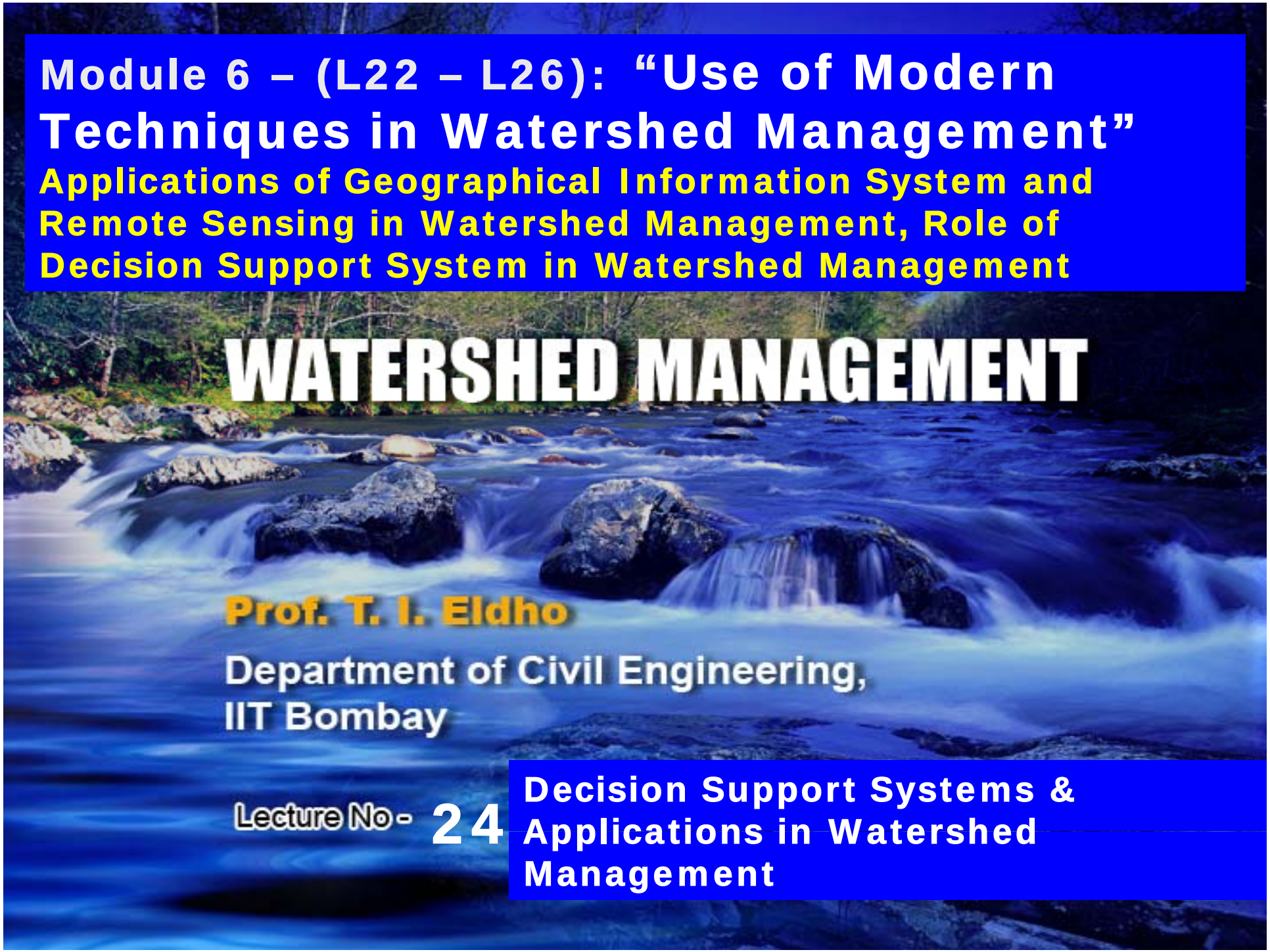
Module 6 – (L22 – L26): "Use of Modern Techniques in Watershed Management"

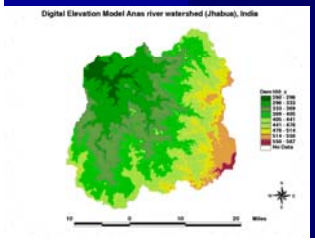
Applications of Geographical Information System and Remote Sensing in Watershed Management, Role of Decision Support System in Watershed Management

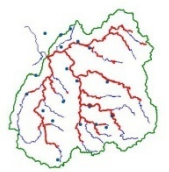


WATERSHED MANAGEMENT

L24– Decision Support Systems & Applications in Watershed Management

- **Topics Covered**
- Decision support systems (DSS), Basics, Characteristics of DSS, Components of DSS, DSS structure, Applications of DSS in water management, Applications of DSS in Watershed Management.
- Keywords: Decision support systems, characteristics, components, structure.





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Decision Support Systems - Basics

- Decision: a reasoned choice among alternatives
- DSS: a system that supports a manager or managers working as a problem-solving team in the solution of a semi-structured problem by providing information or making suggestions concerning specific decisions.
- In general terms, DSS are:
  - computer-based systems designed to support decision makers interactively in thinking & making decisions.
  - Dedicated- restricted but well defined area of application
  - systems incorporating modelling, analysis with data, database management systems & facilitate logistics of decision making process
  - interactive systems that help decision maker systematise decision making process

Decision Support Systems ...

- In general terms, DSS are:
  - providers of custom-built information

Decision making:

- a decision is a choice between alternatives to meet specific objectives
- the alternatives may represent:
  - different courses of action
  - different hypotheses
  - different use of a geographical entity etc.

Decision support:

- role of aiding the decision making process
- simplest level:
  - expert advice regarding a decision between alternatives
- most complex level:
  - dedicated computer systems
  - i.e. DSS eg. General climatic model

Characteristics of DSS

- Ability to support complex decision making
- Fast response to unexpected situations
- Ability to try different strategies quickly and objectively
- Improves management control and organizational performance
- Reduces cost of modeling considerably
- Large data handling capabilities, modeling capabilities & Interactive & graphical functions to make data easily usable.

Why Do We need DSS?.

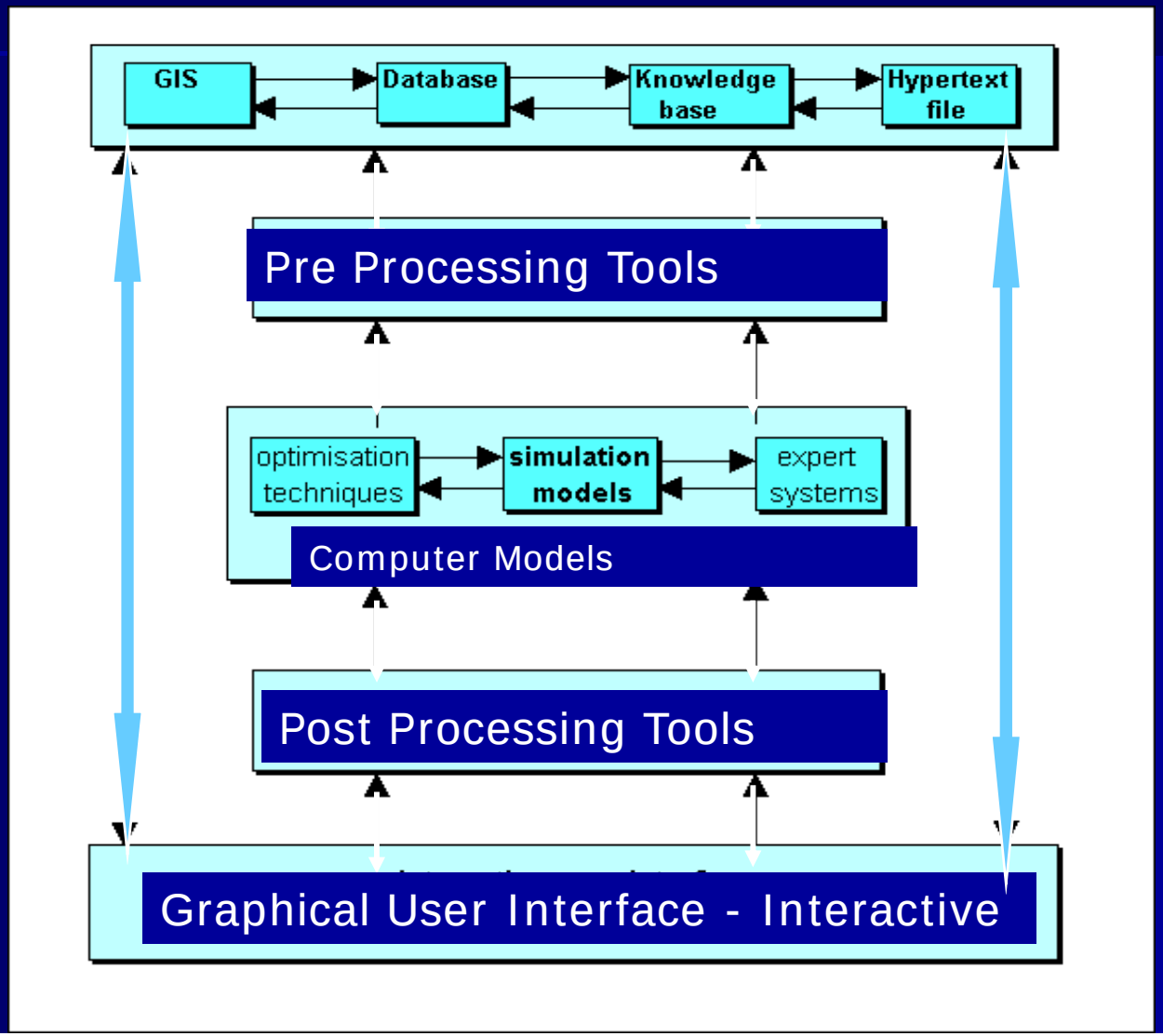
- Semi-structured approach to problem solving
- Large volume of information
- Integrate many information sources
- Models are difficult to use
- Deal with trade-offs: social, economic, biophysical, legislation
- Identify preferred options for further follow up

- Conflict! Making decisions to meet specific objectives often involves CONFLICT
- Solving these conflicts is the art of good decision making

Why DSS?.

- DSS does not take decisions
- Provides timely information
- Communicate result to a larger audience
- Open and unbiased working
- Scenario analysis
- *Using a DSS, a person responsible for the actual project is able to make rational use of the system without an in-depth knowledge of modeling techniques*

Typical DSS


GIS
Database
Knowledge base
Hypertext file
Pre Processing Tools
optimisation techniques
simulation models
expert systems
Computer Models
Post Processing Tools
Graphical User Interface - Interactive

Components of DSS

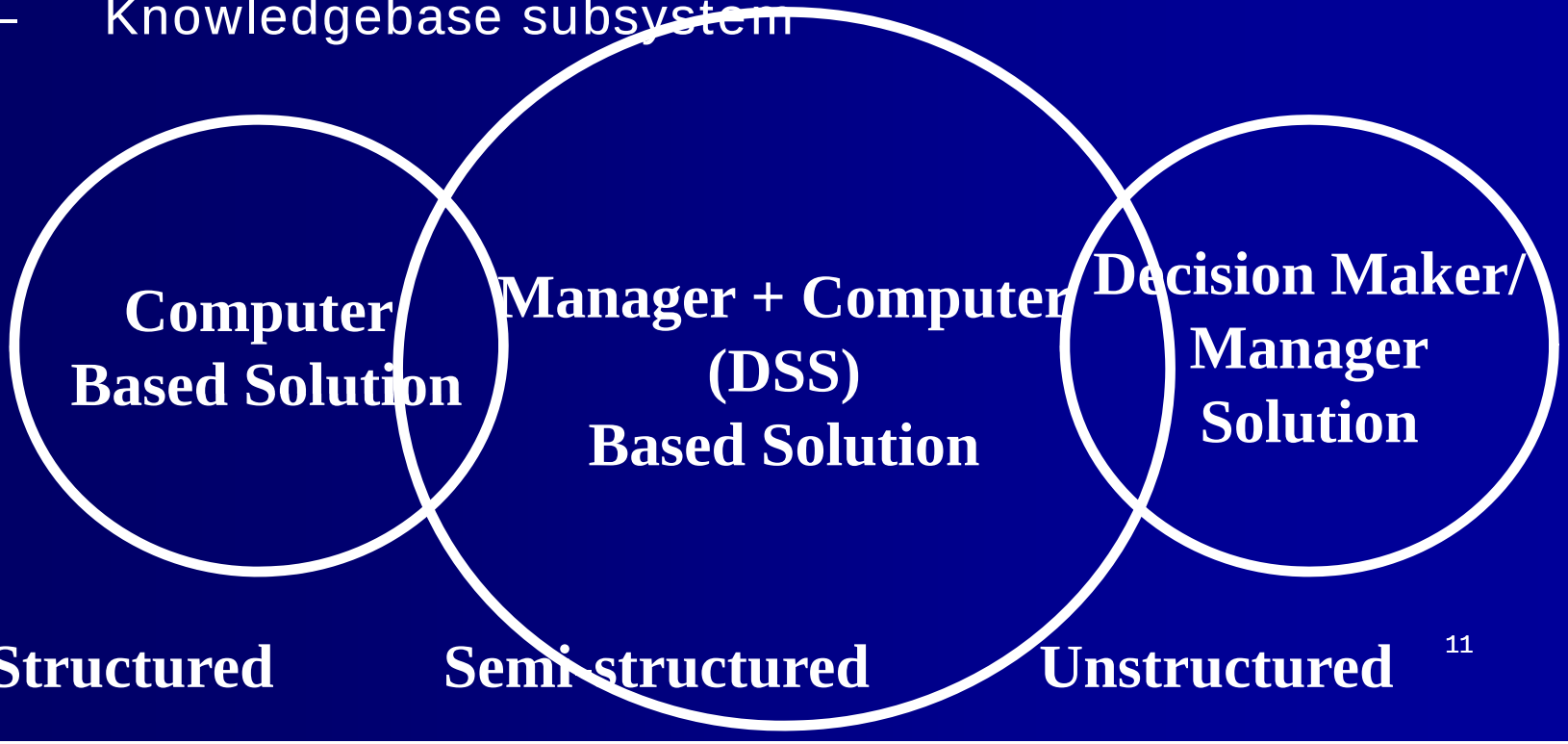
- Databases – Temporal, spatial
- GIS for spatial data
- Mathematical models
- Expert systems
- Statistical, graphical software, spreadsheets
- User interface
- **Database in a DSS** - data that are stored in a large pool from which different applications with different data requirements can retrieve.
- **Four major categories of data:** Spatial data; Temporal data; Relation data; Attribute data

Components of DSS...

- User Interface is software that helps the decision-maker to use the application easily & effectively.
- Well-designed user interfaces can free the user from learning complex command languages.
- A major part of the DSS development effort goes in design of user interface.
- Mathematical models are an important component of a DSS.
- The commonly used models include optimization, simulation, statistical models, decision analyses, genetic algorithms, neural networks etc.

DSS Structure

- The basic DSS structure include:
  - Database subsystem
  - Model base subsystem
  - User interface or dialog subsystem
  - Knowledgebase subsystem



DSS Structure

- **Database Management Tools**
  - Database management system is the software used for management of database
- **Model Base Subsystem**
  - It is the heart of the system
- **Dialogue Subsystem (User interface)**
  - It is the face of the system
- **Knowledgebase Subsystem**
  - Expertise for solving critical problems stored as rules to be followed during typical situations
  - It provide intelligence to decision makers @ decision

DSS Structure

- **Database Management Tools**

- Contains a procedural language along with hierarchical & relational data structure

The key capabilities of a Data base

- Extraction
- Updating
- Interrelate data from different source
- Retrieves data
- Provide comprehensive data security
- Complex data manipulation
- Manage Data through a data Dictionary

DSS Structure….

- **Model Base Subsystem**
- It contains 4 basic types of models:
- Strategic models; Tactical models; Operational models; Model building blocks and sub routines

- The key capabilities of a model base
- Create new models quickly
- Maintain wide range of models to support all levels of management
- Inter relate the models with the database
- Access and integrate the model building blocks
- Manage model base with management functions analogous to database management

DSS Structure….

- **Model Base Tools**

- Different modeling techniques commonly used in DSS model bases are:
- Optimization models
- Numerical models
- Artificial Neural Networks
- Fuzzy Logic based models
- GIS and Remote Sensing based models

Model Base Tools

- **Optimization Models:** Different techniques
  - Linear programming
  - Non-linear programming
  - Dynamic programming
  - AI Techniques
- **Numerical Models:** Used for solving partial differential equations;
- Commonly used methods
  - Finite element method (FEM)
  - Finite difference method (FDM)

Model Base Tools

- **GIS based Spatial Modeling:**
- GIS is a computer based system used for storing, manipulating and analysing data
- It provides timely information in a readily usable form
- **Remote Sensing Tools**
- Remote sensing data gives the detailed distribution of the parameters basin wide
- Useful for distributed modelling of the watershed
- Delineation of watershed, soil type, land use classification

Spatial Decision Support Systems

- Provides a decision-making environment to enable analysis of geographical information
- SDSS are DSS with mechanisms for input of spatial data
- Allow representation of the complex spatial relations and structures commonly found in spatial data
- Include analytical techniques unique to spatial and geographical analysis (including statistics)
- SDSS: Three level architecture
- **Tools:** general purpose hardware and software tools that can be assembled to build a variety of system modules
- **Technical supporter:** SDSS that can be configured to address specific problems
- **Builder:** takes domain specific data and develops the SDSS for a given application

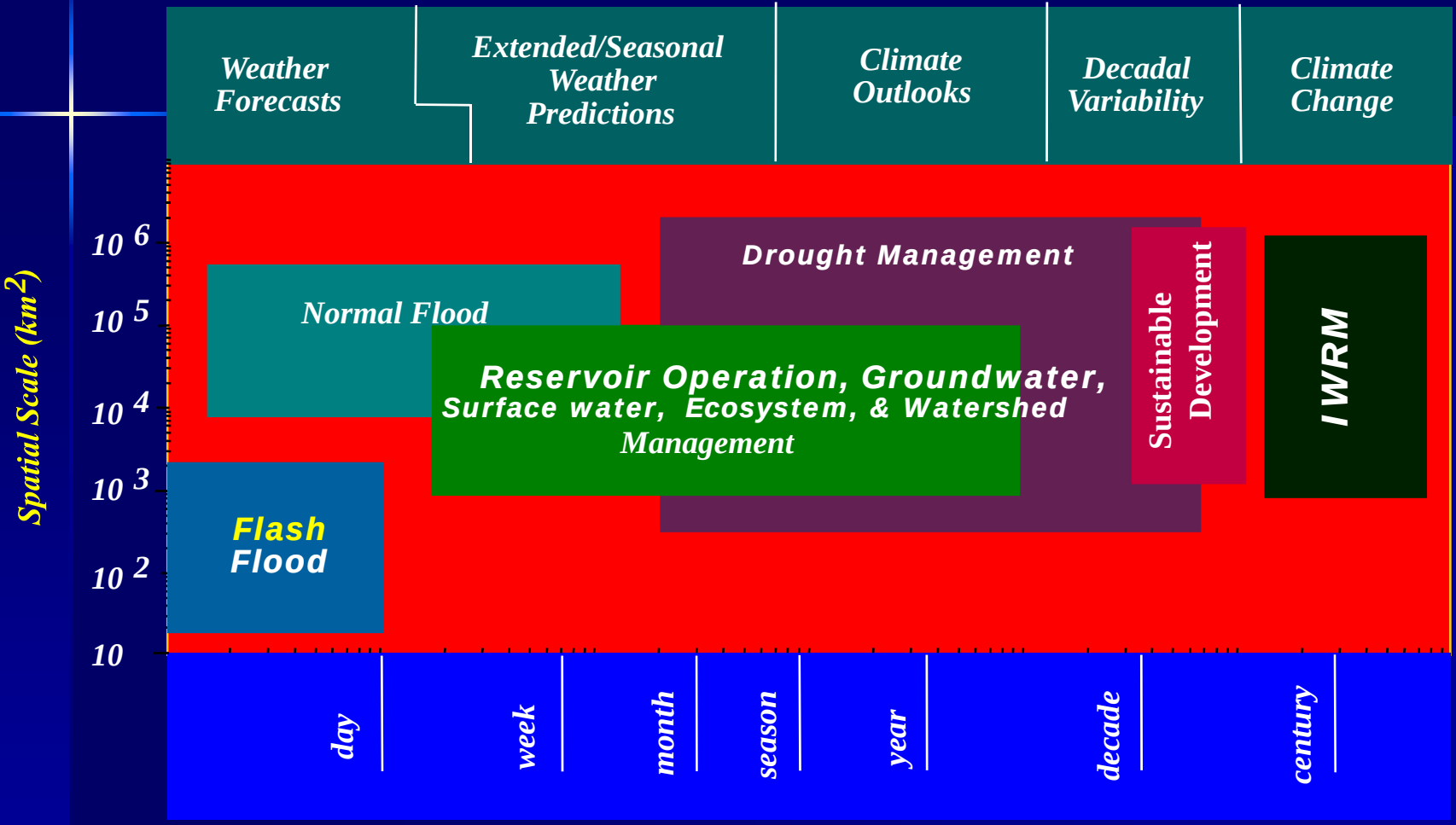
Spatial Decision Support Systems...

- DBMS - locational, topological and thematic data types to support cartographic display, spatial query, analytical modeling
- MBMS - model base management system to support statistical and numerical models which stores models instead of data
- Each model may be a small piece of code to solve a part of an algorithm
- Knowledge based reasoning, image processing may be part of the MBMS
- Graphical and tabular report generators
- 2-d and 3-d displays
- Bar charts, pie-charts, scatter plots, line plots, ...
- Application specific plots and reports

DSS Development Methodology

- DSS needs assessment
- DSS model Conceptualization
- Database Development
- Generic DSS Development
- DSS Customization
- DSS Testing/Refinement
- DSS Applications and Demonstration
- DSS Evaluation/ Fine tuning
- Dissemination/ Training & Out Reach Plan
- Preparation of Final Report

Water Issues in Space & Time – DSS Needs



DSS for Water Resources Planning

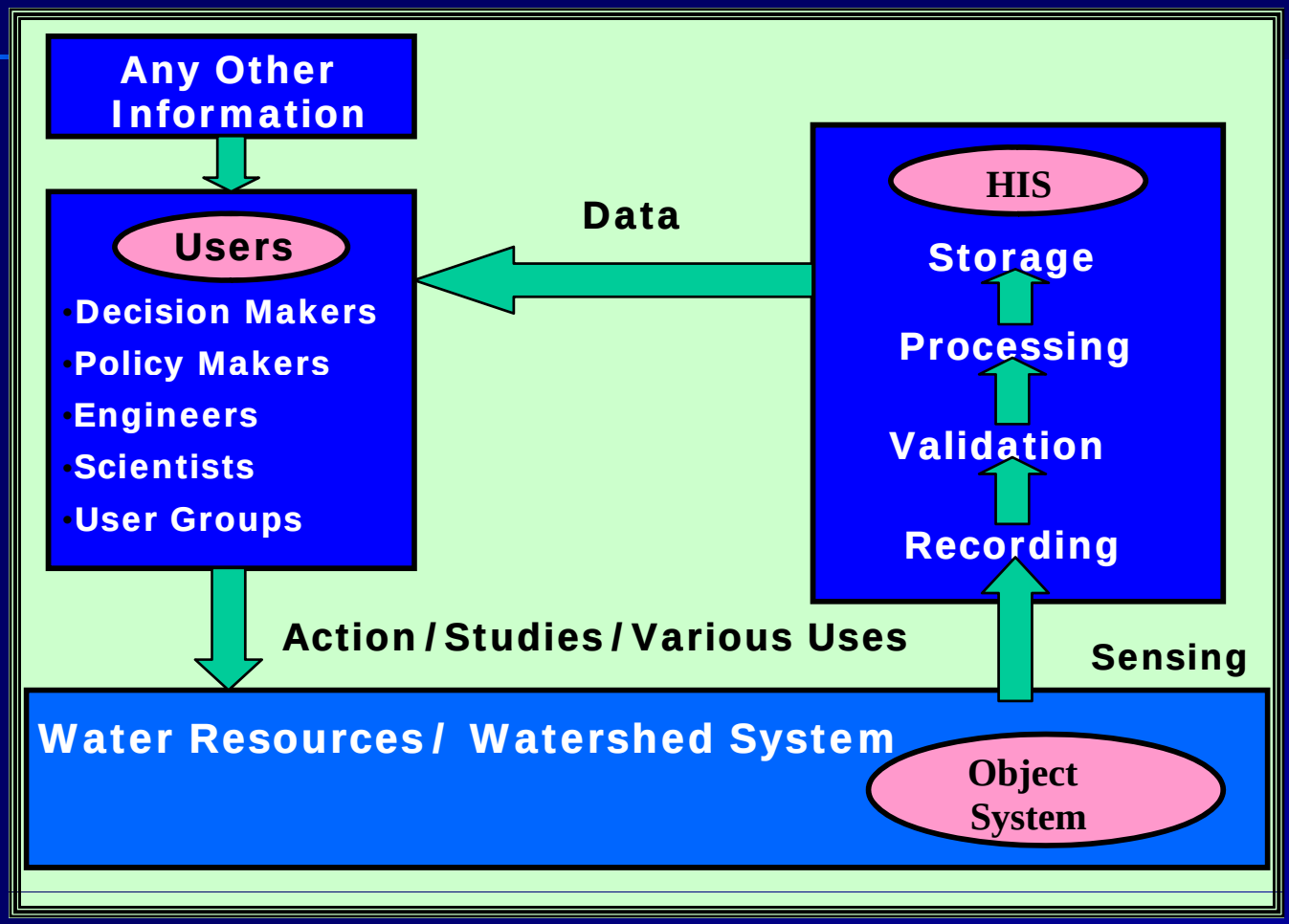
- Decision Support System (DSS) provides Water Management Authorities a well-structured, user-friendly, practical and complete water resources management information system.
- DSS may assist decision makers in taking the right decisions on the basis of good comparison of different strategies under various scenarios, & combine the benefits of GIS, expert systems & simulation models
- Water Resources Planning - Daunting challenge

- *Resource-wise complexity*
- *Society-wise complexity*
- *Economy-wise complexity*

DSS in Water Resources Planning - Typical Components

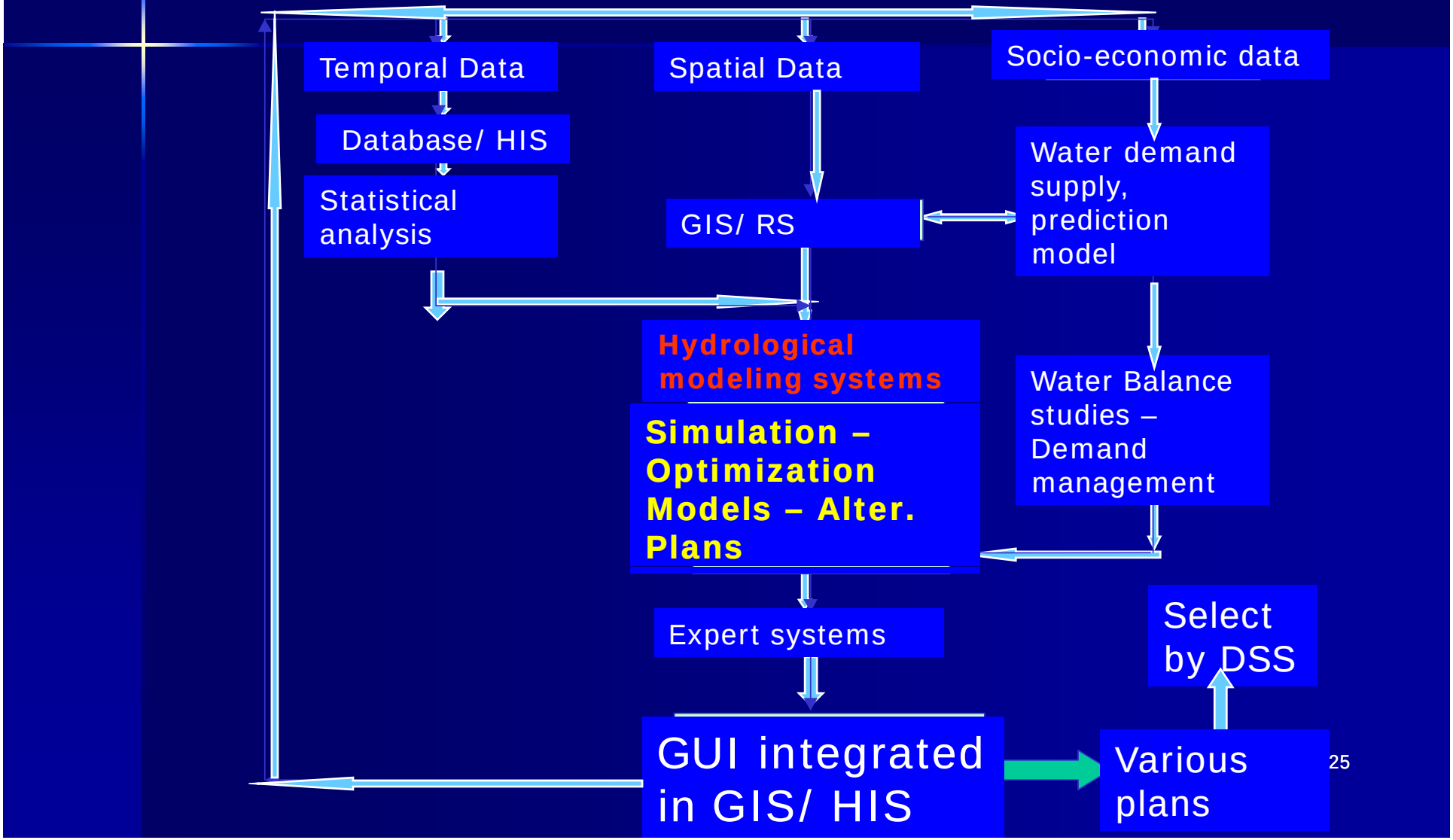
- Hydrological Information System
- Geographical Information System
- Information System for other required Data
- Remote Sensing Data Analysis System
- Statistical and Time Series Analysis Tool
- Demand Projection Module
- Hydrological Data Analysis System and Planning
- Optimization and Simulation Module
- Economic Analysis Module
- Graphical User Interface

Hydrological Information Systems & Data Processing



Architecture of Typical Hydrological Information System

Typical DSS for Watershed Management



DSS Software for Water Resources Planning

- MULINO decision support system (mDSS), Venezia, Italy.
- MIKE BASIN, by the Danish Hydraulic Institute (DHI);
- BASINS, U.S.- Environmental Protection Agency
- SDSS for Evaluation of Water Demand & Supply Management Schemes, Technical University of Athens
- IQQM, Queensland Department of Natural Resources
- ENSIS, by the Norwegian Institute for Water Research
- REALM, Victoria University of Technology & Dept. Natural Resources & Environment, Victoria, Australia
- RIBASIM, by Delft Hydraulics
- WEAP, by the Stockholm Environment Institute
- AQUATOOL, by the Universidad Politecnica de Valencia, Spain
- IRAS, Civil Dept. Cornell University & Resources Planning Asso.

Case Study: Barvi Reservoir on Barvi River in Badlapur – DSS based on GIS

- Length of Dam : 746.70 m; Storage Capacity Gross: 178.50 MCM; Dead : 1.64 MCM; Live/Usable: 176.86 MCM Catchment area: 166.02 Sq.Kms; Original Natural Source: Barvi river at village Pimploli Taluka : Kalyan District : Thane
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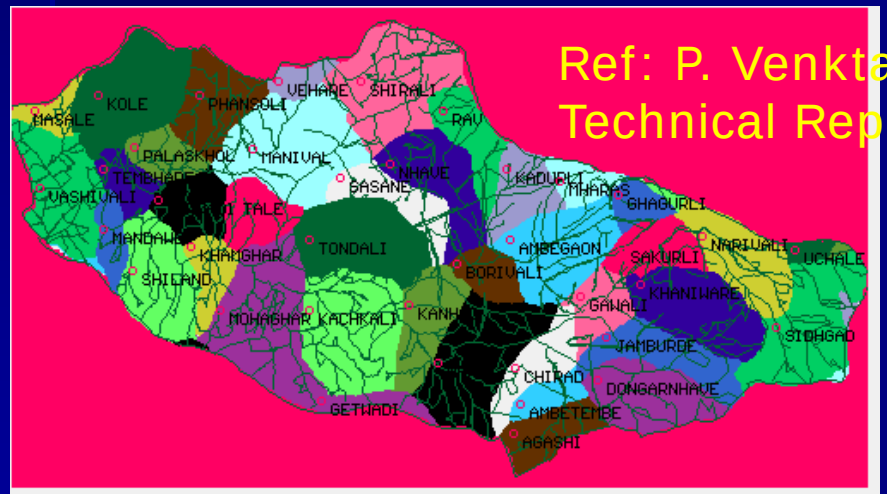
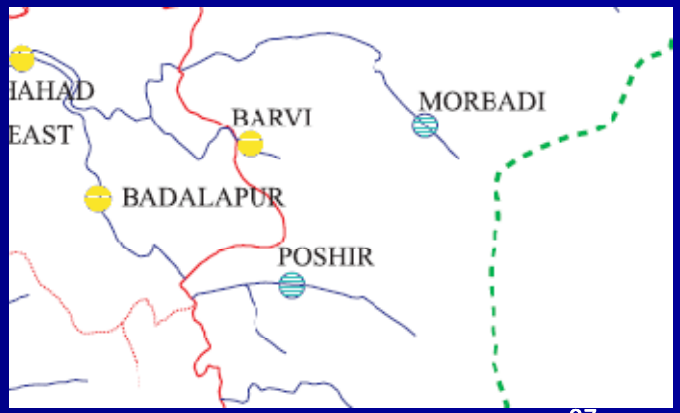


BARVI CATCHMENT DRAINAGE MAP

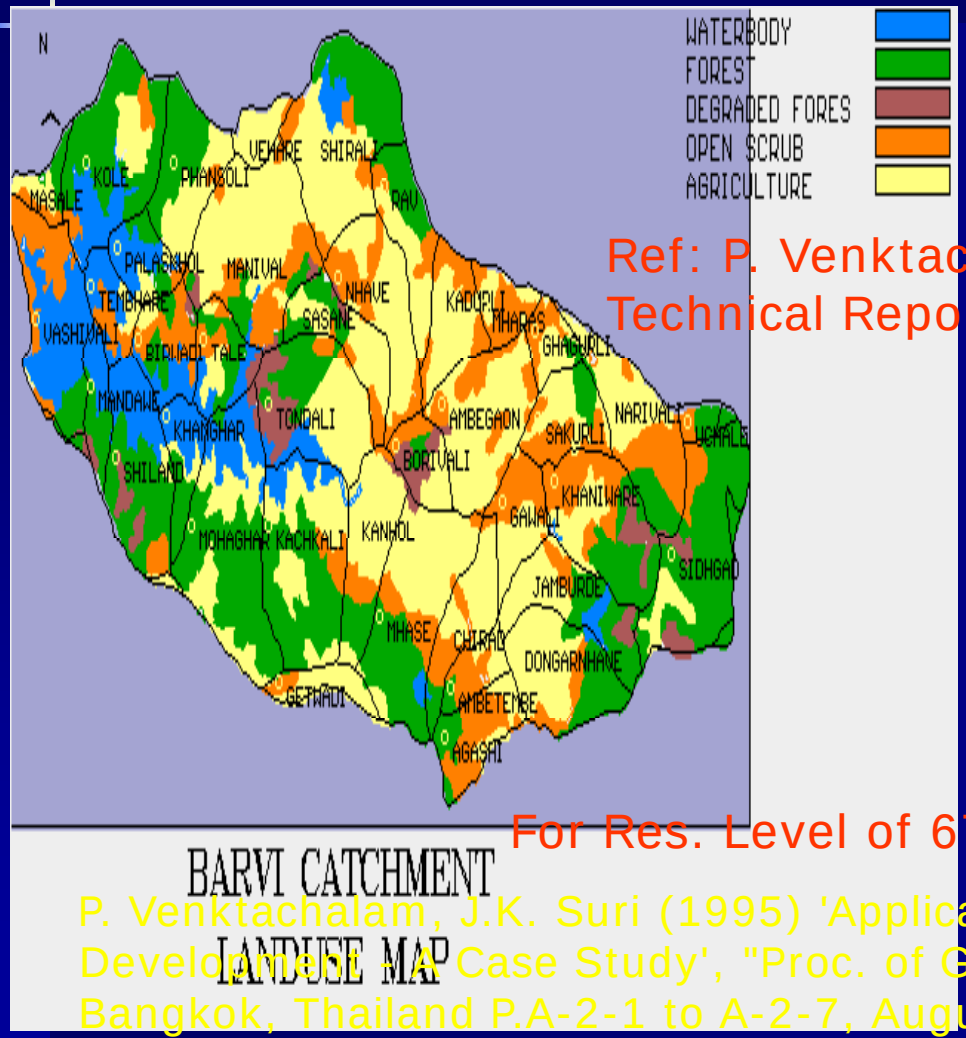
Ref: P. Venktachalam, J.K. Suri,(1995) CSRE Technical Report, IIT Bombay



Case Study: GIS based DSS

- **Objectives**
- Generate current landuse/ landcover information from remote sensing.
- Simulate new submergence for each value of raised height of Barvi reservoir.
- Compute increase in capacity of reservoir.
- Identify submergence village-wise, landuse/ land cover-wise.
- Provide necessary inputs for the decision makers to take optimal decisions based on cost v/s benefit analysis.

Case Study: GIS based DSS

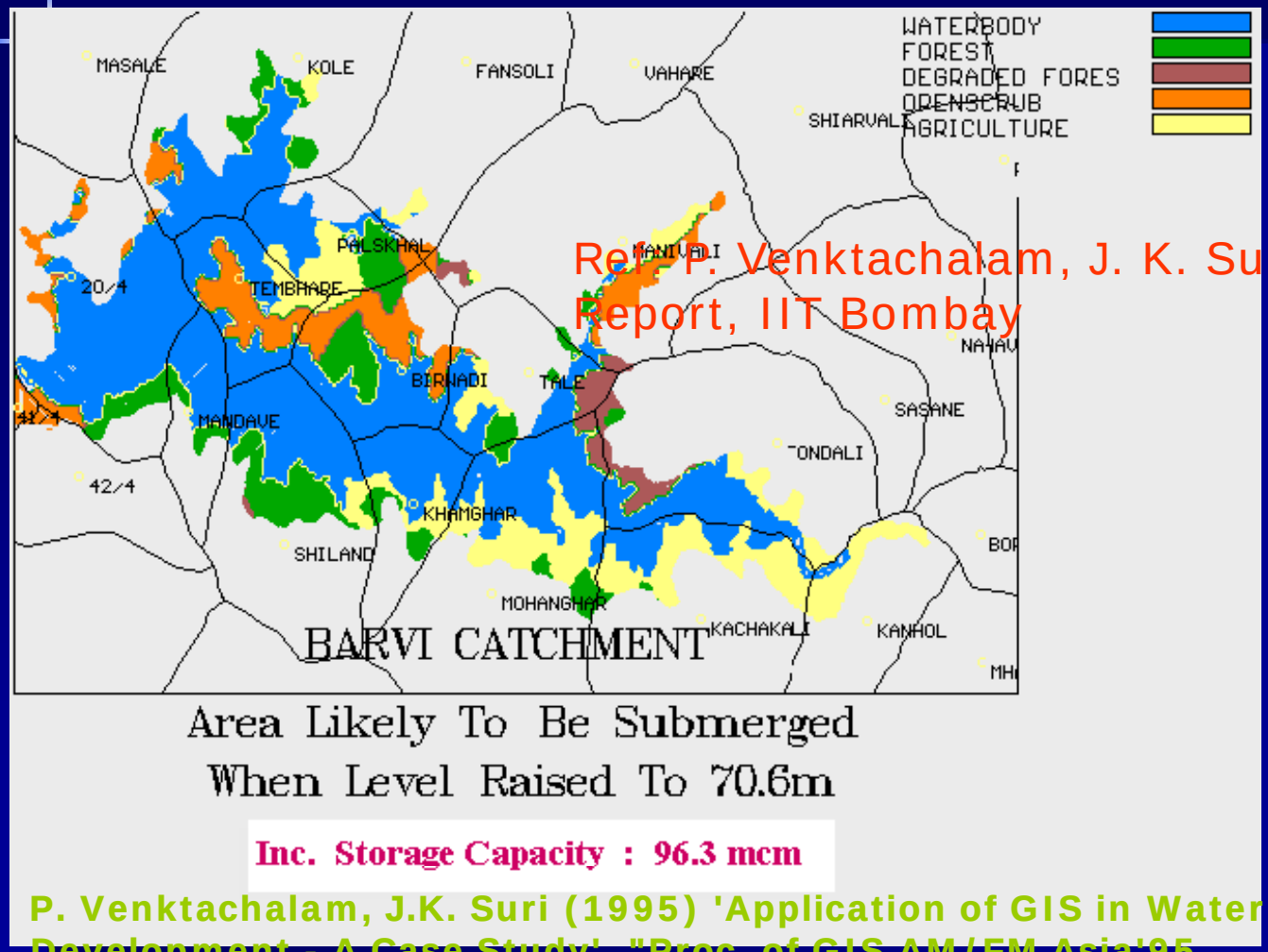


Ref: P. Venktachalam, J.K. Suri (1995) CSRE Technical Reportt, IIT Bombay

For Res. Level of 67m

P. Venktachalam, J.K. Suri (1995) 'Application of GIS in Water Resources Development – A Case Study', "Proc. of GIS AM/FM Asia'95, Bangkok, Thailand P.A-2-1 to A-2-7, August, 1995.

Case Study: GIS based DSS



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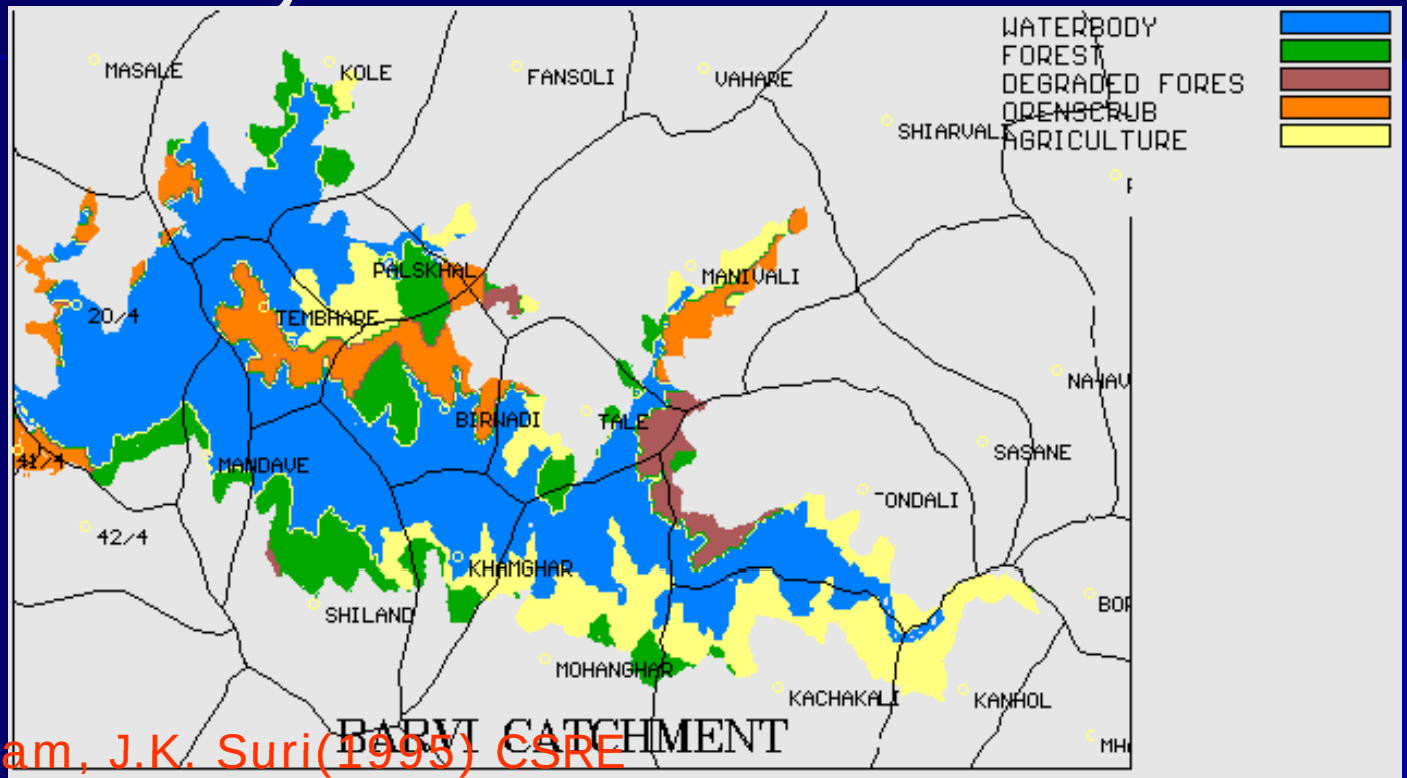

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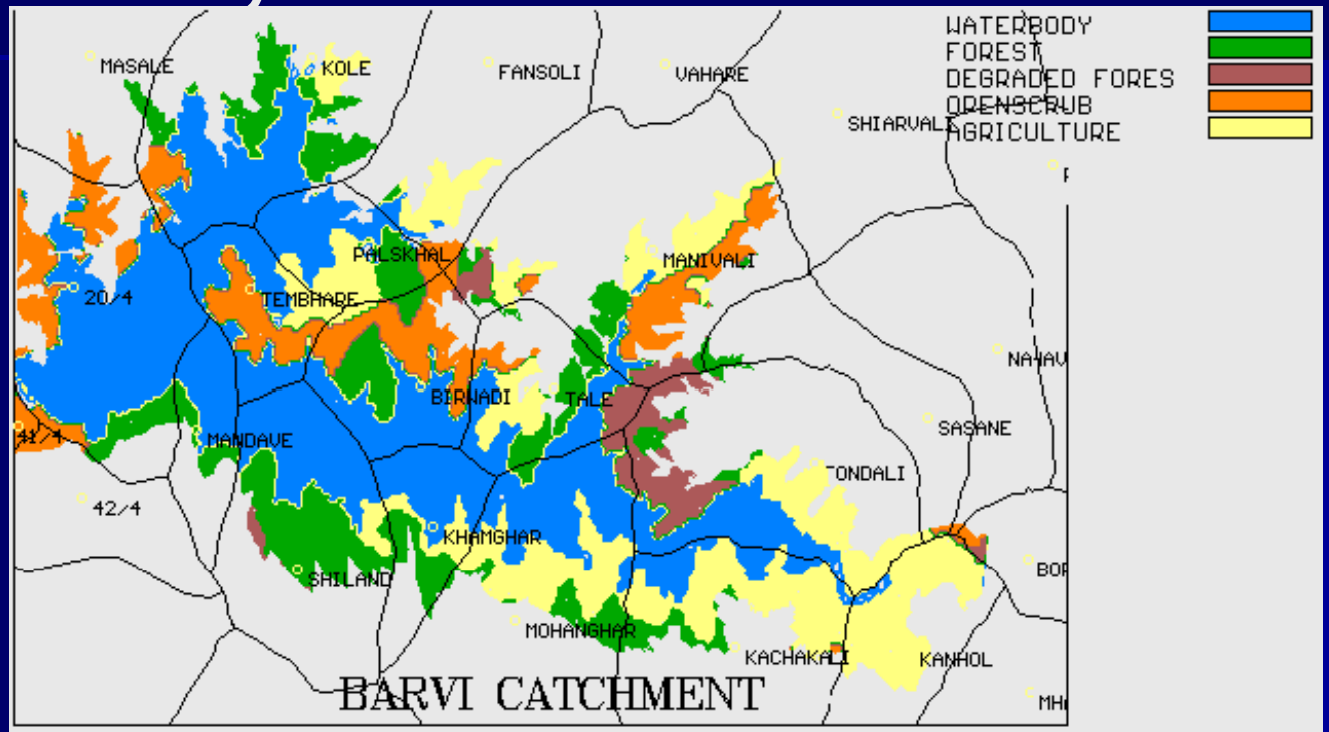

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Case Study: GIS based DSS

Result

GIS methodology is used to visualize alternative scenarios of impact on landuse and population at different elevation levels with the increased volume of water storage and presented to Government (MIDC) to plan the suitable action of the optimum elevation level i.e. (72.6m).

Barvi Dam Area Under Submergence-Landuse(in Hec.)

Sr no	Landuse	Level(70.6m)	Level(72.6m)	Level(76 m)
1	Agriculture	38.6	97.9	391.6
2	Forest	50.8	95.9	418.6
3	Degraded Forest	8.2	17.0	85.9
4	Open Scrob/Stony	10.6	23.9	148.4
5	**Total**	109.9	234.4	1044.0

Elevation Level	Increased Storage Capacity
70.6	96.3
72.6	145.6
76	246.1

Increased Storage Capacity At Different Elevation Level(in mcm)

Ref: P. Venktachalam, J.K. Suri (1995) CSRE Technical Report, IIT Bombay

DSS – Concluding Remarks

- Water management involves many processes, which are modelled individually or collectively by DSS
- DSS helps the water managers to take the optimal decisions in complex situations
- DSSs developed - applied to a particular basin or a basin with similar characteristics
- DSS – needed for all the irrigation watersheds, to make most of the available fresh water resources
- Watershed management - participatory decision making - INTERACTIVE DSS - end user can input his data, analyse & query to get optimum solutions in less time with minimum cost.

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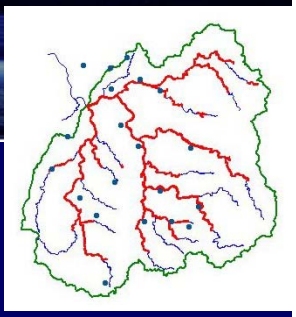
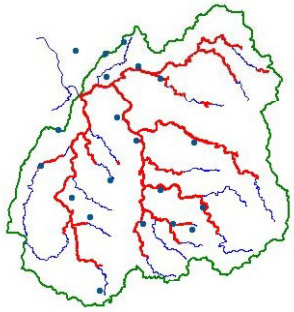


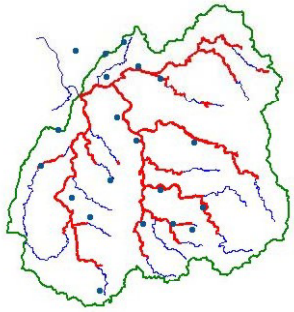
Tutorials - Question!.?.

- Critically study role of Decision Support Systems in development of effective Watershed Management Plans (details can be obtained from Internet).
- Evaluate the capabilities of various DSS software used for Water Resources planning. (details can be obtained from Internet).



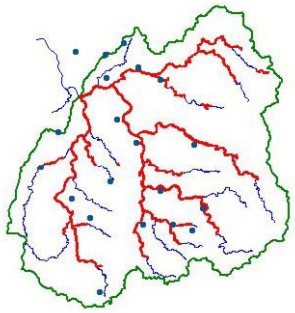
Self Evaluation - Questions!.

- Illustrate characteristics of a typical DSS.
- What are the important components of a DSS?.
- Describe important Model Base Tools.
- Mention step by step methodology for DSS development & implementation.
- Describe a typical Hydrological Information Systems.



Assignment- Questions?.

- Why do we need a DSS?.
- Explain the typical structure of DSS.
- Illustrate the characteristics of Spatial DSS.
- Describe the typical features of DSS for Water Resources Planning.
- Illustrate a typical Decision Support Systems for Watershed Management?.



Unsolved Problem!.

- For your watershed area, explore the possibility of using a DSS for effective water management plans.
- From the literature, identify a suitable DSS package for watershed management plans.
- Which are the other areas where DSS can be effectively used in watershed management development plans?.

THANK YOU

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