	0	0.004	0.039	0.056	19.625
3	Jun_03	19.625	0	0.026	0.026	0	0	0	0	0	0.013	0	0	0	0	0.004	0.039	0.056	20.012
4	Jun_04	20.012	0	0	0	0	0	0	0	0	0.013	0	0	0	0	0.004	0.039	0.056	19.321
5	Jun_05	19.321	0	0	0	0	0	0	0	0	0.013	0	0	0	0	0.004	0.039	0.056	19.42
6	Jun_06	19.42	0	0.03	0.03	0	0	0	0	0	0.013	0	0	0	0	0.004	0.039	0.056	19.223
7	Jun_07	19.223	0	0.03	0.03	0	0	0	0	0	0.013	0	0	0	0	0.004	0.039	0.056	19.124
8	Jun_08	19.124	0	0.03	0.03	0	0	0	0	0	0.013	0	0	0	0	0.004	0.039	0.056	18.976
9	Jun_09	18.976	0	0	0	0	0	0	0	0	0.013	0	0	0	0	0.004	0.039	0.056	18.729
10	Jun_10	18.729	0	0	0	0	0	0	0	0	0.013	0	0	0	0	0.004	0.039	0.056	19.025
11	Jun_11	19.025	0	0.03	0.03	0	0	0	0	0	0.013	0	0	0	0	0.004	0.039	0.056	18.927
12	Jun_12	18.927	0	0.017	0.017	0	0	0	0	0	0.013	0	0	0	0	0.004	0.039	0.056	19.173
13	Jun_13	19.173	0	0	0	0	0	0	0	0	0.013	0	0	0	0	0.004	0.039	0.056	19.568
14	Jun_14	19.568	0	0	0	0.804	0	0	0	0	0.013	0	0	0	0	0	0.039	0.056	19.765
15	Jun_15	19.765	0	0.336	0.336	0	0	0	0	0	0.013	0	0	0	0	0.004	0.039	0.056	22.737
16	Jun_16	22.737	0	1.459	1.459	0	0	0	0	0	0.013	0	0	0	0	0.004	0.03	0.048	23.315
17	Jun_17	23.315	0	1.327	1.327	0	0	0	0	0	0.013	0	0	0	0	0.004	0.032	0.049	24.147
18	Jun_18	24.147	0	1.522	1.522	0	0	0	0	0	0.013	0	0	0	0	0.004	0.033	0.051	24.836

TRENDS



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THANK YOU

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