Presentation on

Assessing a varying demand scenario using WEAP for Damanganga project, India

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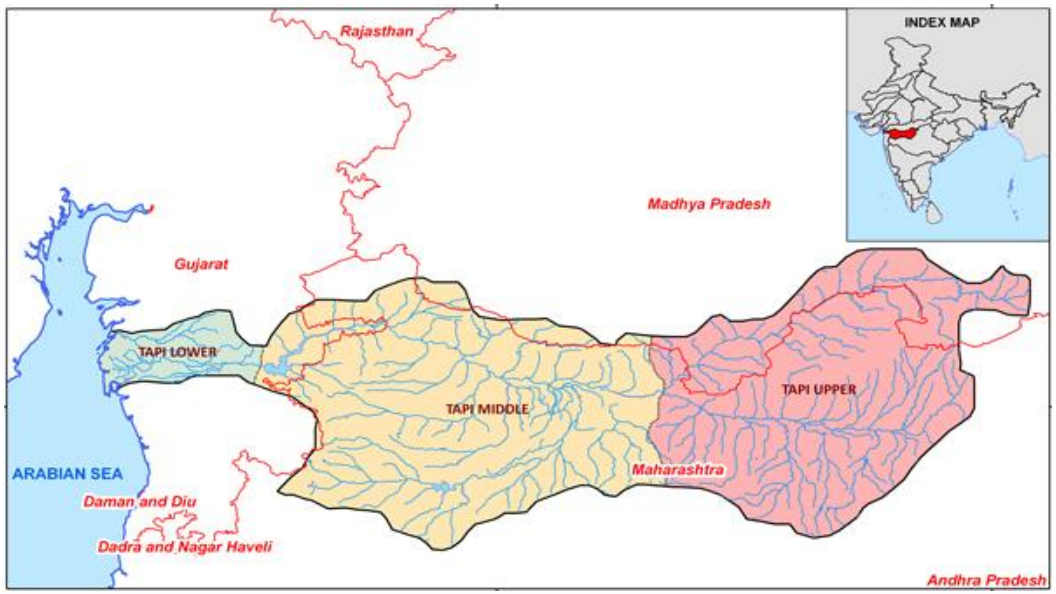
CONTENTS

River Basins

River basins

- Inherently complex systems with many interdependent components (streams, aquifers, reservoirs, canals, cities, irrigation districts, farms etc)



River Basin Model

- A Mathematical model that represents the relevant processes in a river basin
- Can predict the behavior of the basin under different conditions or management scenarios
- Helps decision-makers to make rational water allocation among various users and sectors

Issues among various users in river basins

- Water Resources allocation
- Maintaining water quality
- Rapidly growing demand

- Neither water managers nor water users have incentives to conserve water in India

- **Result →** Overuse and wastage of water instead of being treated as a scarce resource.

Remedy for sustaining Water Resources→ Integrated Water Resources Management

- Efficient and comprehensive ***River Basin Models***

➢SOBEK

➢HYMOS

➢MODSIM

➢MIKE-BASIN

➢WBalMO (Water Balance Model)

➢RIBASIM (River Basin Simulation Model)

➢**WEAP (Water Evaluation And Planning)**

- ***River Basin Models*** utilizes ***simulation*** and **optimization** algorithms :

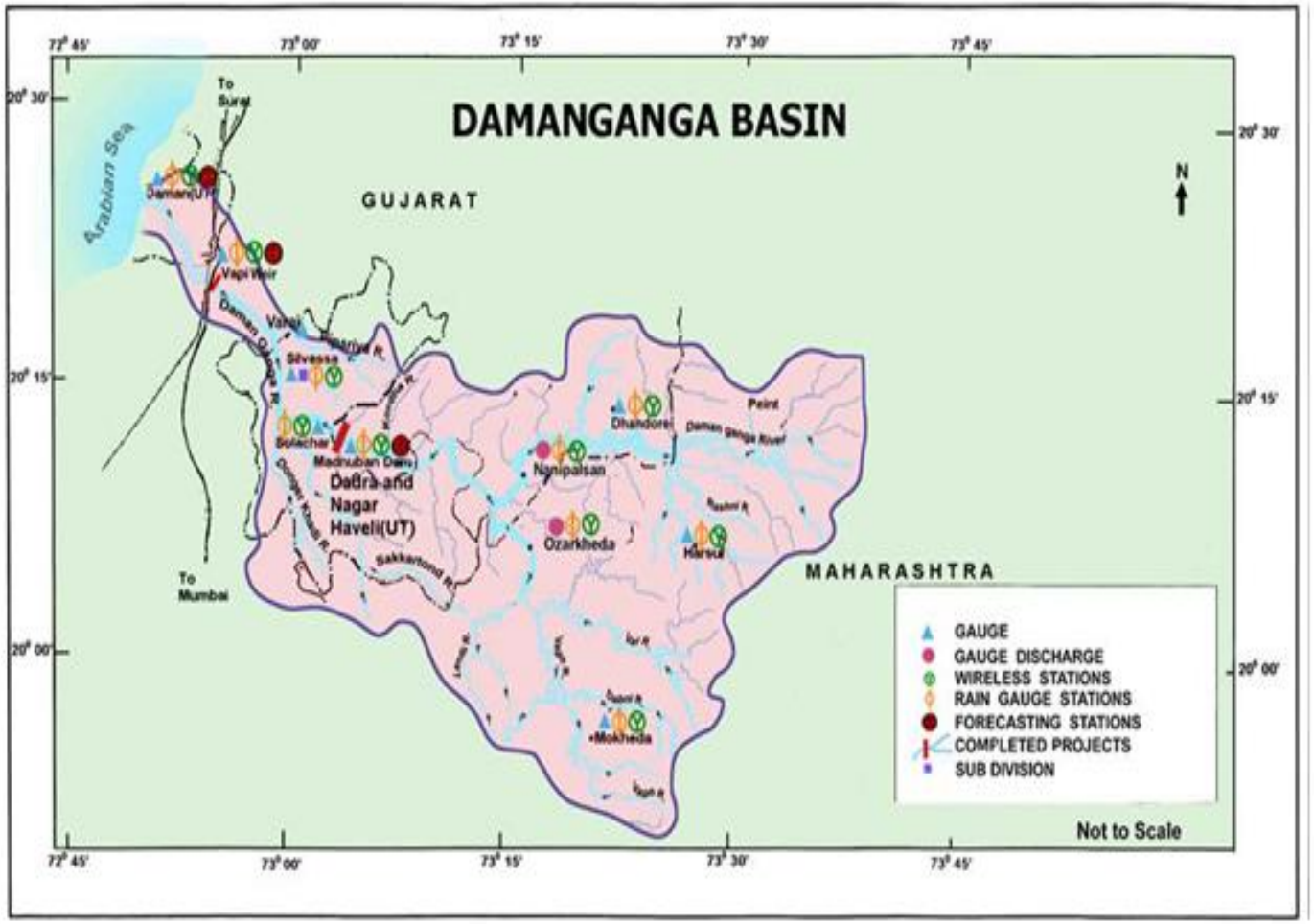
  - ➢To formulate water resources alternatives
  - ➢Analyze their impacts
  - ➢Interpret
  - ➢Select the appropriate options for implementation

Critical Review

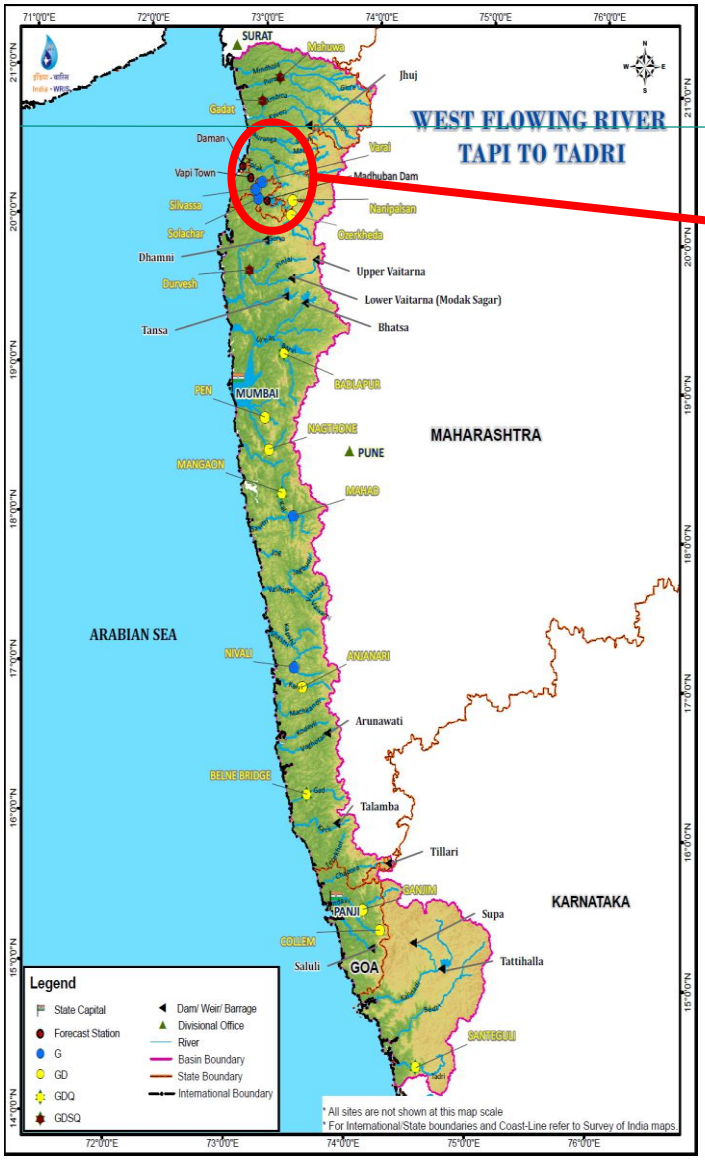
- Through the Hydrology Project at Water Resources Department Government of Maharashtra, India, ***RIBASIM*** model was used to predict the water shortages in the ***Godavari river basin***, India for years ***2015*** and ***2020***, and to develop decisions for minimizing deficit.
- ***Omar (2013)*** used ***RIBASIM*** to simulate and evaluate water demands and shortages for ***Fayoum, Egpyt.***
- ***Zakari (2011)*** used **WEAP** to investigate scenarios of future water resource development in the ***Niger River Basin*** in Niger Republic.

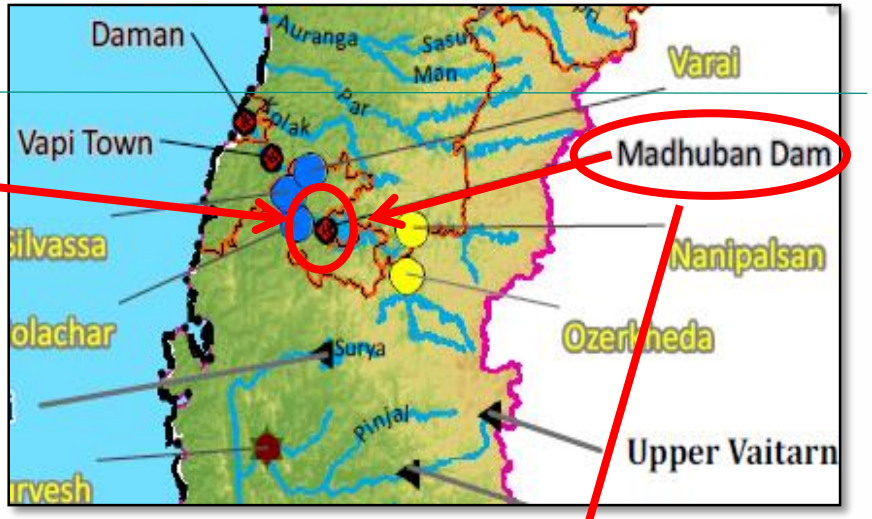
- **WEAP** model was used to simulate current and future water demands by **McCartney et al. (2009)** for **Blue Nile.**
- **Arranz and McCartney (2007)** used **WEAP** model to assess future water demands and resources in the **Olifant catchment,** South Africa
- **Rukuni (2006)** modeled the response of small multi-purpose reservoirs to hydrology for improved rural livelihoods in Mzingwane catchment using **WEAP** for **Limpopo Basin**

Study Area -Damanganga Basin, India



Among 22 CWC Basins, Damanganga lies under Basin name West Flowing river from Tapi to Tadri with basin code 14 having total drainage area of 55940 sq km


WEST FLOWING RIVER
TAPI TO TADRI
SURAT
Mahuwa
Jhuj
Gadat
Daman
Vapi Town
Silvassa
Solachar
Dhamni
Durvesh
Tansa
Varai
Madhuban Dam
Nanipalsan
Ozarkheda
Upper Vaitarna
Lower Vaitarna (Modak Sagar)
Bhatsa
RADLAPUR
PEN
MUMBAI
NASHONE
PUNE
MAHARASHTRA
MANGAON
MAHAD
ARABIAN SEA
NIVALI
ANJANARI
Arunawati
BELNE BRIDGE
Talamba
Tillari
SANJIM
PANJI
Supa
KARNATAKA
COLLEM
Saluli
GOA
Tattihalla
SANTEGULI
Legend
State Capital
Forecast Station
G
GD
GDQ
GDSQ
Dam/ Weir/ Barrage
Divisional Office
River
Basin Boundary
State Boundary
International Boundary
* All sites are not shown at this map scale
* For International/State boundaries and Coast-Line refer to Survey of India maps.


Daman
Auranga
Sasu
Man
Par
Kolak
Varai
Vapi Town
Madhuban Dam
Nanipalsan
Ozerkheda
Surya
Pinjal
Upper Vaitarn


INDIA-WRIS

Distribution of Drainage Area

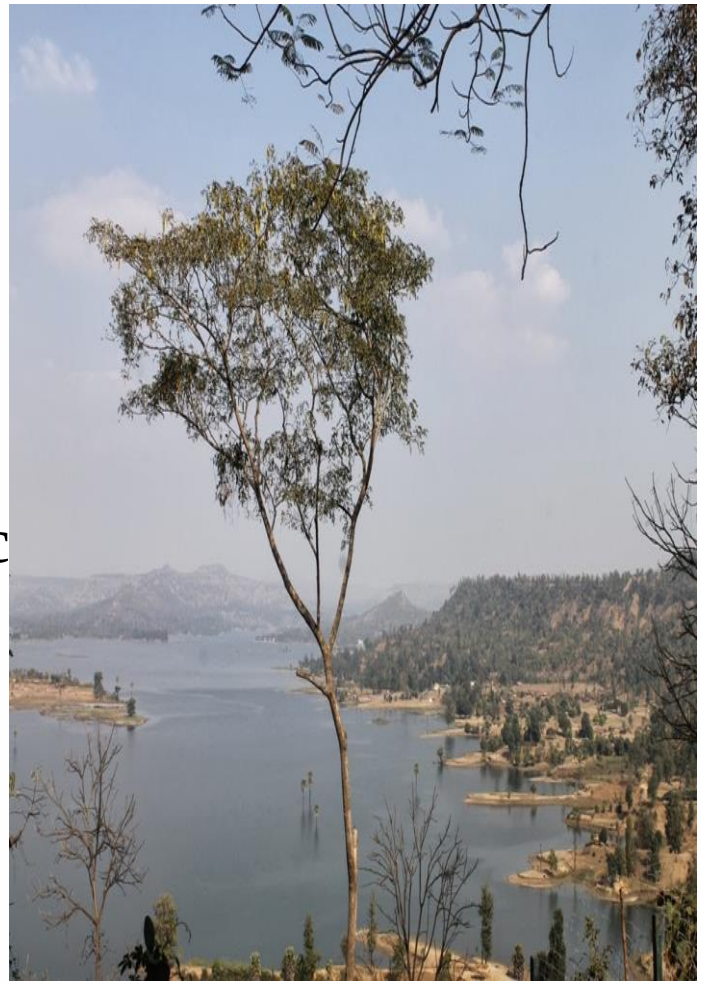
Sr. No	Name of District / State	C.A. in sq. km.	% of Total C.A.	Volume of water shared
1	Nasik / Maharashtra	1408	60.74	34.20 Mm^3
2	Valsad / Gujarat	495	21.36	399.19 Mm^3
3	Dadara & Nagar Haveli & Daman /U.T.	415	17.90	83.33 Mm^3

Madhuban dam - Damanganga -Reservoir

- Madhuban dam is Located near Madhuban village in Dharampur taluka of Valsad district of Gujarat, India
- Canal network irrigates area of 566.30 sq km
- Dam height above the deepest foundation : 50 m

Madhuban dam - Damanganga -Reservoir

- Gross storage: 567 Mm^3
- Effective storage: 502 Mm^3
- Major purpose
  - Irrigation,
  - Water supply for Domestic and Industrial use
  - Power generation (2.0 MW)



Need of the study

Damanganga reservoir project faces water-related problems :

- Acute shortage of drinking water in the downstream area
- Daman and Silvassa drinking water problems (Downstream Area)
- Poor agricultural practices

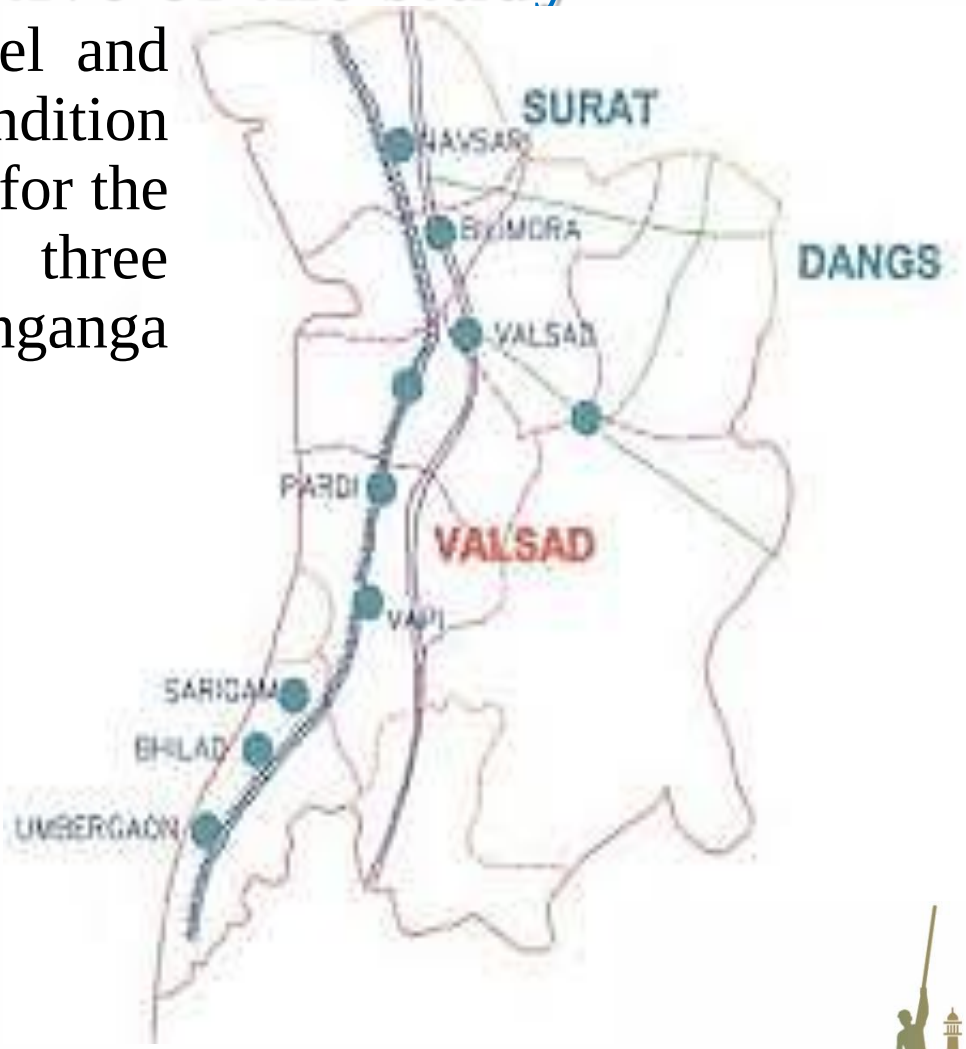
Need of the Study (Continued)

Damanganga reservoir project faces water-related problems :

- Decreasing rainfall trend.
- Repeated floods
- Industries in Vapi, Pardi and Bhilad draw water from Madhuban dam

Objective of the study

- To calibrate **WEAP** model and simulate the base year condition and predict water demand for the future year **2021** for three districts of Damanganga reservoir project
  - **Vapi**
  - **Pardi**
  - **Bhilad**
- To evaluate the influence of increased population on the future water demands on Damanganga project.



Vapi

- It is situated on the banks of the Damanganga River and is the largest city in the Valsad district and also the second largest city after Surat in South Gujarat.

- It can be called the most developed city in Gujarat followed by Ahemdabad, Surat, Vadodara and Rajkot.

- it is the largest industrial area in Asia in terms of small-scale industries, dominated by the chemical industry.

PARDI

- Pardi is a town and a municipality in Valsad district in the Indian state of Gujarat.

- The city of Vapi, a large industrial township for small-scale industries, Roughly 14 km south of Pardi town. Pardi has its own industrial zone which is governed by GIDC and caters mainly to the Textil industry.

BHILAD

- Bhilad is a Village in Umbergaon Taluka in Valsad District of Gujarat State, India.

- It is located 44 KM towards South from District head quarters Valsad 17 KM.

Methodology

- **Water Evaluation And Planning (WEAP)** developed by the **Stockholm Environment Institute's U.S. Center** is used

- Deals with problems pertaining to water resources allocation among agricultural, municipal and environmental uses:

  - Water supply
  - Water demand
  - Water quality

WEAP Modeling

- Defining study area

  *Establishing the **time frame**, **spatial boundaries**, system **components***

- Formulation of current accounts

- Implementation of scenarios

- Evaluation of scenarios

- Data collected (from two divisions: Madhuban Division, Silvasa and Irrigation Division, DCSD Div No.3 Balitha, Vapi) includes:

  - Population number and population growth for year 2001 and 2011
  - Total agricultural area (ha of area irrigated, water use rate etc)
  - Number of factories and total industrial demand

Data collected. (Continued)

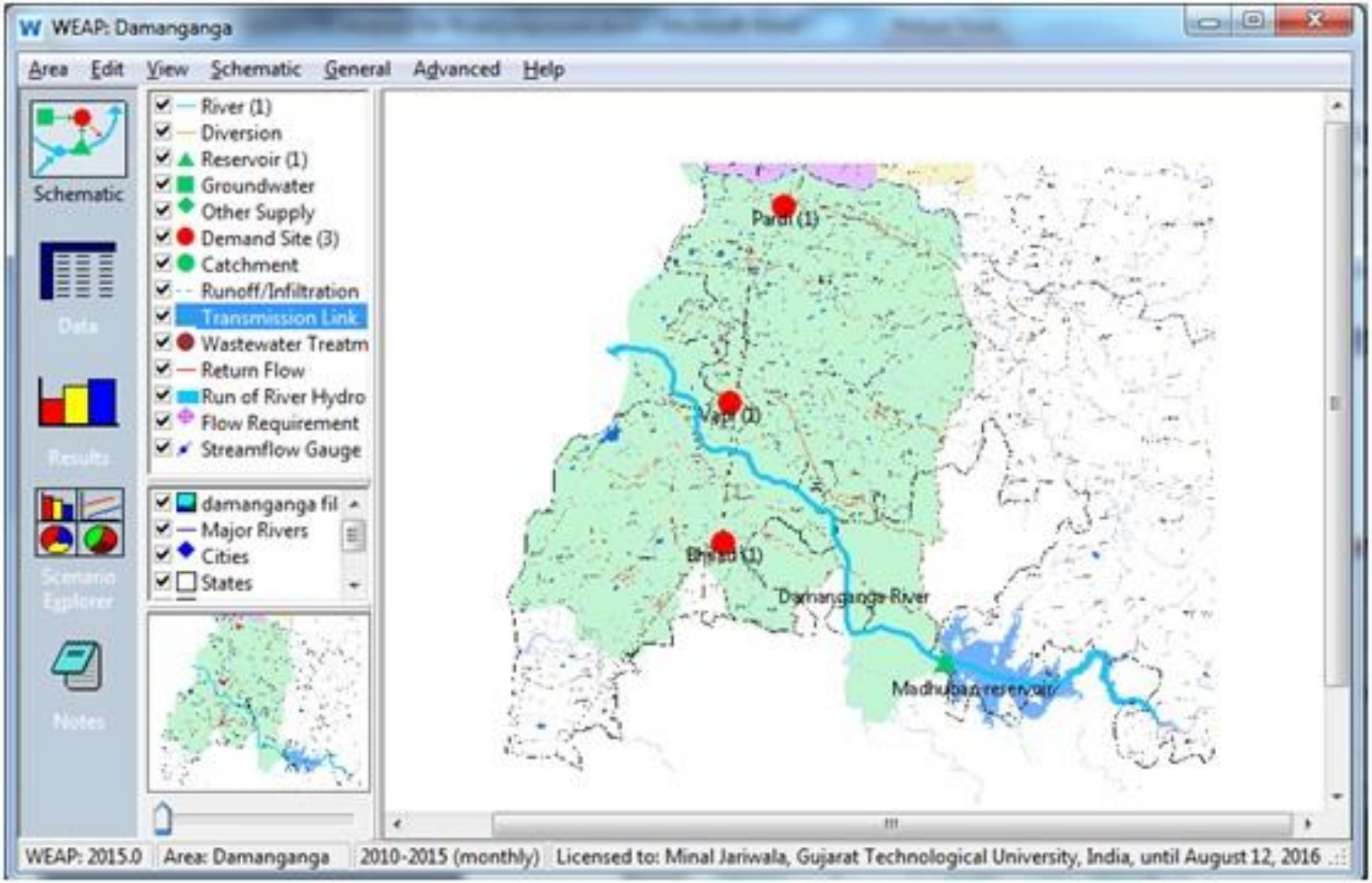
- Streamflow data (River Inflow)
- Reservoir storage data (Gross storage, effective storage, Dead storage, initial storage at the beginning of simulation, observed storage)
- Water released for demand sites viz. Drinking, Industrial and Irrigation use

- Based on site visits and assembled data, Damanganga water balance was developed for Water Resources analysis for the year 2014.
- Water Balance for Damanganga Reservoir for the year 2014
  - Inflow = 3045.132 MCM
  - Total Spillover = 2788.3925 MCM
  - Storage = 256.74 MCM

Table 2. *Water Balance for Damanganga Reservoir for the year 2014*

Water consumed (MCM)		Losses (MCM)	
Irrigation	102.20	Evaporation	59.8
Drinking	3.37	Others	16.7
Industries	49.40		
Tanks/Ponds	24.51		

WEAP Schematization



- The schematization of WEAP was done for present study using

  - River element
  - Reservoir node (Madhuban dam)
  - Demand site nodes (Vapi, Pardi and Bhilad)

- Each demand site node was disaggregated showing the percent of annual share for Irrigation, Domestic and Industry.

Model Validation

- For the model to be used to evaluate future water demands, validation was done by entering data for demand sites for base year 2014 and comparing with actual (observed) water demand

Table 3. Input data for WEAP Model for base year 2014

Month	Jan	Feb	Mar	April	May	June
River Inflow (CMS)	00.00	00.00	00.00	00.00	00.00	19.18
Observed Storage (MCM)	455.56	394.56	332.26	254.250	190.030	124.560
Month	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**
River Inflow (CMS)	189.9	143.6	106.1	60.53	13.41	0.894
Observed Storage (MCM)	95.170	268.830	382.870	510.160	510.160	457.750

Demand site	Vapi	Pardi	Bhilad
Agricultural Area (ha)	2191.34	2875.75	2524.49
Water use rate(m^3/ha)	6041.96	9614.88	12877.85
Population for year 2014	206100	29500	9800
Water use rate (lpcd)	200	200	200

- Simulated water demand obtained using WEAP were compared with the actual observed water demand obtained from Damanganga Canal Distry divisions for three demand sites.

Table 4. Simulated vs. Actual Demands (MCM) for year 2014

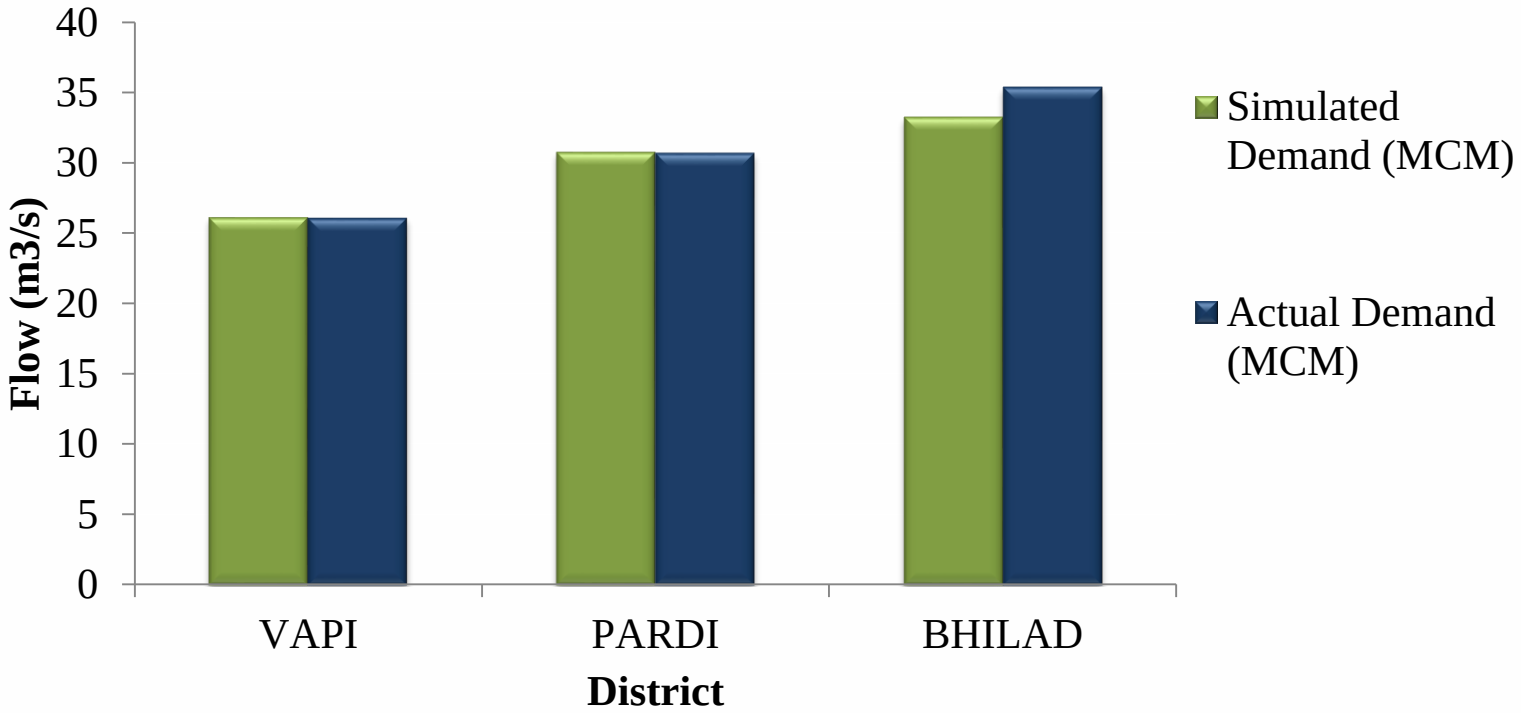
Division	Simulated water demand (MCM)	Actual water demand (MCM)
Vapi	26.1018642	26.093
Pardi	30.7252733	30.71
Bhilad	33.2086203	35.38
SUM	**90.0357577**	**92.183**

- For the verification of base case 2014 and to measure the accuracy of numerical model predictions for the current scenario, Root Mean Square Error was used which is calculated as:

$$RMSE = \sqrt{\frac{\sum_{i=1}^{n}(y_s - y_i)^2}{n}}$$

Where, Y_s is simulated demand and Y_i is actual demand

Simulated and Actual (observed) water demands for year 2014



The lower RMSE value of 0.865 indicated that WEAP can perform well to evaluate the future scenario

Future Scenario

- Future scenario was formulated to show the impact of increase in population growth (varying demand) on water demands
- It assumes the population growth of 10% for Vapi, 3% for Pardi and 4% for Bhilad

Table 5. Input Data for WEAP model for Future year 2021

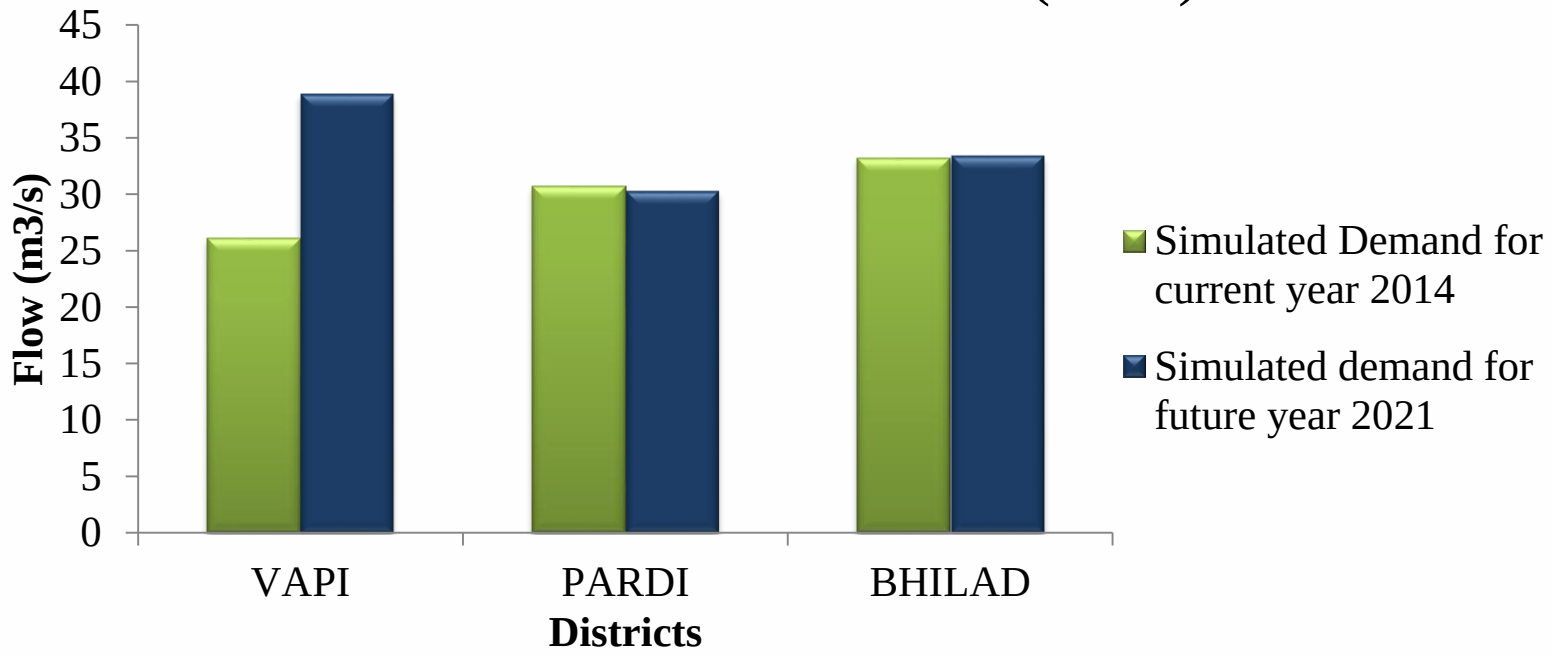
Demand site	Vapi	Pardi	Bhilad
Water use rate (lpcd)	200	200	200
Increased Population growth for year 2021	10%	3%	4%

Table 6. Comparison of Simulated water demands (MCM)

Division	Current scenario	Future scenario
Vapi	26.10	38.83
Pardi	30.72	30.27
Bhilad	33.21	33.37
Sum	**90.04**	**102.48**

- Scenario formulated indicates a total water demand of 102.48 MCM for future scenario of increased population

Comparison of water demand for Current scenario (2014) and Future scenario (2021)



The water demand for Vapi and Bhilad increases by 12.73 MCM and 0.16 MCM respectively. However, the demand is reduced by 0.46 MCM for Pardi.

Key Findings

- The total simulated water demand obtained using WEAP for base year 2014 was 90.04 MCM
- However, the total actual water demand, as estimated from the data collected, for base year 2014 was 92.18 MCM
- Future scenario formulated to show the impact of increase in population growth, assuming the population growth of 10% for Vapi, 3% for Pardi and 4% for Bhilad, resulted to total water demand of 102.48 MCM

Implications

- The predicted value deviate from the actual water demand of the year 2014 with low RMSE of *0.865* which can be inferred as ***good prediction***

- The results for formulated scenario indicate that increase in population growth, yields in increase in the water demands by 12.44 MCM

- The gross storage capacity of Damanganga reservoir is 524.857 MCM. Hence, the reservoir is able to supply increasing demand for full reservoir condition as well as 50% of Gross storage.

Implications (Continued)

- As observed from past storage conditions of Damanganga Reservoir from year 2001 to 2014, the minimum storage was observed as 63.37 MCM (12% of Gross storage)

- Water shortage may occur under such storage conditions

Research Limitations

- The future scenario was formulated considering the impact of increased population growth. Thus, present study is limited to yield results for varying demand

- However, Water demand may vary for water supply conditions. Varying water supply condition can be assessed using water year method and water demand can thus be predicted

- Thus the study needs to be extended to obtain the cumulative effect for applying the model to other districts

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THANK YOU

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