

Decision Support System Planning DSS (P) for Integrated River Basin Planning & Management

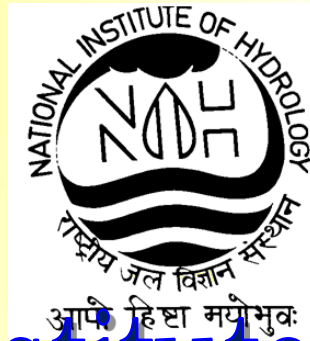
World Bank Workshop
September 16 – 17, 2014



Dr. M. K. Goel, Scientist “F”
National Institute of Hydrology
Roorkee

INDIA: HYDROLOGY PROJECT-II

**Development of Decision Support System (Planning)
[DSS(P)] for Integrated Water Resources
Development & Management**

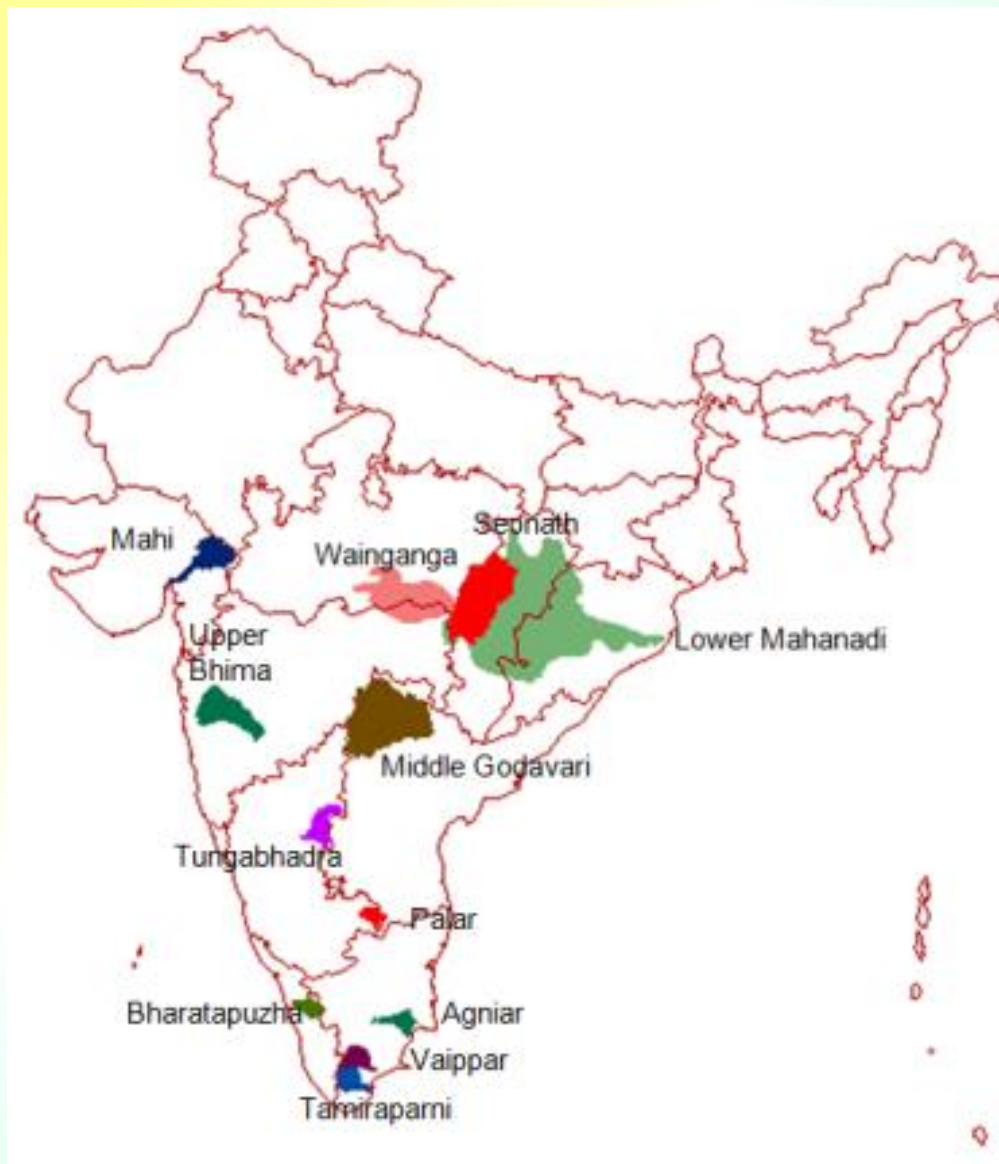


National Institute of Hydrology Roorkee, India



DHI Water Environment Health
Agern Alle 5, Denmark

Participating States



A Decision Support System

Decision

A reasoned choice among alternatives

Definition of a DSS

Computer based systems integrating tools and databases that assist a decision-maker in making informed decisions and analyze consequences.

Why a Decision Support System

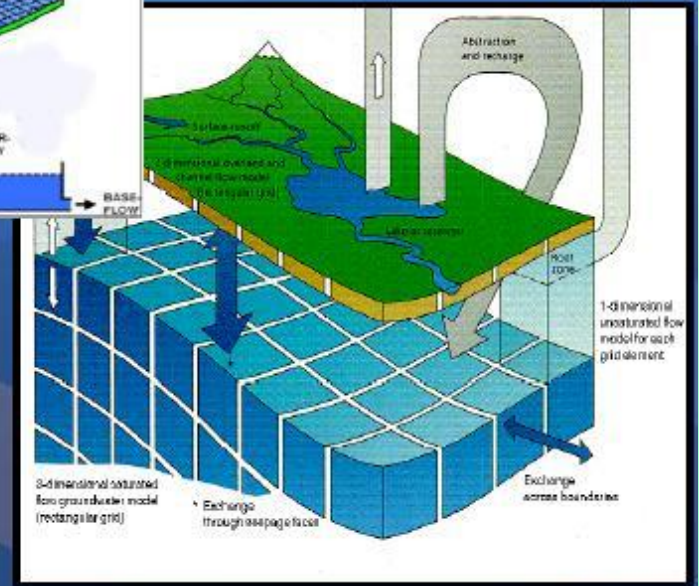
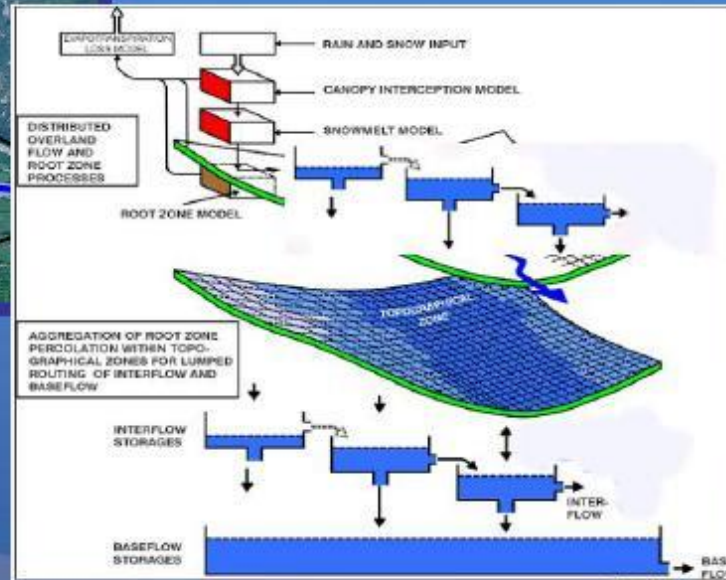
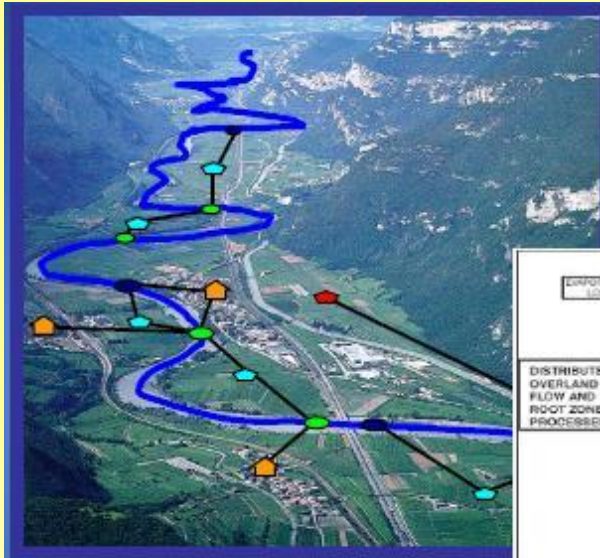
Misconception: A DSS takes decisions

- **Using a DSS, a project manager is able to make rational use of resources without an in-depth knowledge of modeling techniques**
- **Provides timely information**
- **Communicate result to a larger audience**
- **Open and unbiased working**
- **Scenario analysis**

Modeling Methodology under DSS (P)

- A river basin is divided into a number of sub-basins based on the location of hydraulic structures and hydrological network
- A hydrological model (**NAM**) is calibrated for each sub-basin to estimate the hydrological components (evaporation, rainfall recharge, overland flow, interflow and base flow) ~ **Soul**
- An allocation model (**MIKE Basin**) in conjunction with hydrological inputs is used to allocate the available SW and GW ~ **Heart**
- **DSS** is used to analyze scenarios ~ **Brain**

Hydrological Model under DSS (P)



NAM Model under DSS (P)

Objective

- **NAM model provides a conceptual representation of land phase of hydrological cycle and simulates rainfall-runoff processes at the catchment scale.**

Basic data requirements

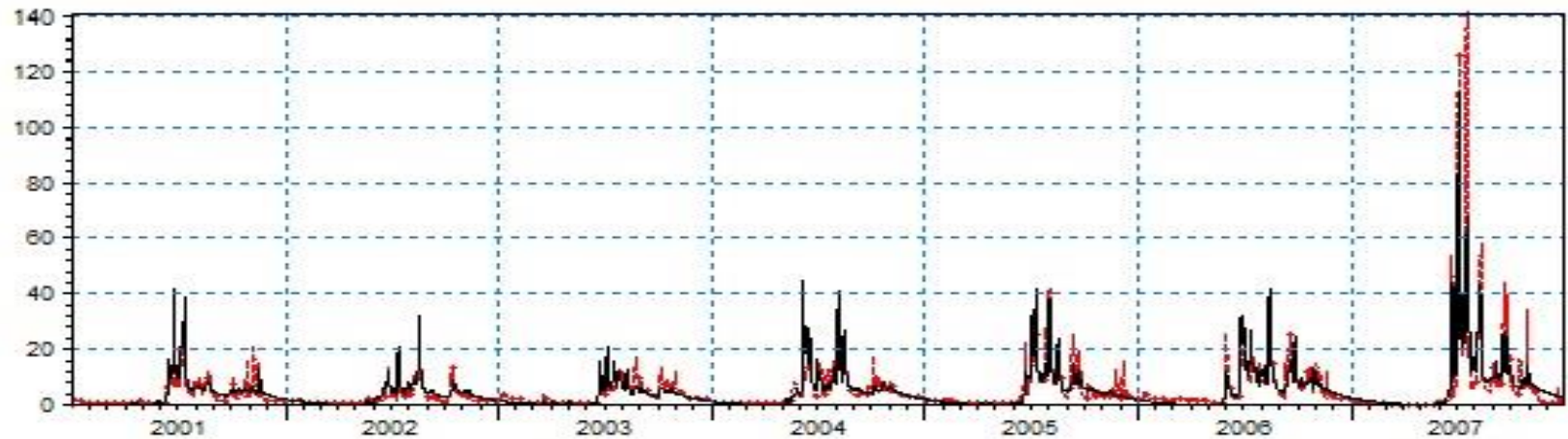
- **Precipitation time series**
- **Temperature time series (for snow melt modeling)**
- **Evapo-transpiration time series**
- **Observed discharge time series**

Basic model outputs

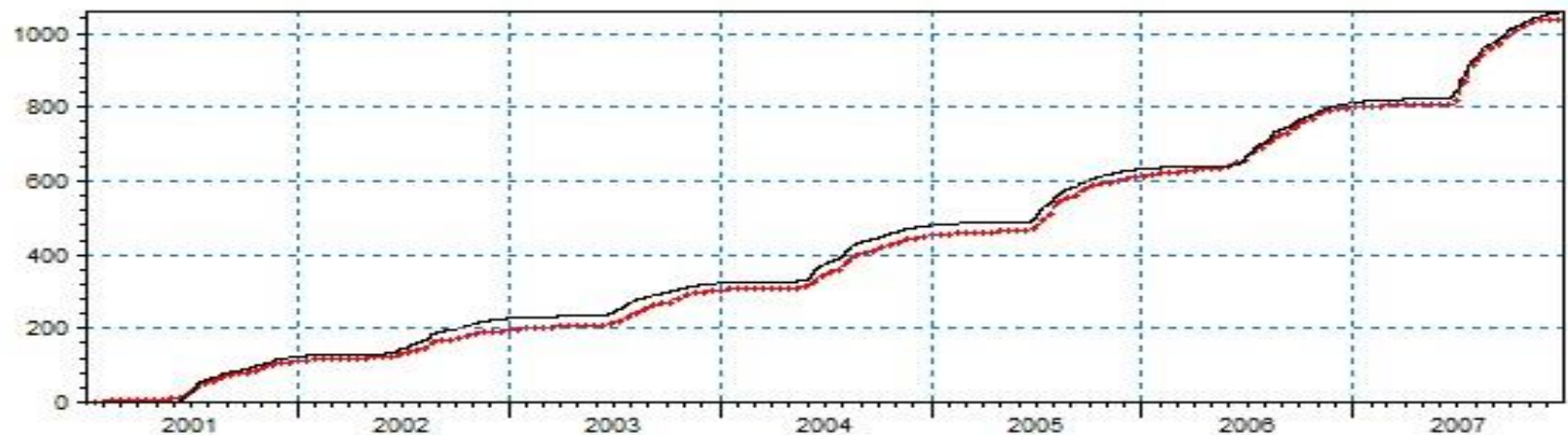
- **Catchment runoff**
- **Subsurface contributions (base flow, interflow)**
- **Actual evapo-transpiration**
- **Groundwater recharge and levels**
- **Soil moisture storage content**

NAM Results

Observed/Simulated Surface Water Flows



THIRUVAGAPURA, Accumulated Obs. Million $[m^3]$ - - - - -
THIRUVAGAPURA, Accumulated Sim. Million $[m^3]$ ———



NAM Results

Tabular Presentation of Components of Hydrologic Cycle

```
*****
*
* RAINFALL RUNOFF SIMULATION
* PARAMETER FILE      :      Thiruvegapura.rr11
* SIMULATION DATE    : 15-AUG-2012  13:22:10
*
*****
```

SIMULATED PERIOD : From: 2001/ 1/ 1 8:00 To: 2007/12/31 8:00

TIMESTEP : 24.00 HOURS

(Accumulated values in mm)

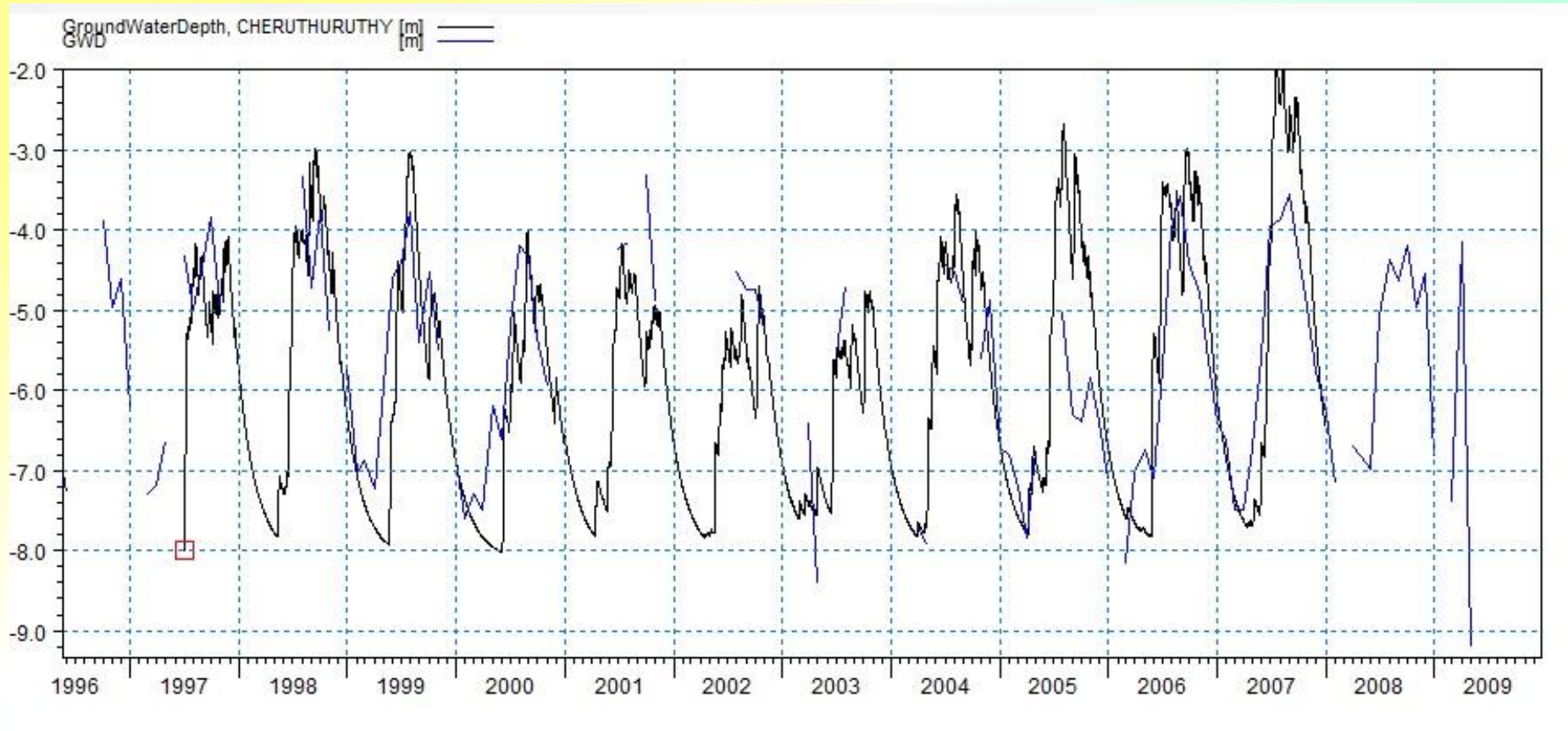
Catchment: THIRUVAGAPURA, Area= 94.62 km2

Period	Q-obs	Q-sim	%diff	Rainfall	PotEvap	ActEvap	CapFlux	Recharge	Pumping	Irrig.	OF	IF	BF
2001/ 1/ 1 - 2002/ 1/ 1	1174.6	1307.8	-11.3	2375.3	1466.6	783.1	0.0	1006.0	107.9	0.0	385.2	140.4	782.2
2002/ 1/ 1 - 2003/ 1/ 1	878.1	1094.7	-24.7	2006.4	1591.5	850.1	0.0	830.0	107.9	0.0	220.9	123.8	750.1
2003/ 1/ 1 - 2004/ 1/ 1	1170.6	1010.8	13.6	2031.1	1540.4	932.6	0.0	798.3	107.9	0.0	196.1	111.6	703.0
2004/ 1/ 1 - 2005/ 1/ 1	1547.9	1656.3	-7.0	2550.6	1490.0	744.5	0.0	1164.7	107.9	0.0	506.6	129.9	1019.8
2005/ 1/ 1 - 2006/ 1/ 1	1707.1	1618.5	5.2	2586.3	1519.7	854.5	0.0	1009.7	108.2	0.0	574.1	130.6	913.8
2006/ 1/ 1 - 2007/ 1/ 1	1981.8	1897.3	4.3	2824.5	1514.9	775.2	0.0	1274.3	107.9	0.0	638.0	140.2	1119.1
2007/ 1/ 1 - 2007/12/31	2521.6	2612.9	-3.6	3485.7	1509.5	764.4	0.0	1436.7	107.5	0.0	1141.1	147.8	1323.9
2001/ 1/ 1 - 2007/12/31	10981.7	11198.3	-2.0	17859.8	10632.6	5704.5	0.0	7519.7	755.0	0.0	3662.0	924.4	6611.9

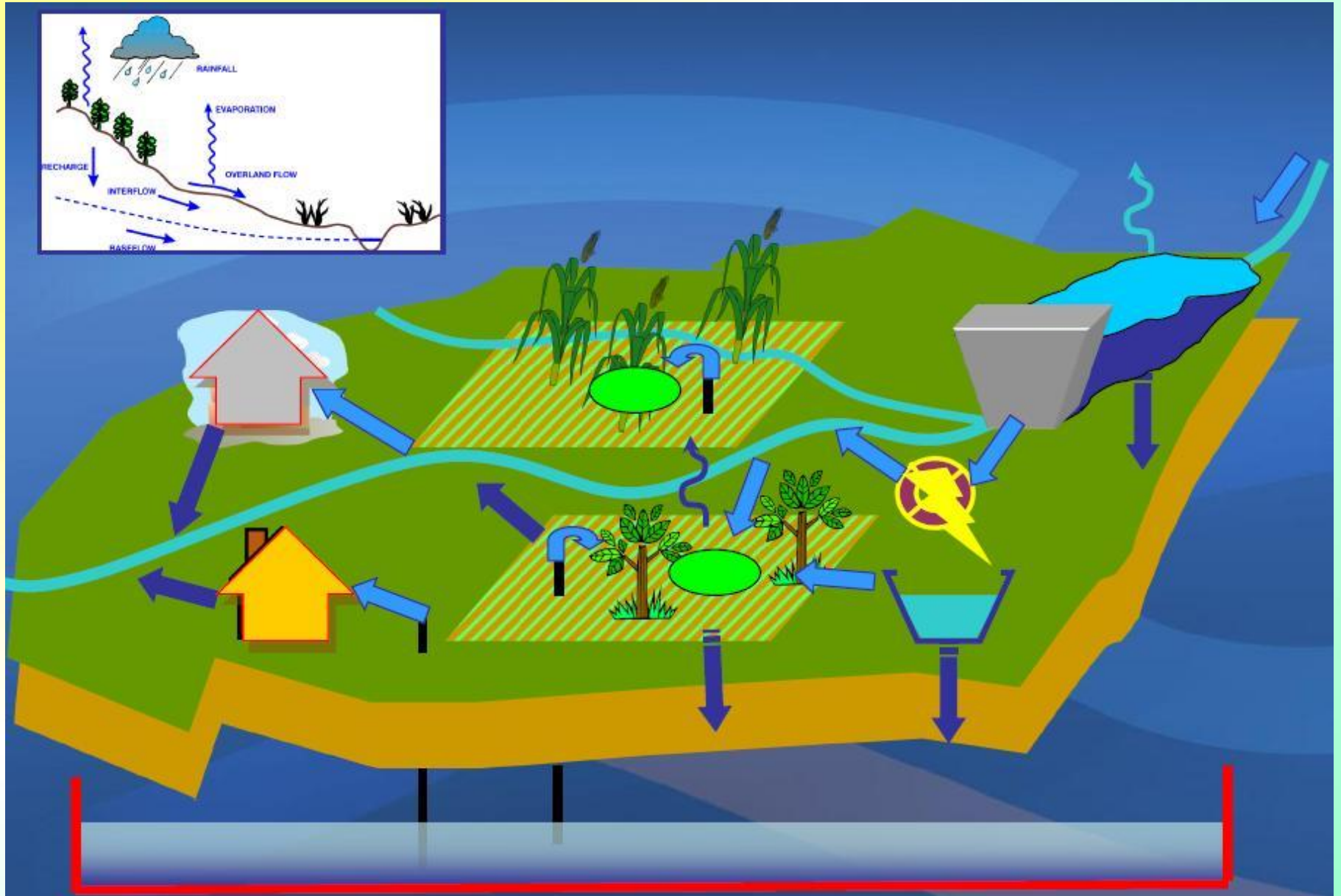
Coefficient of determination: R2 = 0.745

NAM Results

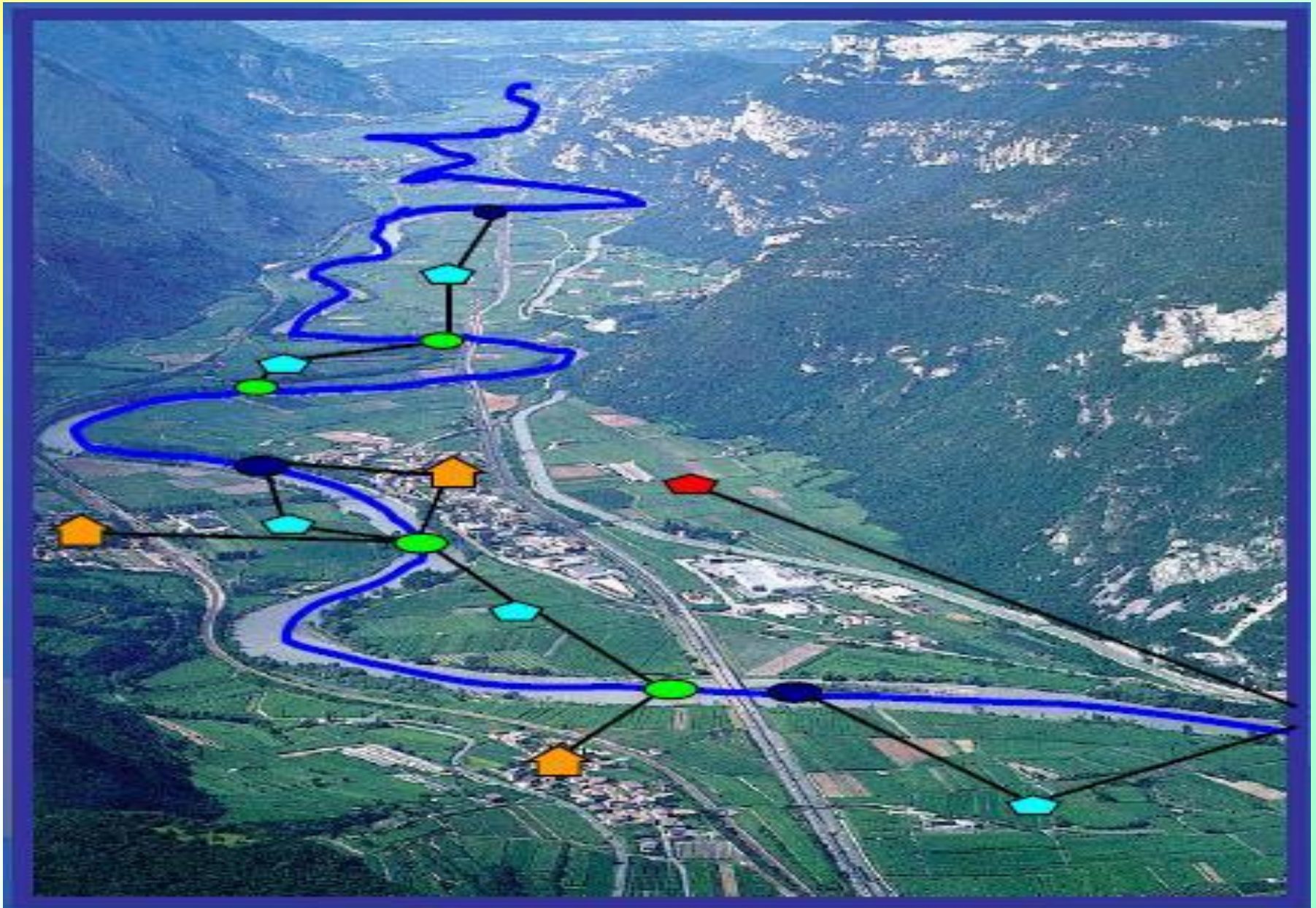
Observed/Simulated Groundwater Levels



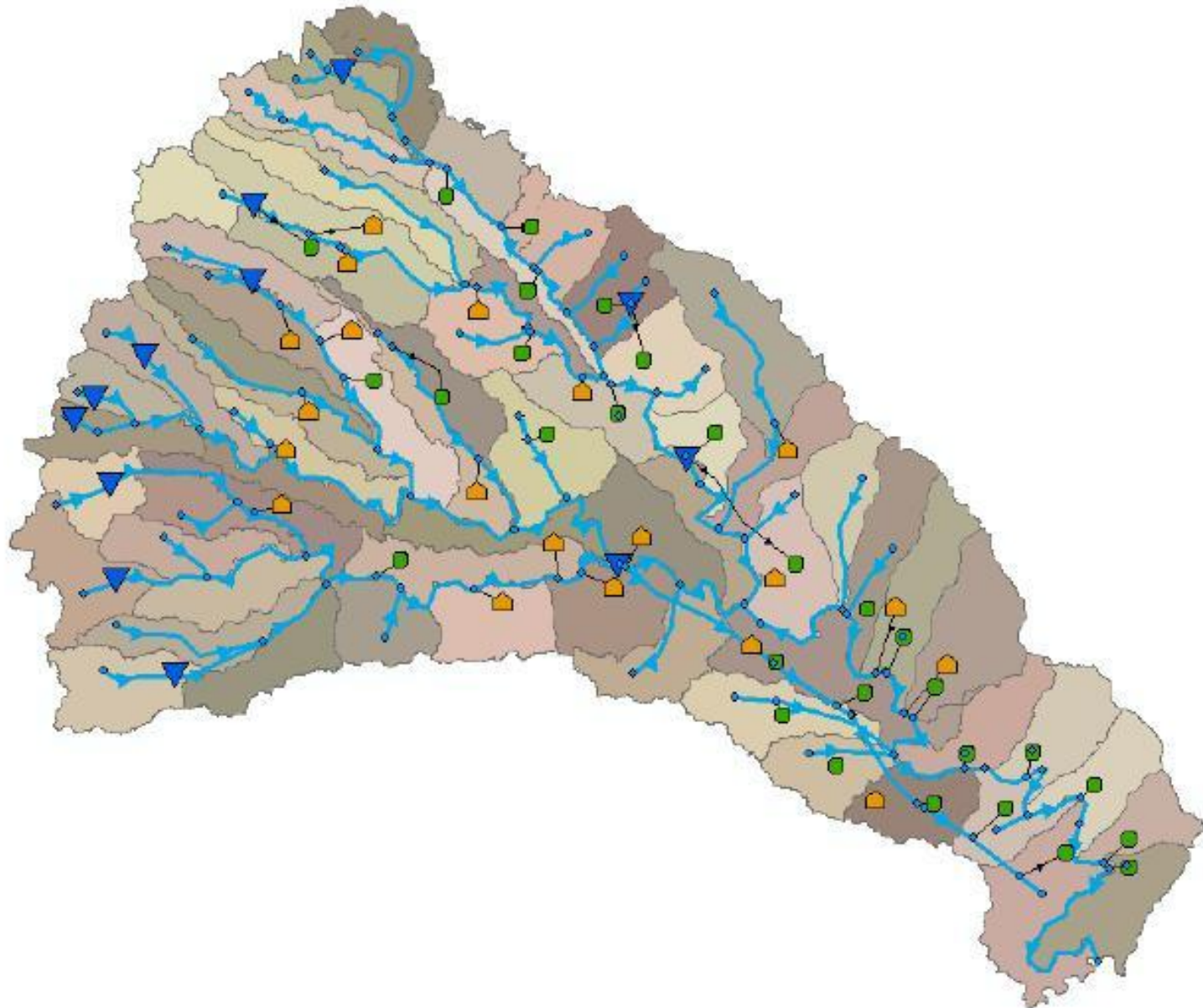
River Basin Model Concept



River Basin Schematization



Sample Basin Schematization in a Model



DSS (P) Main Functionalities

- Process and analyse GIS and time series information
- Publish selected information (general, drought, flood..)
- Model applications for long-term/short-term planning



Scenarios

Time Series

GIS

Indicators

Dashboard
(web publishing)

Scripting

Meta data

Work spaces

Spread-sheets

DSS (P) - Generation & Comparison of Scenarios

Model explorer

Model structure

Properties

Tools

Name	Count	Type
HydroPowerNode	2	Model Object Group
ReservoirNode	5	Model Object Group
WaterUserNode	5	Model Object Group
• MBLogfile	1	Other Output Data
• MZAdapter	1	Other Output Data

DSS (P) - Association between GIS & Time Series

DHI Solutions - workspace1

Connection View Settings

Time series

- Database (by Group)
 - annual recharge
 - CARM
 - Models and Scenarios
 - Padas
 - Palar
 - UpperBhima
 - GroundWater
 - Meteorology
 - Evaporation
 - Rainfall_IMD
 - Rainfall_State_Automatic
 - Askhed
 - Budhawadi
 - Chaskaman
 - Kashli
 - Khamgaon
 - Khandala
 - Kumbheri
 - Nighoje
 - Pargaon
 - Paud
 - Pimpalgaon
 - Pimpalwandi
 - PimpleGurav
 - Rakshewadi
 - Shirur
 - Wagholi
 - Wegre
 - Rainfall_State_older
 - Rainfall_State_Standard
 - Reservoirs
 - SurfaceWater
 - Discharge_CWC
 - Dhond
 - Phulgaon
 - Discharge_State_Daily
 - Discharge_State_Hourly

Chart1 Start Page ThinkGeo Map Data View ThinkGeo Map Data View ThinkGeo Map Data View

Active Layer RainGaugesStateHP1

- RainGaugesStateHP1
 - WaterBodies
 - CatchmentsBasinModel

Properties

Time series

Description	
Members	1
Name	
Time Zone	
Url	
Unit	mm
Variable	Rainfall
Time axis properties	
Number of time steps	
Last time step	01/11/2007 08:30:00
Number of missing val	
First time step	

Description

Tools Explorer

Search toolbox

DataSeries Tools

- Advanced statistics
 - Cross-correlation
 - Data quantile
 - Drought duration and volume
 - Duration curve
 - Ensemble statistics
 - Exceedance duration and volume
 - L-Moments
 - Mann-Kendall test
 - Mann-Whitney test
 - Mode
 - Residual mass
 - Run test
 - Within-year statistics
- Basic statistics
 - Accumulation
 - Annual maximum series (seasonal)
 - Average

20 km 20 mi

8365339.4866, 2143385.7867 (75.1471, 18.9019)

admin Connected to: Maharashtra Status: Ready

11:32 07/08/2013

DSS (P) - Use of Spreadsheets

DHI Solutions - workspace1

Connection View Settings

Spreadsheet

Database (by Group)

- AR BM26
- Forthnightly_Irrigation_requirements
- Forthnightly_Irrigation_requirements_org
- NewSpreadSheet1
- NewSpreadSheet2
- Palar_CC
- Pawna pipeline
- Percolation and abstraction
- Seasonal Planning
- Seasonal Planning Ujjani
- Seasonal Planning Wainganga
- TBA Conjunctive Use
- Test_avg_recharge
- Wainganga runoff

Start Page Fortnightly_Irrigation_requirements*

C17 5000

1 Irrigation requirements

2 Calculation of crop water requirements for an irrigation area as a function of cropping pattern

3 The season, total irrigation requirements, and Kc values are given for a range of crops in Table 2.

4 Users are encouraged to update these values in accordance with local conditions

5 The proposed area for each crop should be given in Table 1

6 The corresponding water demands in m3/s may be transferred to the model using the sheet "Export to model"

7

8 **Table 1** Fortnightly Irr

9 (m

Crop	Period (Days)	Crop Area (ha)	Total Irrigation Requirement (mm)	June		July		August		Sept
				I	II	I	II	I	II	
Kharif Jowar	105	0	150	0	0	0	0	0	0	
Kharif Bajra	90	0	50	0	0	0	0	0	0	
Kharif Groundnut	120	0	150		0	0	0	0	0	
Kharif Chillies	150	0	150			0	0	0	0	
Kharif Cotton	180	0	300			0	0	0	0	
Rabi wheat	120	5000	500							
Rabi jowar	135	0	300							0
Hot weather G'nut	120	0	750							
Annual Sugarcane	365	0	1080	0	0	0	0	0	0	0
Paddy	125	5000	900		4341176	4923529	5294118	6088235	6882353	6882353
My crop 1		0								
My crop 2		0								
My crop 3		0								
My crop 4		0								
My crop 5		0								
My crop 6		0								
Totals	Area ha	10000	Demand MCM	0.00	4.34	4.92	5.29	6.09	6.88	6.88
			Demand TMC	0.00	0.15	0.17	0.19	0.22	0.24	0.24

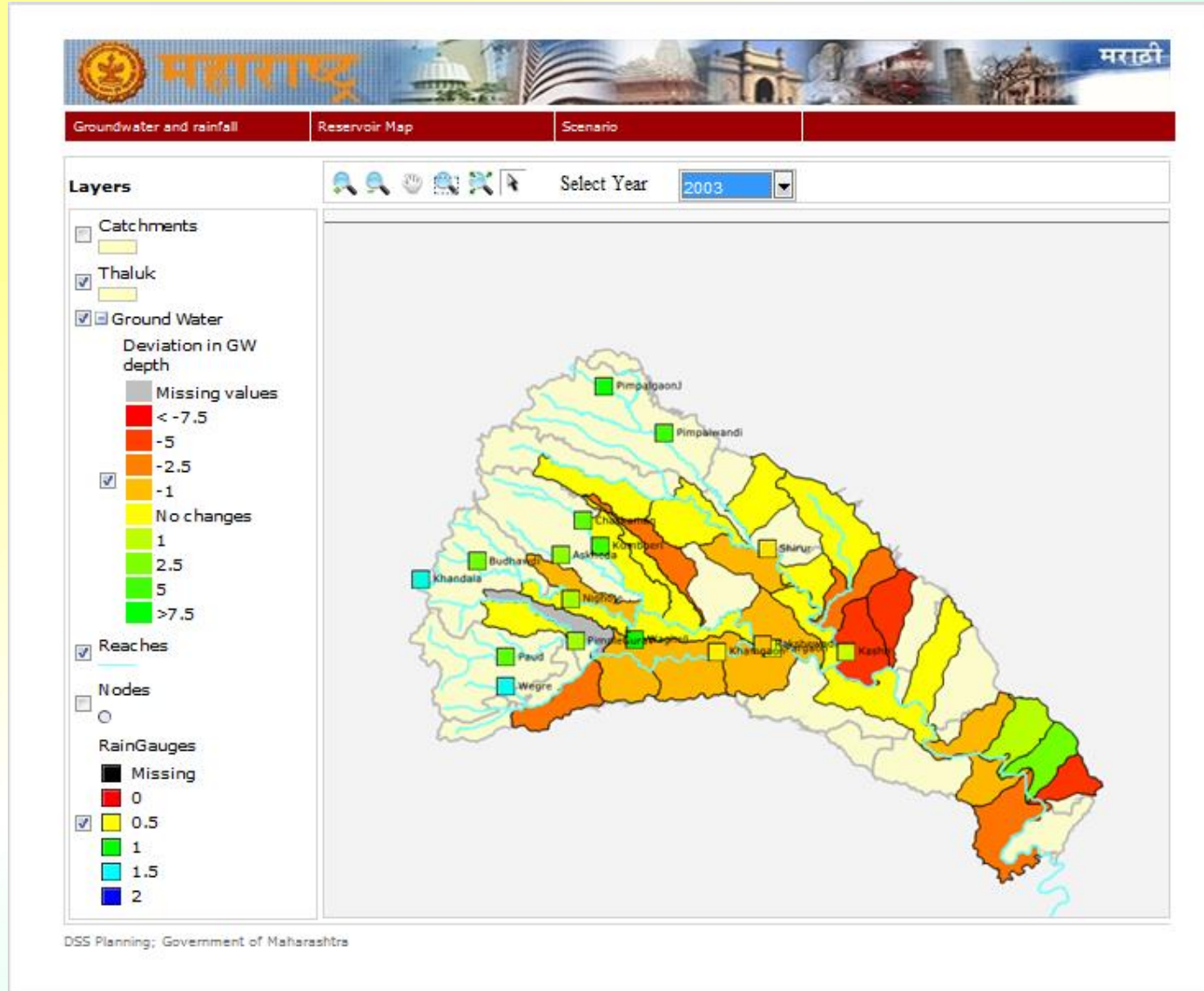
32 **Table 2** Fortnightly Kc

33

admin Connected to: Maharashtra Status: Ready

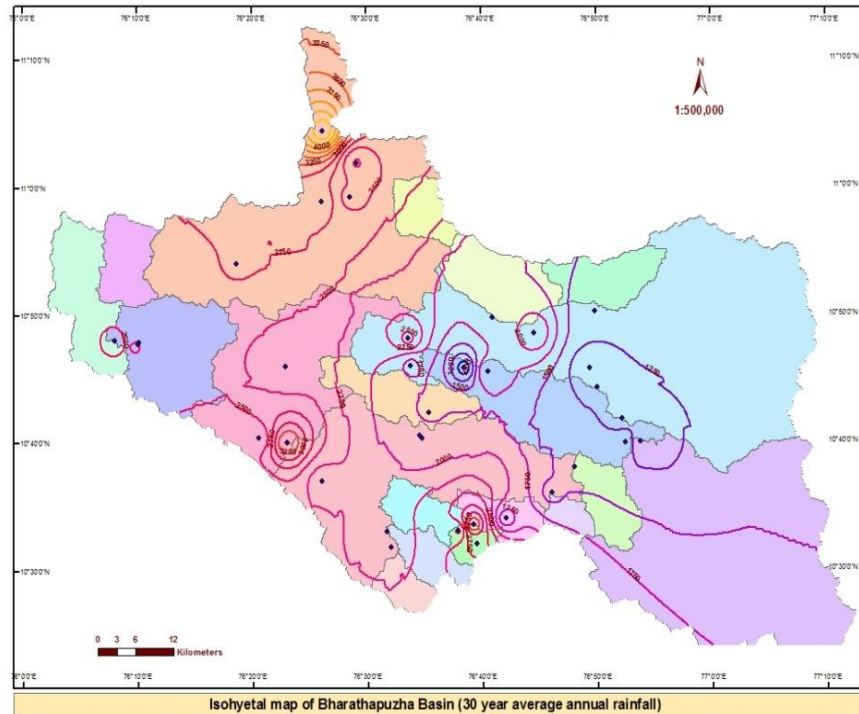
15:35 07/08/2013

DSS (P) - Publishing information on web

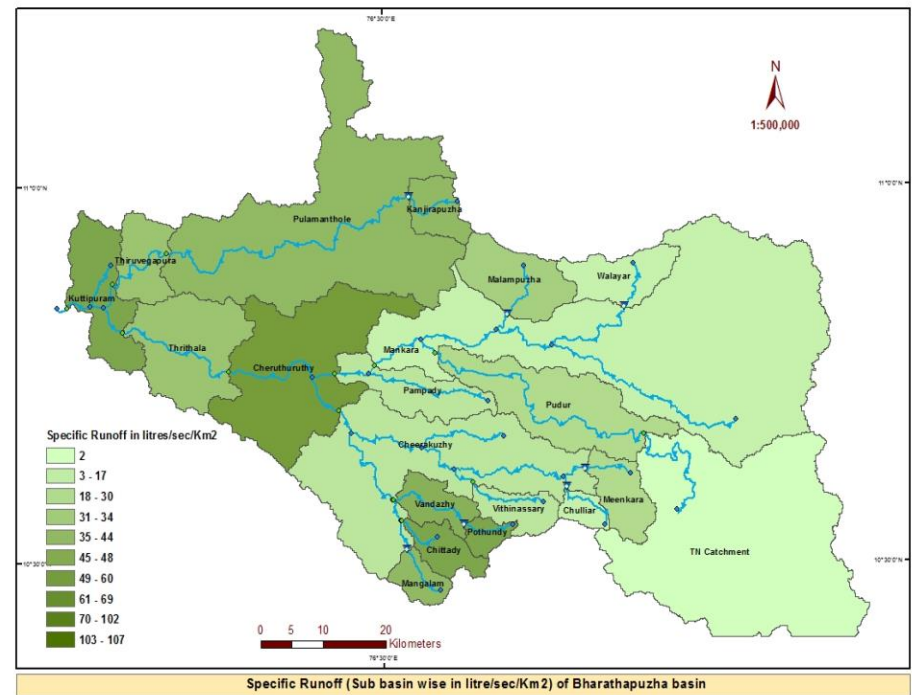


DSS (P) - Brief Description of Some Applications

Water Availability in the Basin



Rain fall distribution



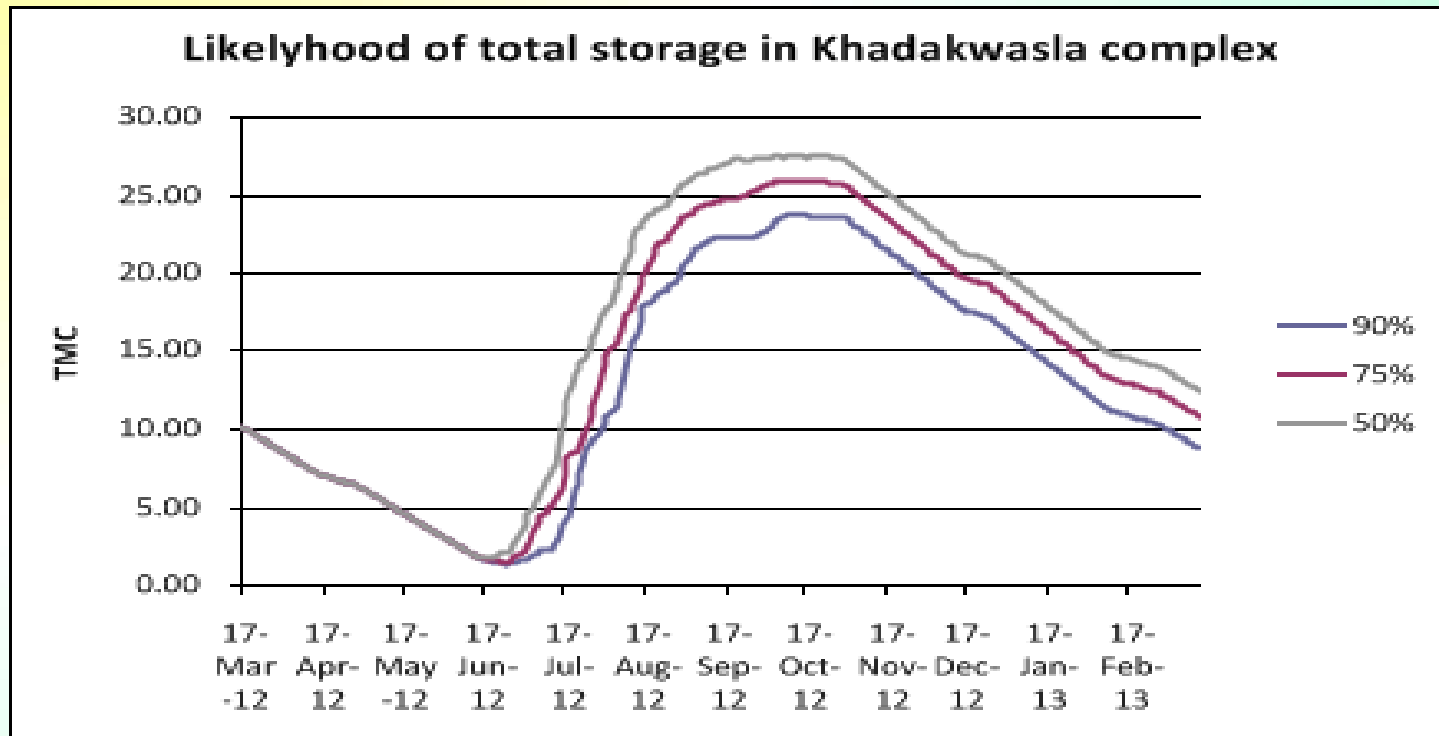
Specific runoff in the basin

DSS (P) - Brief Description of Some Applications

Seasonal Planning of Reservoirs

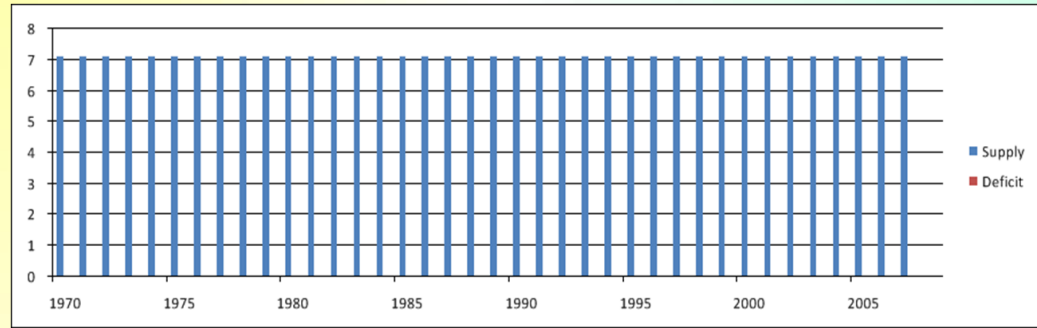
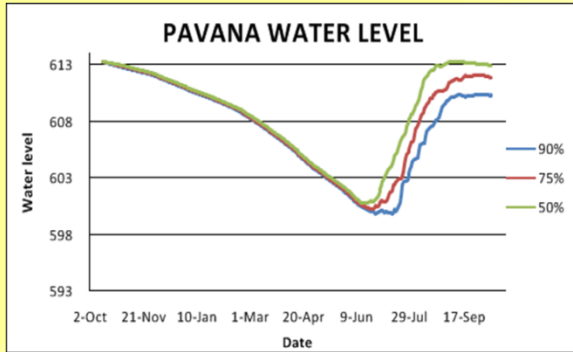
For given scenarios of planned water allocation:

- **What is the risk of reaching critically low levels in coming dry season?**
- **What is the likelihood of filling the reservoir in the coming wet season?**

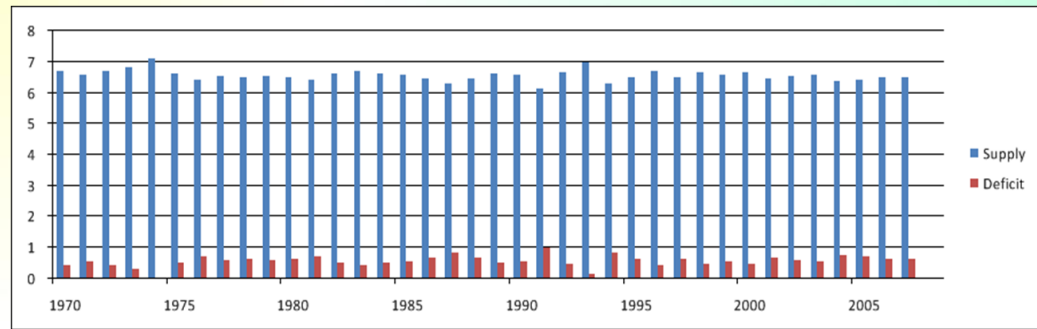
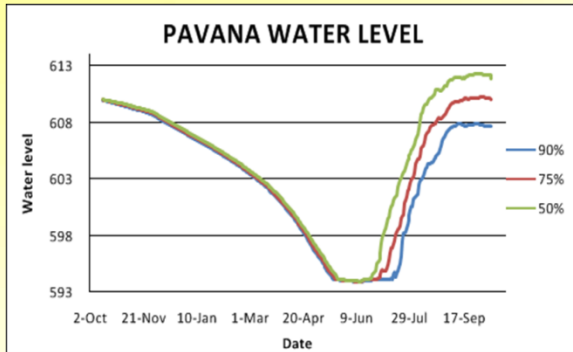


DSS (P) – Applications

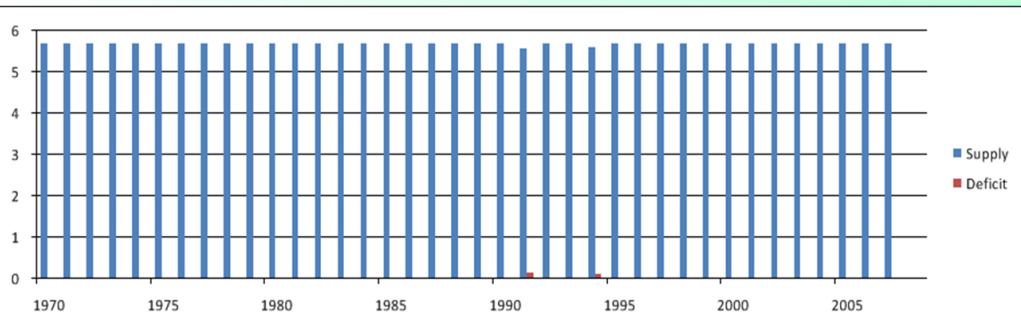
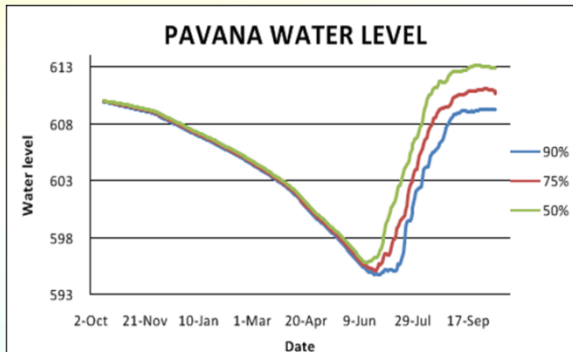
Pavana Seasonal Planning



**Initial
Level
FRL**



**Initial
Level
Reduced**



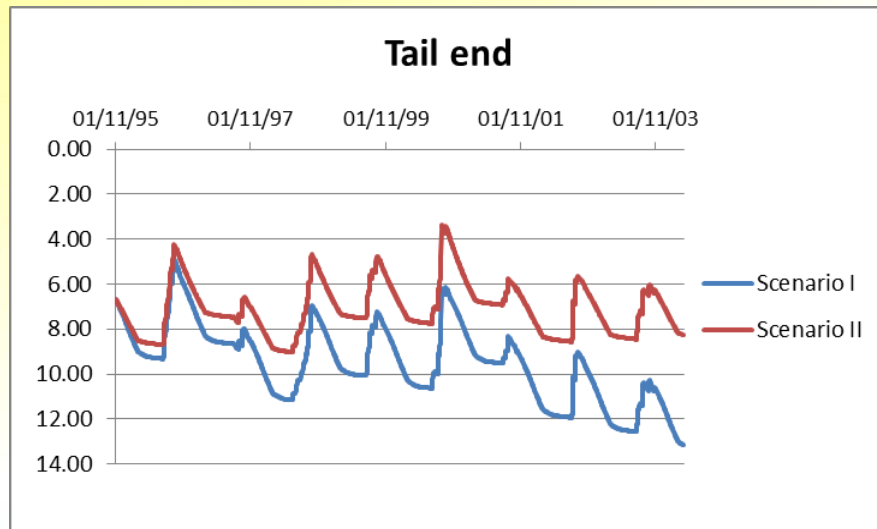
**Reduced
Demands**

DSS (P) - Brief Description of Some Applications

Conjunctive Use of SW & GW

Combined use of SW & GW in Sri Ram Sagar Project

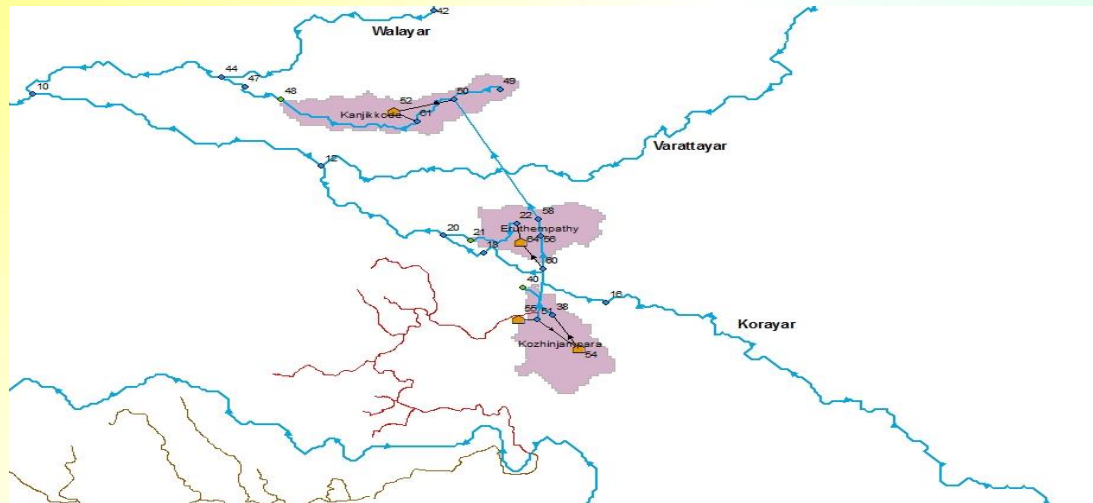
- ✓ **Scenario I: no restriction on SW use**
- ✓ **Scenario II: limited SW abstraction by head and middle section users permitted**



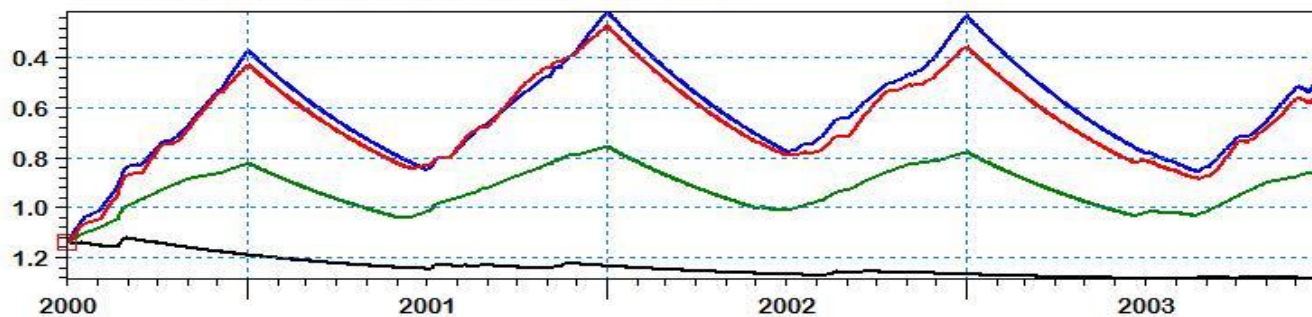
DSS (P) - Brief Description of Some Applications

Inter Sub-basin Transfer

To study viability of inter sub-basin water transfer during monsoon to rain shadow regions to augment ground resource.



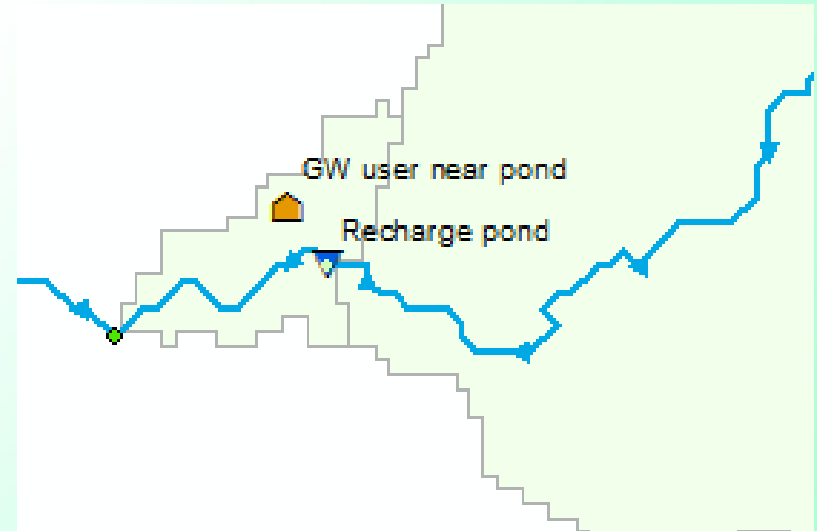
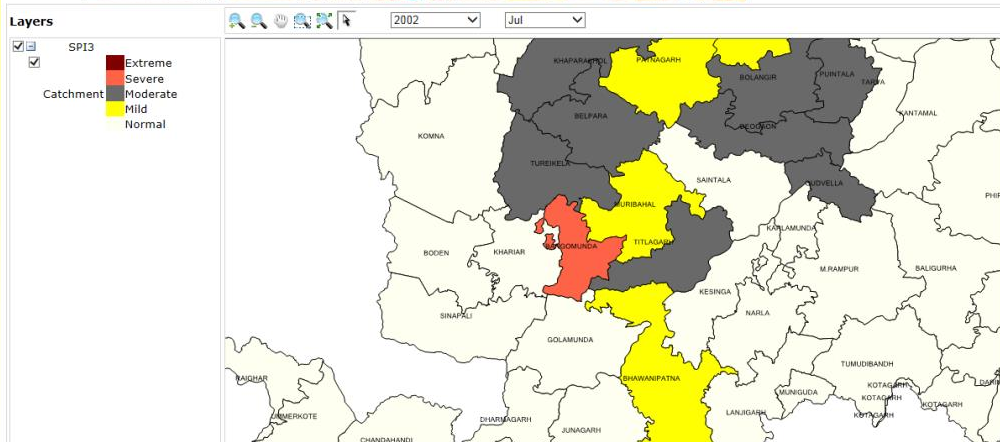
Before Recharge - Depth to deep groundwater [m] ———
Kanjikode - Depth to deep groundwater [m] ———
Eruthempathy - Depth to deep groundwater [m] ———
Kozhinjanpara - Depth to deep groundwater [m] ———



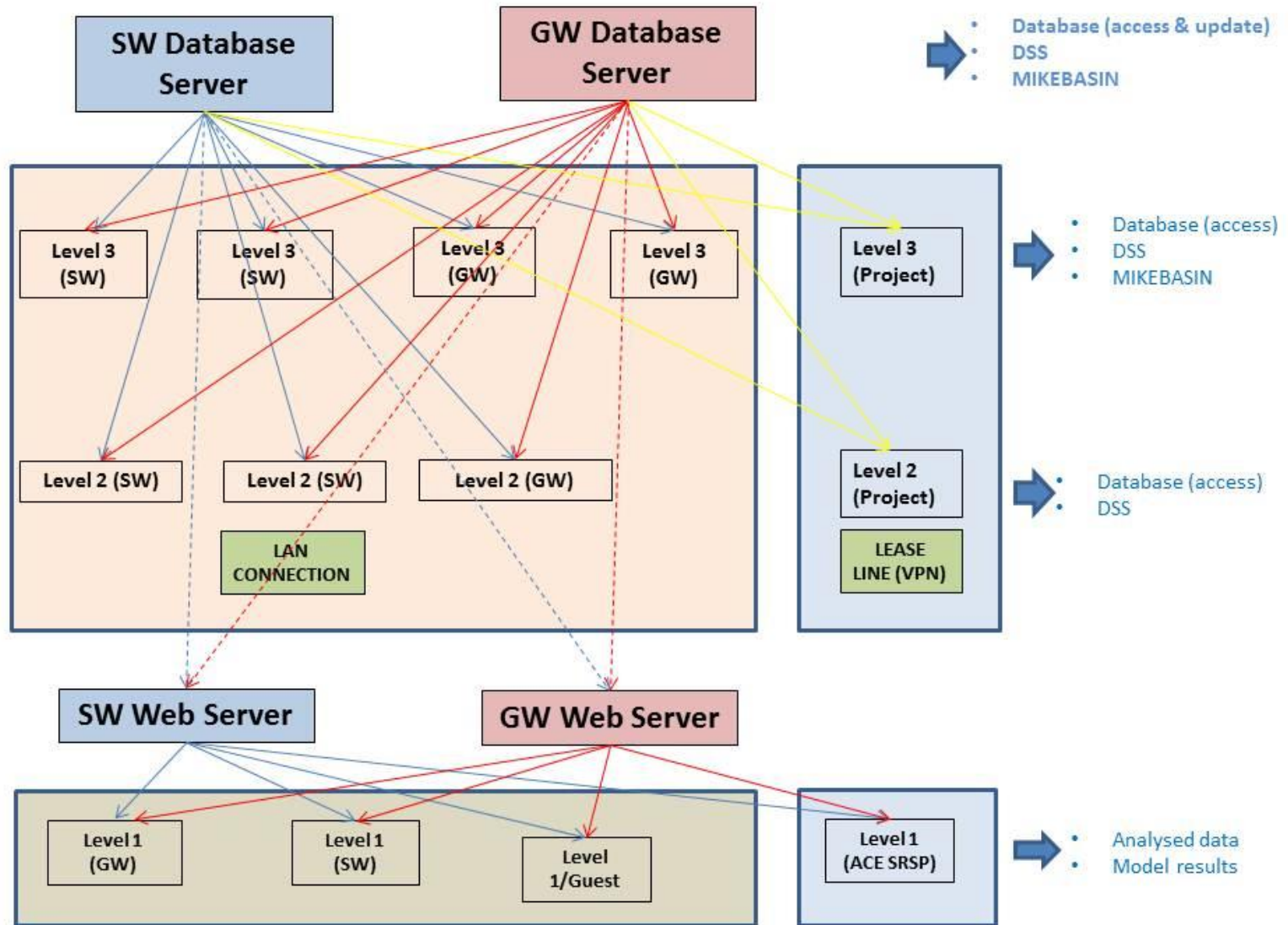
DSS (P) - Brief Description of Some Applications

Drought management

- Drought Indicators
- Assessing the impact of check dams and artificial recharge measures



State SW-GW Installations in Servers





THANKS