RECENT SIGNS OF WATER RELATED DISASTERS IN INDIA

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STATUS OF WATER RESOURCES IN INDIA

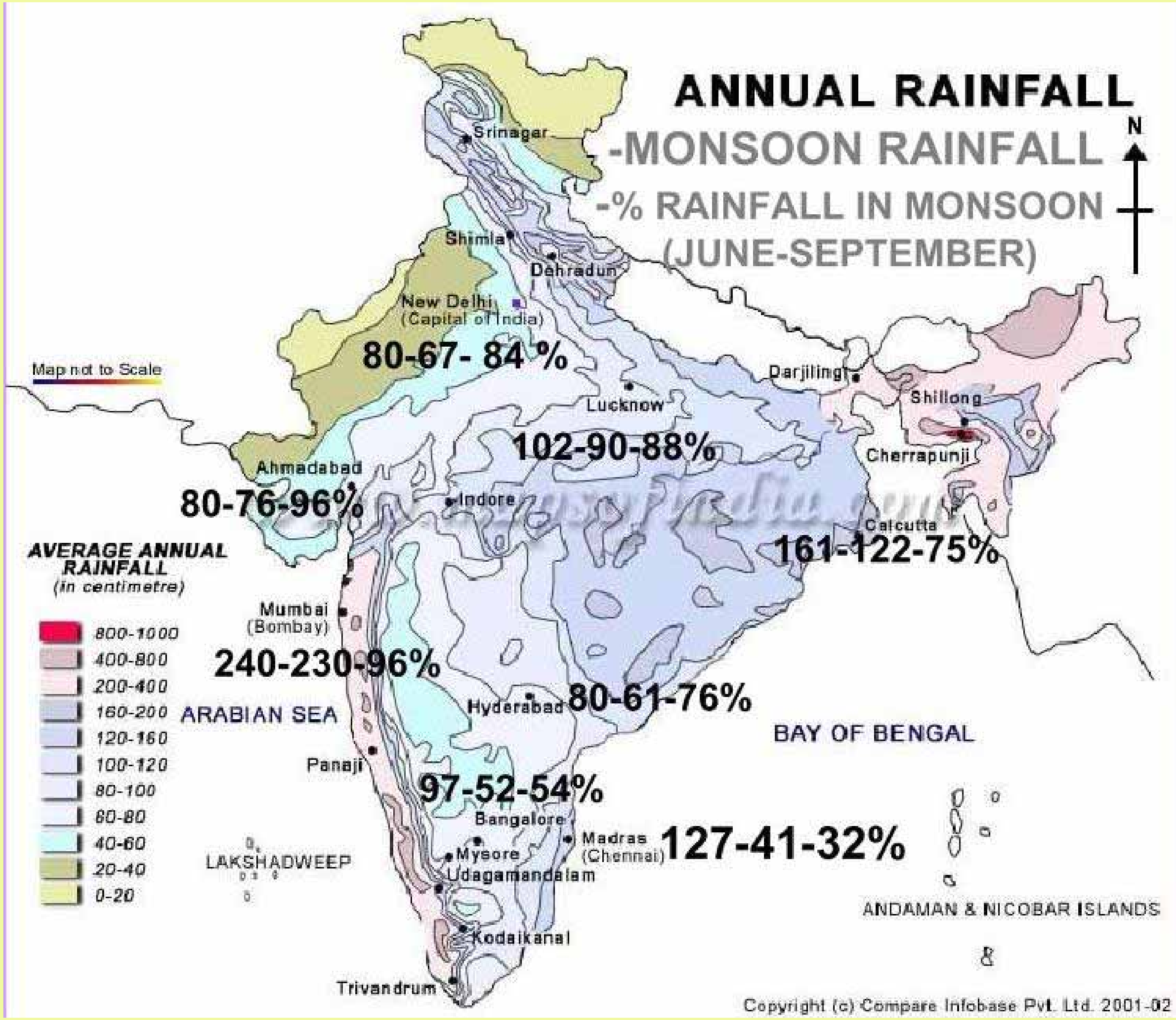
- **Although, India occupies only 3.29 million sq km geographical area, which forms 2.4% of the world's land area.**
- **It has 4% of water resources of the World.**
- **It supports over 16% of the world's population.**
- **Thus, India has about 1/50th of world’s land.**
- **It has 1/25th of world’s water resources.**
- **India also has a livestock population of 500 million, which is about 15% of the world's total livestock population.**

RAINFALL IN INDIA

- India receives annual precipitation of about 4000 km3, including snowfall. Out of this, monsoon rainfall is of the order of 3000 km3.

- The long-term average annual rainfall for the country is 1160 mm, which is the highest anywhere in the world for a country of comparable size.

- The annual rainfall in India however fluctuates widely. The highest rainfall in India of about 11,690 mm is recorded at Mousinram near Cherrapunji in Meghalaya in the northeast.



ANNUAL RAINFALL
-MONSOON RAINFALL
-% RAINFALL IN MONSOON
(JUNE-SEPTEMBER)
N
Map not to Scale
AVERAGE ANNUAL RAINFALL
(in centimetre)
800-1000
400-800
200-400
160-200
120-160
100-120
80-100
60-80
40-60
20-40
0-20
Srinagar
Shimla
Dehradun
New Delhi
(Capital of India)
80-67- 84 %
Lucknow
Darjiling
Shillong
Cherrapunji
102-90-88%
Ahmadabad
80-76-96%
Indore
Calcutta
161-122-75%
Mumbai
(Bombay)
240-230-96%
ARABIAN SEA
Hyderabad
80-61-76%
BAY OF BENGAL
Panaji
97-52-54%
Bangalore
Madras
(Chennai)
127-41-32%
Mysore
Udagamandalam
LAKSHADWEEP
ANDAMAN & NICOBAR ISLANDS
Kodaikanal
Trivandrum
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WATER RELATED HAZARDS

- FLOODS
- CYCLONES
- TSUNAMIS
- TIDAL SURGES
- AVALANCHES
- LANDSLIDES
- MUDSLIDES
- DROUGHTS

FLOOD PRONE AREAS IN THE WORLD

FLOOD HAZARDS

- Flood is the most frequent natural disaster claiming loss of life and property compared to any other natural disaster. About one-third of all losses due to nature's fury are attributed to floods.

- On an average floods claim a loss of more than 50 billion US dollars per year and 40000 victims per year in the last decades of the twentieth century in the world (Berga, 2000).

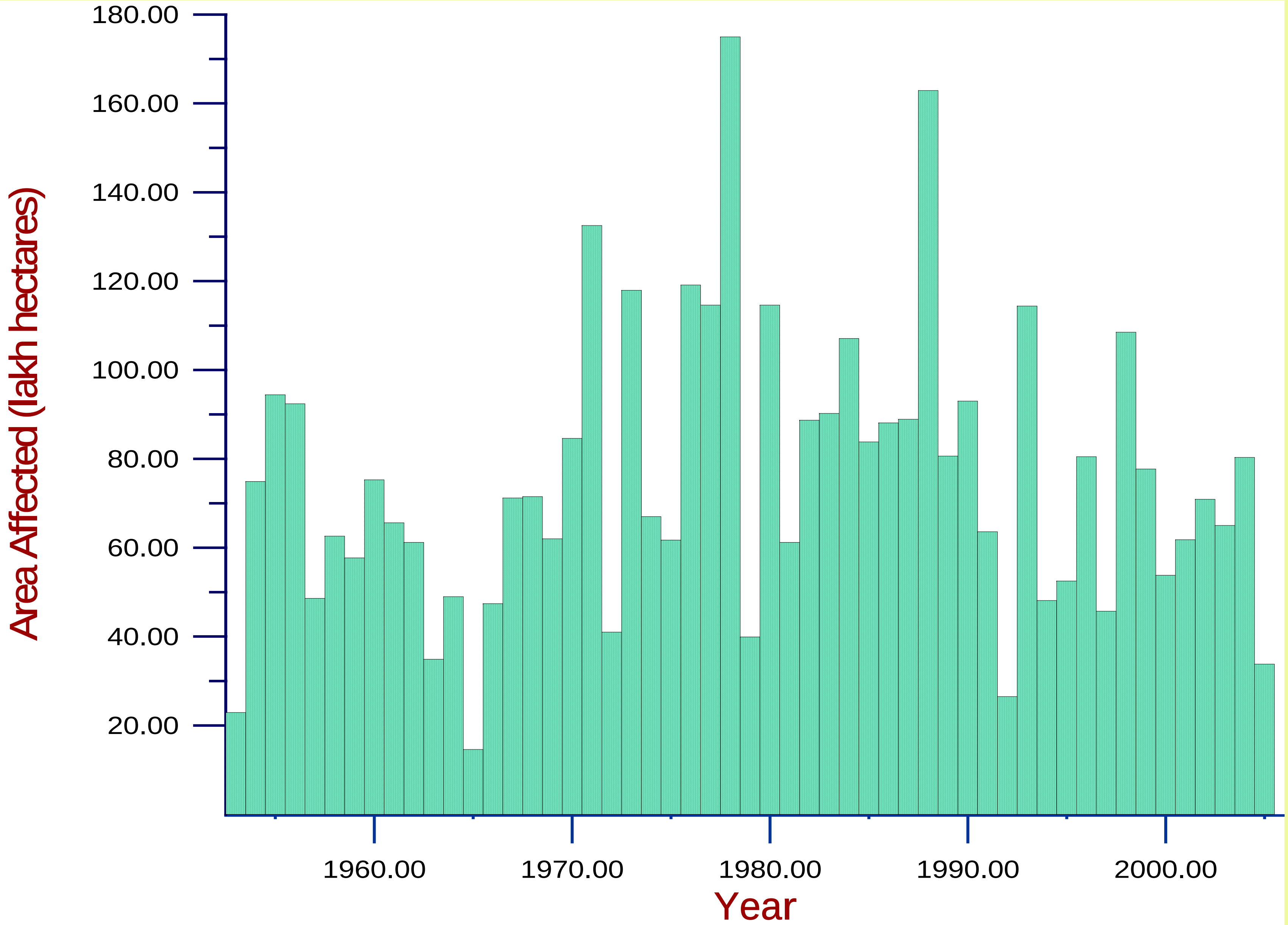
- Among all natural disasters, floods are the most frequent to be faced in India.

FLOOD HAZARD Contd…

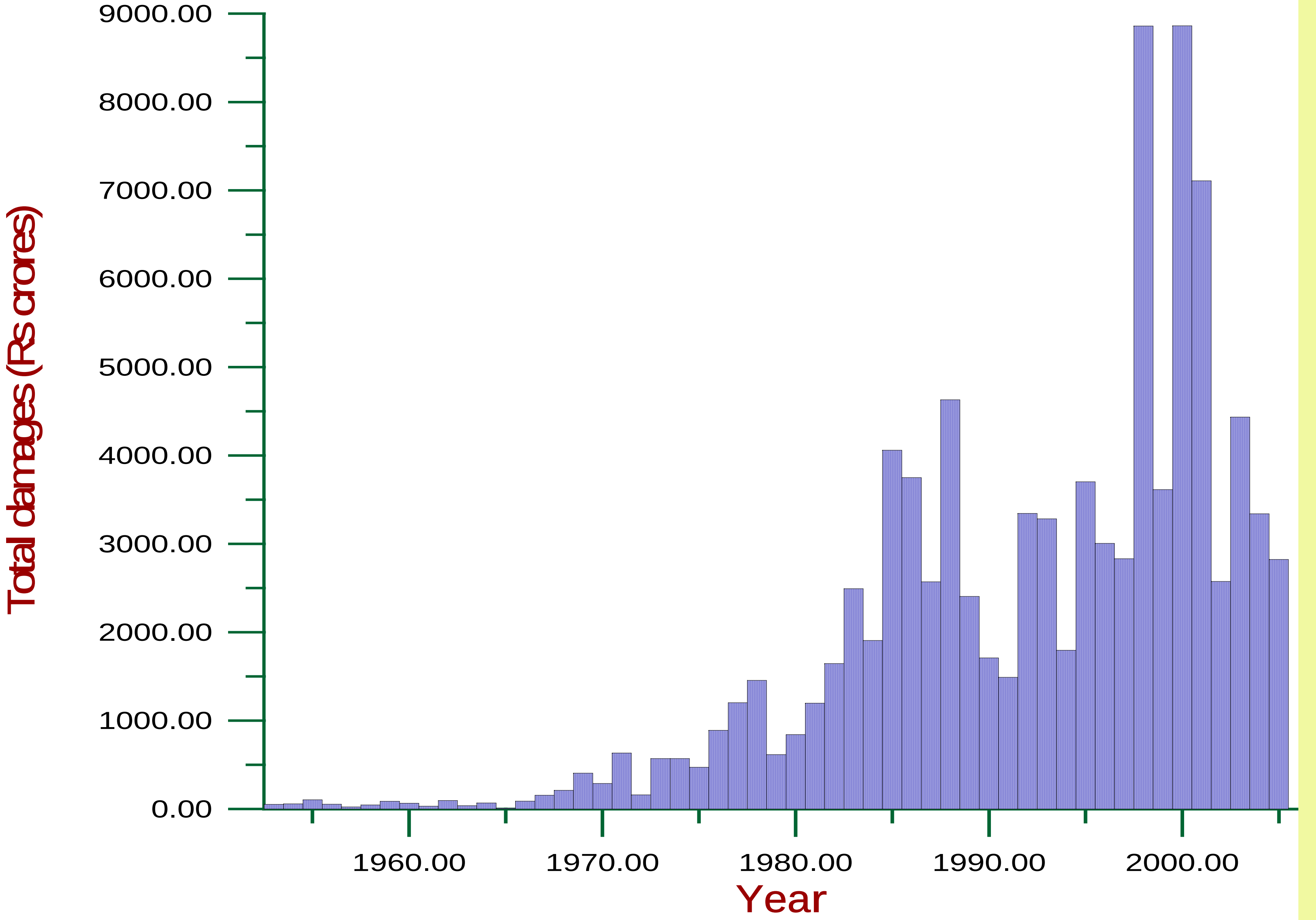
- The total area liable to flooding is about 40 million hectares.
- The annual average area affected by floods is 7.563 million ha.
- The annual average cropped area affected is approximately 3.7 million hectares.
- The average annual total damage to crop, houses and public utilities during the period 1953-95 was about Rs.972.00 crores, while the maximum damage was Rs. 4630.00 crores in 1988. in India.


India Flood Zone Map
Flood Zone

Year wise Area affected by Floods (1953-2005)



Year wise total damage by Floods (1953-2005)





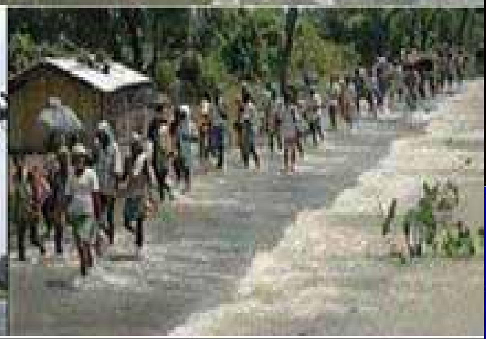
















AP



CAUSES OF FLOODS

- Intense precipitation
- Inadequate capacity within riverbanks to contain high flows, and silting of riverbeds
- Land slides leading to obstruction of flow and change in the river course
- Retardation of flow due to tidal and backwater effects
- Poor natural drainage
- Drainage congestion
- Cyclone
- Heavy rainstorms/cloud bursts
- Snowmelt and glacial outbursts
- Dam break flow and breaching of embankments.

SPECIAL FLOOD PROBLEMS

- **Problem of Tal Areas**
- **Breach of River embankment/ bed erosion**
- **Sediment transport by rivers**
- **Dam Break Floods**
- **Urban Flooding**
- **Flash Floods**
- **Flood due to Snow melt**
- **Flood in Coastal Areas**

FLOOD MITIGATION & MANAGEMENT

The Structural Measures of Flood Mitigation & Management are:

- Dams and reservoirs
- Detention basins
- Embankments
- Channel improvement
- Drainage improvement
- Watershed management

THE NON-STRUCTURAL MEASURES OF FLOOD MITIGATION & MANAGEMENT ARE:

- Flood forecasting
- Flood proofing
- Disaster mitigation system and preparedness
- Flood plain zoning and
- Flood insurance

THE NON-STRUCTURAL MEASURES OF FLOOD MITIGATION & MANAGEMENT:

- **The flood forecasting and flood warning in India commenced in 1958, for the Yamuna river in Delhi.**
- **The CWC has established a flood forecasting system covering 62 major rivers with more than 170 stations for issuing flood forecasts covering almost all the flood prone states.**
- **The response of state governments towards enactment of flood plain zoning bill is not encouraging.**
- **A working group of National Natural Resources Management System (NNRMS, 2002) recommended flood risk zoning using satellite based remote sensing with a view to give thrust towards implementation of flood plain zoning measures.**

NON-STRUCTURAL MEASURES Contd..

- **Flood Plain Zoning may be carried out using the hydrologic-hydraulic approach, remote sensing, GIS, flood frequency analysis and rating curve analysis.**
- **Based on the aforementioned methodology various types of maps such as:**

  (i) flood inundation maps,

  (ii) flood hazard maps,

  (iii) flood risk zone maps and

  (iv) flood plain zoning maps may be prepared.
- **Such maps provide detailed information on the areal extent, depth and duration of flooding as well as the associated risk.**
- **These maps may also be put to the broad spectrum of uses including implementation of land use regulations and flood plain zoning bylaws.**

The forecasts are issued at about 175 stations. Out of these 145 stations are for river stage forecasts and 28 for inflow forecasts to the reservoirs.

A Working Group of National Natural Resources Management System (NNRMS, 2002) standing committee on water resources for flood risk zoning of major flood prone rivers considering remote sensing input was constituted by the Ministry of Water Resources in 1999.

The working group recommended flood risk zoning using satellite based remote sensing with a view to give thrust towards implementation of flood plain zoning measures.

FLOOD HAZARD MODELLING AND FLOOD RISK ZONING

OBJECTIVES:

- To develop flood frequency relationships based on annual maximum peak flood series.
- To develop rating curves for gauging sites of the river reach under study.
- To prepare flood inundation and flood hazard maps for the river reach.
- To prepare flood risk zone maps for the river reach.

METHODOLOGY

- Estimation of floods of various return periods for the gauging sites of the river reach based on L-moments approach.
- Preparation of DEM of the study area using GIS.
- Computation of flooding for various return periods using HEC-GeoRAS 3.1& HEC-RAS 3.1.2 Packages.
- Development of flood inundation and flood hazard and flood risk zone maps for the study area relating the extent of flooding to its frequency as well as risk of occurrence of flooding.
- Evaluation of flooding patterns using satellite data.

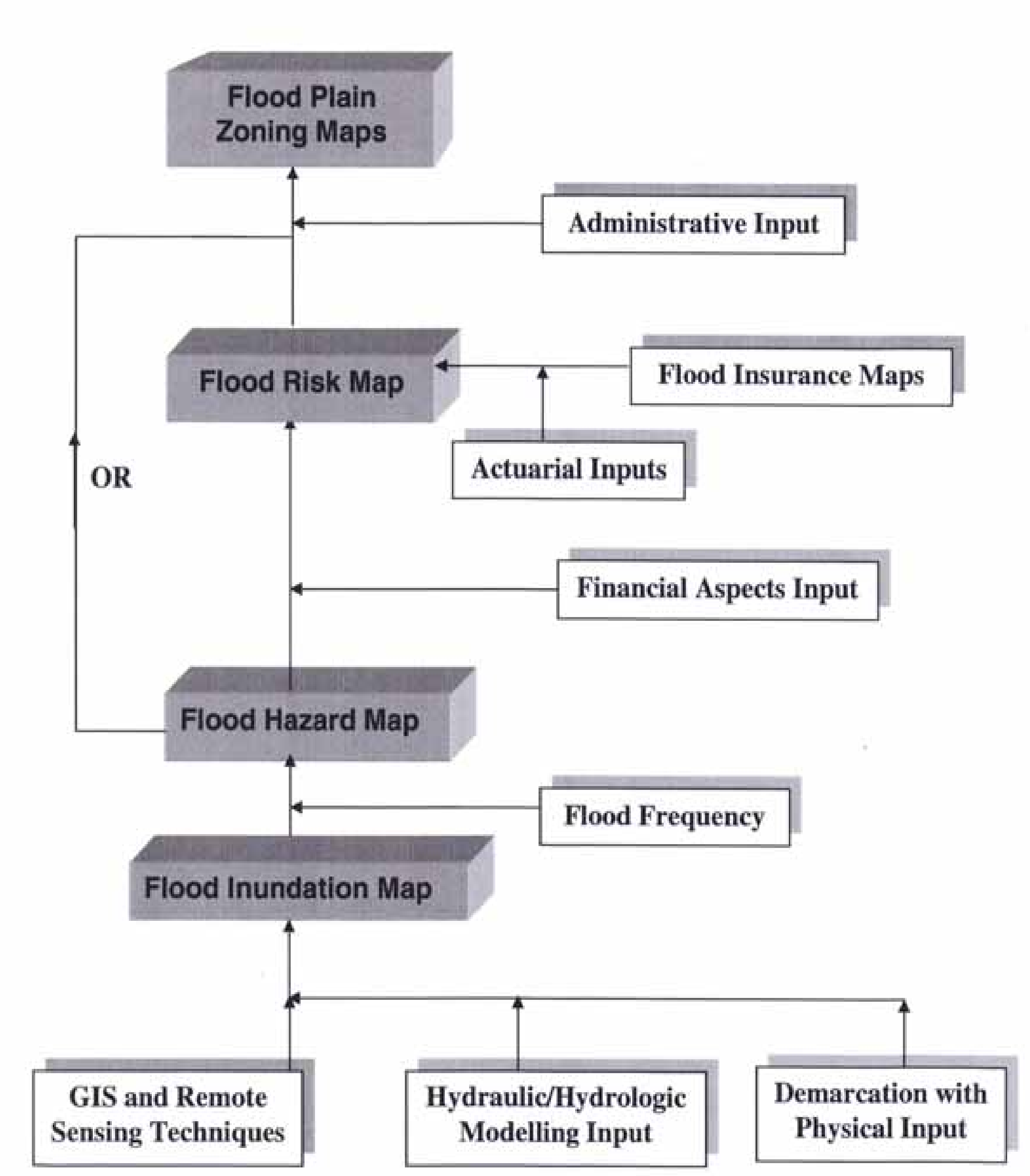


Fig. Flow chart illustrating the general terminology of flood inundation mapping flood hazard mapping, flood risk zone mapping and flood plain zoning

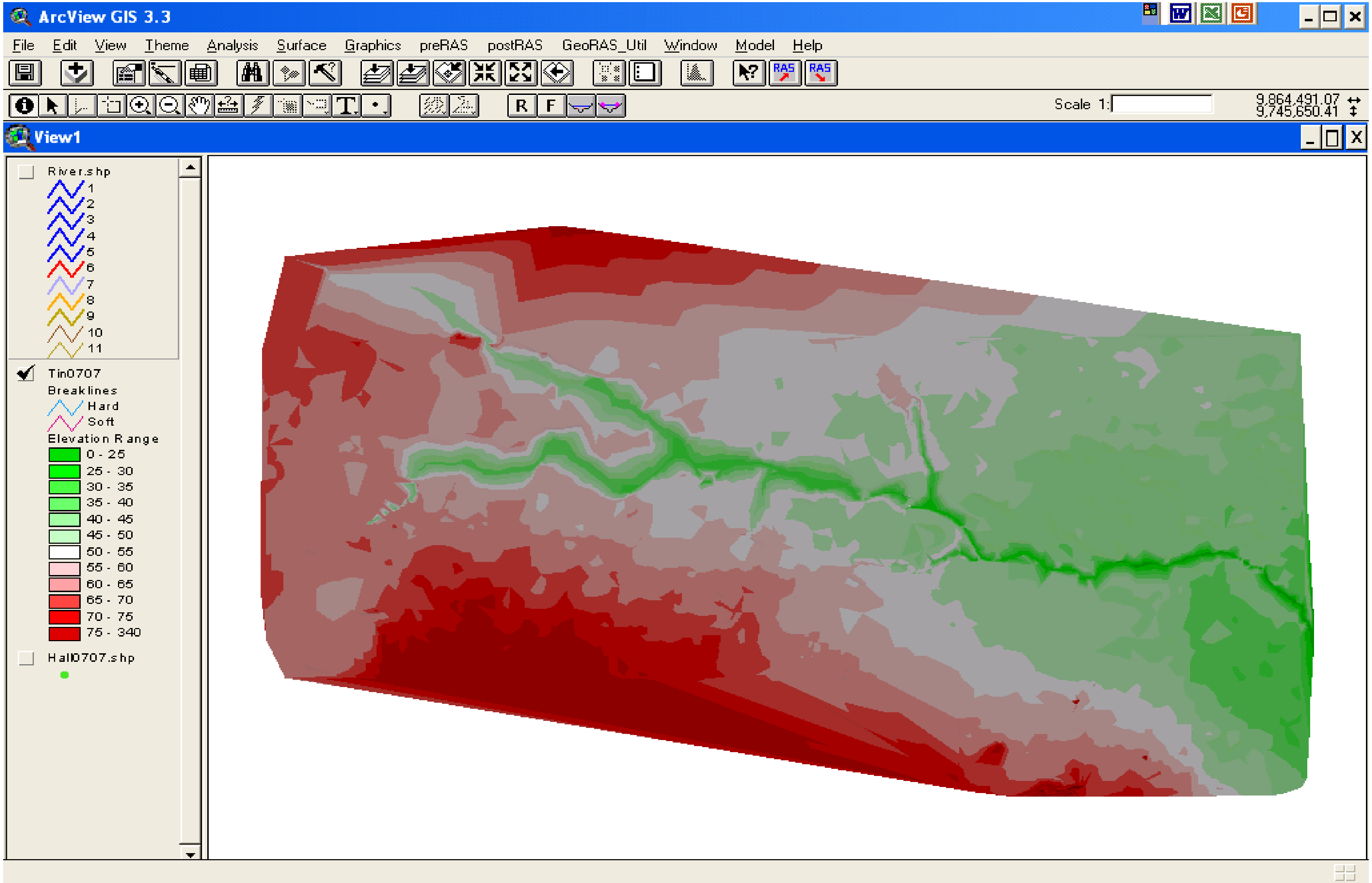


Fig. Digital Elevation Model (DEM) of the Study Area

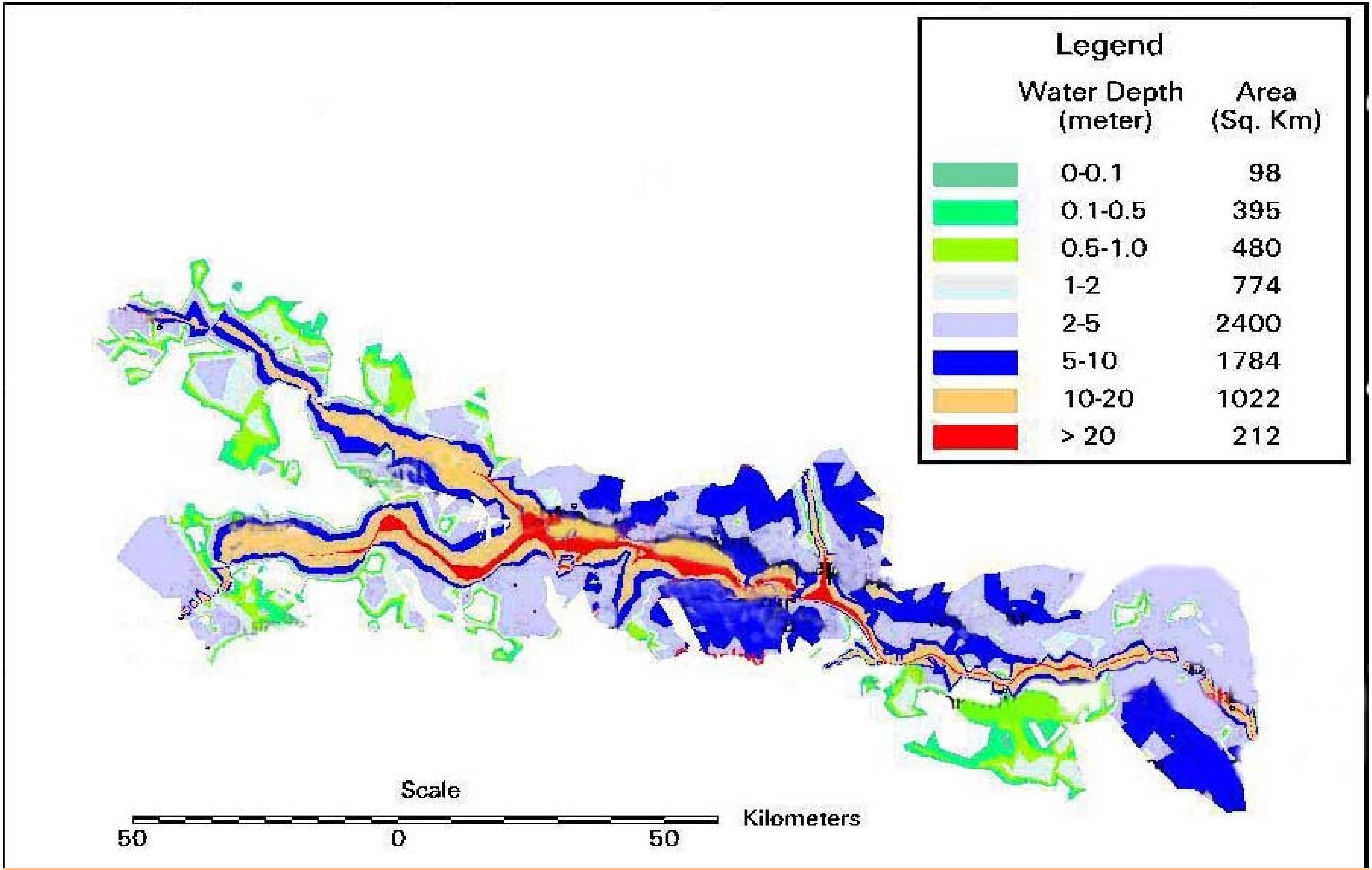
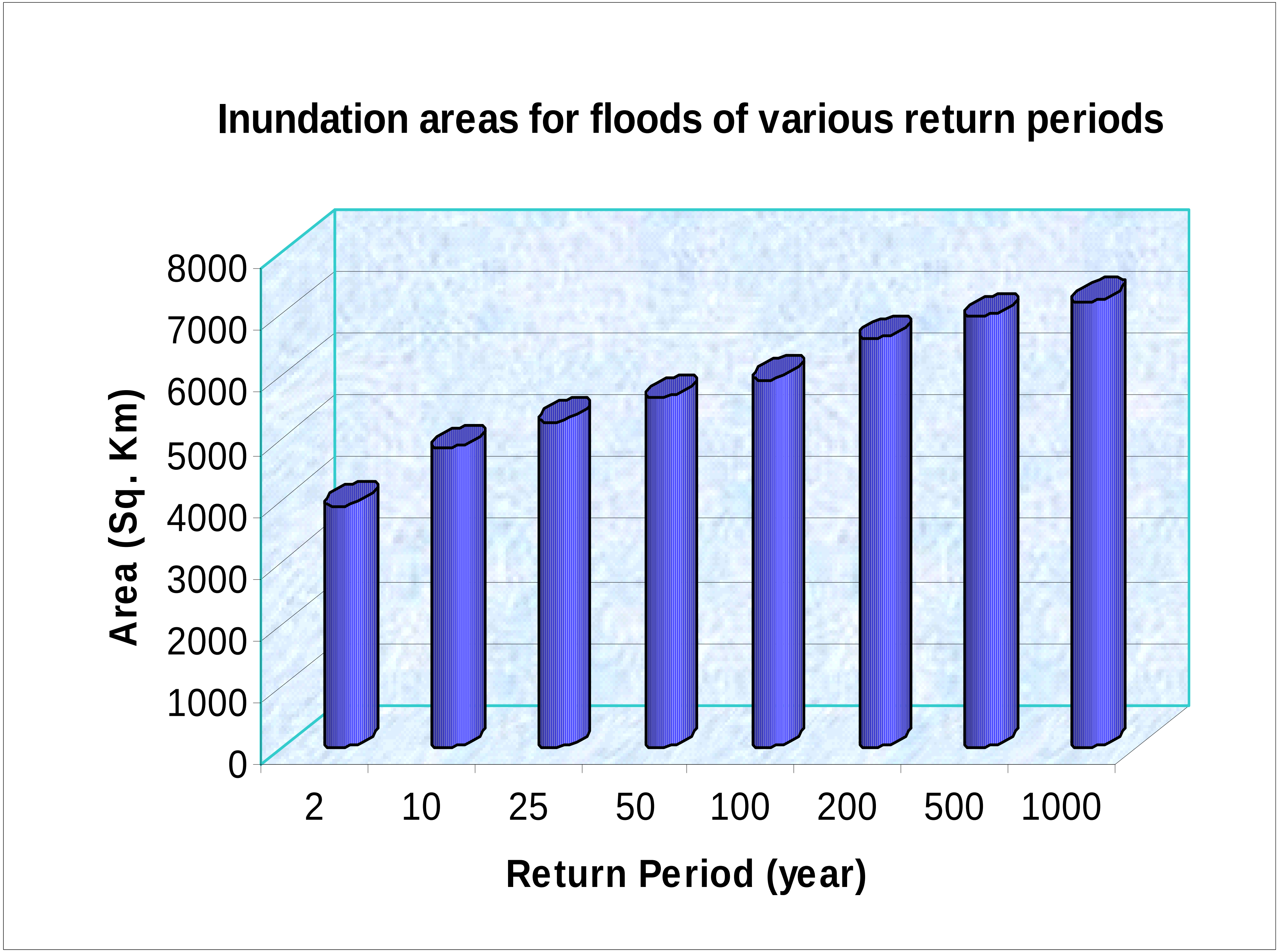


Fig. Flood plain area inundated and depth of flooding for 1000 year return period flood for the study area


Inundation areas for floods of various return periods
8000
7000
6000
5000
4000
3000
2000
1000
0
Area (Sq. Km)
2
10
25
50
100
200
500
1000
Return Period (year)

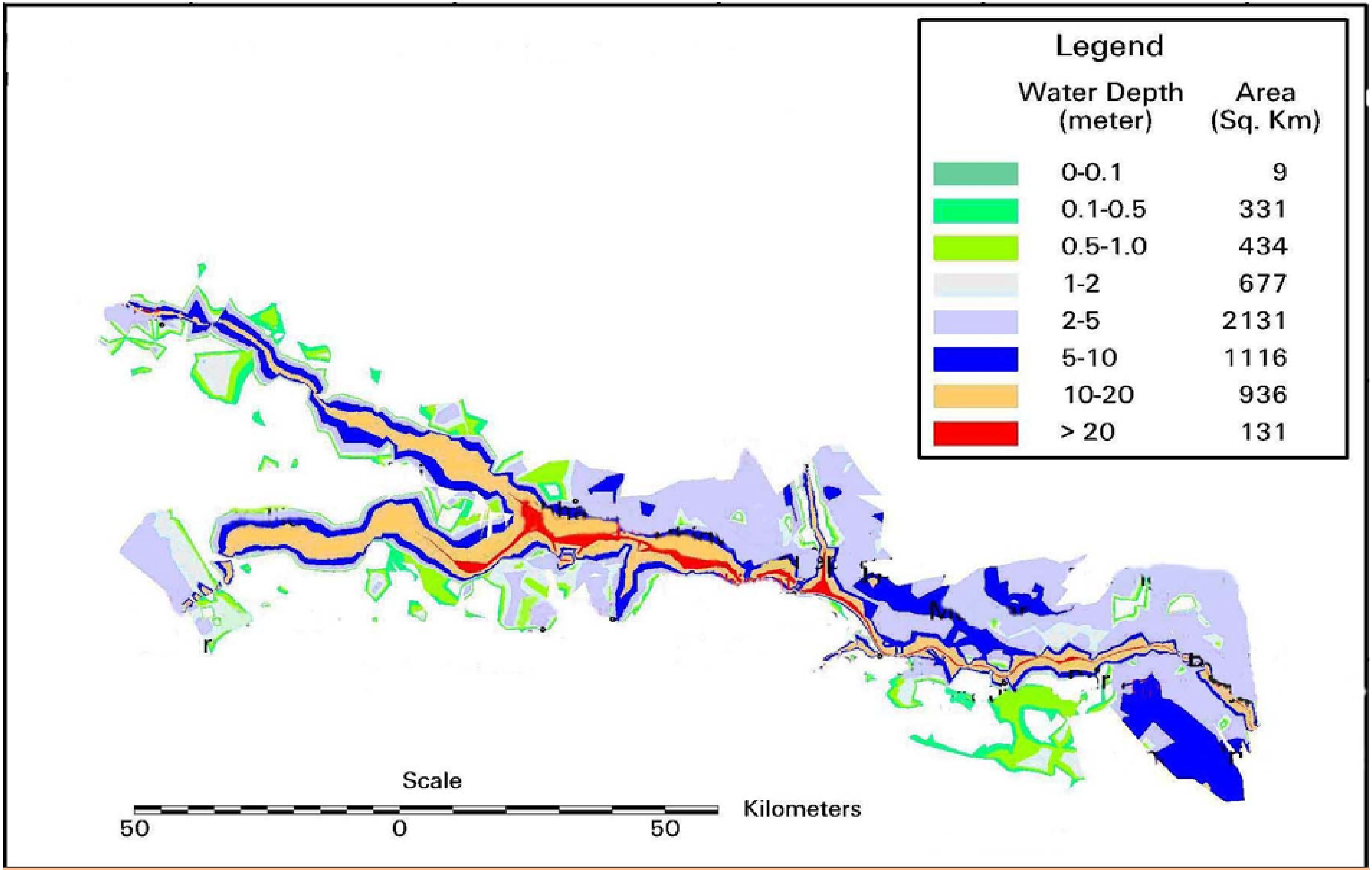


Fig. Flood risk zone map for a risk (R) of 25% over a period (n) of 25 years

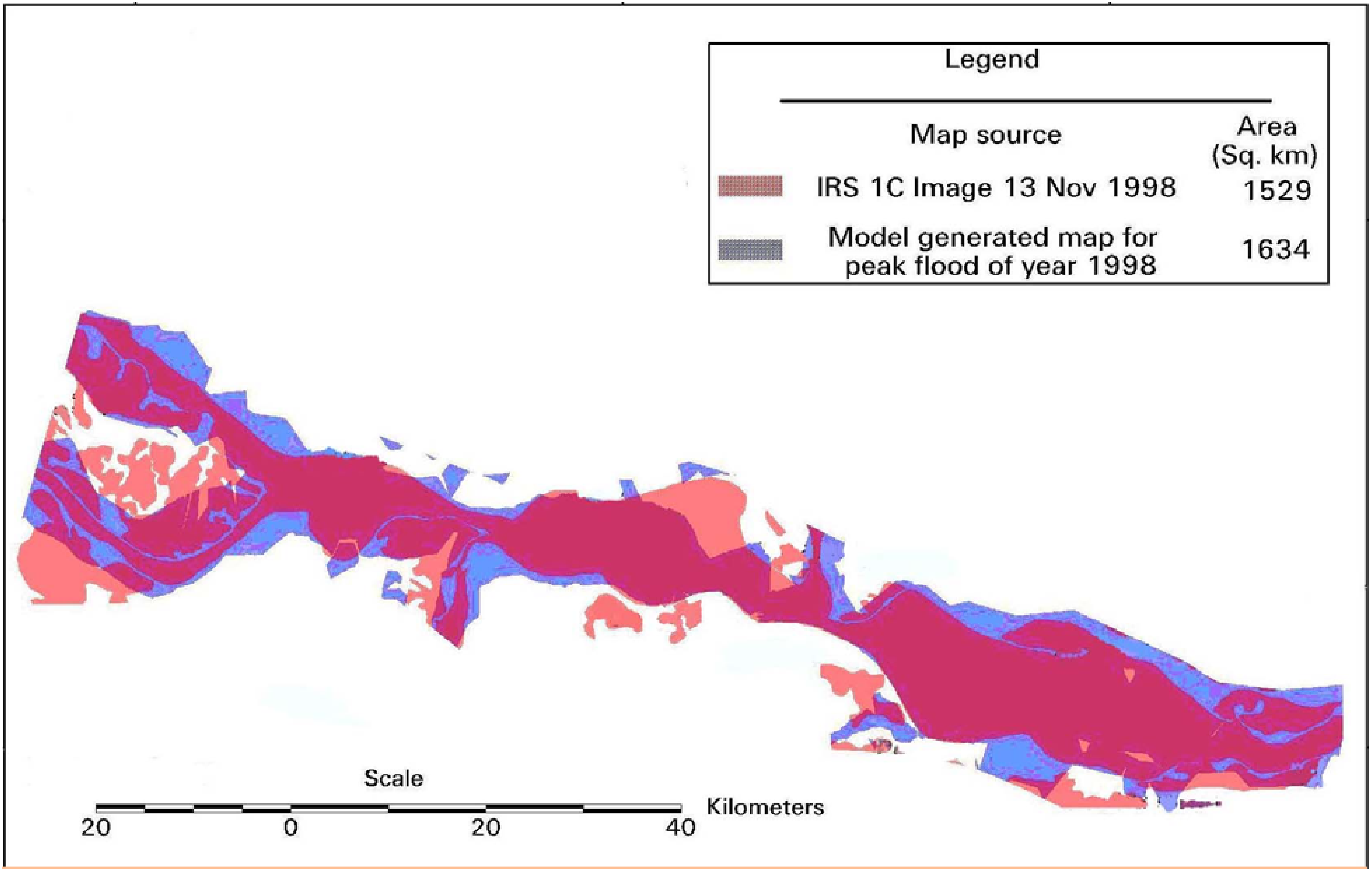


Fig. Comparison of inundated area simulated by hydraulic modelling and remote sensing analysis.

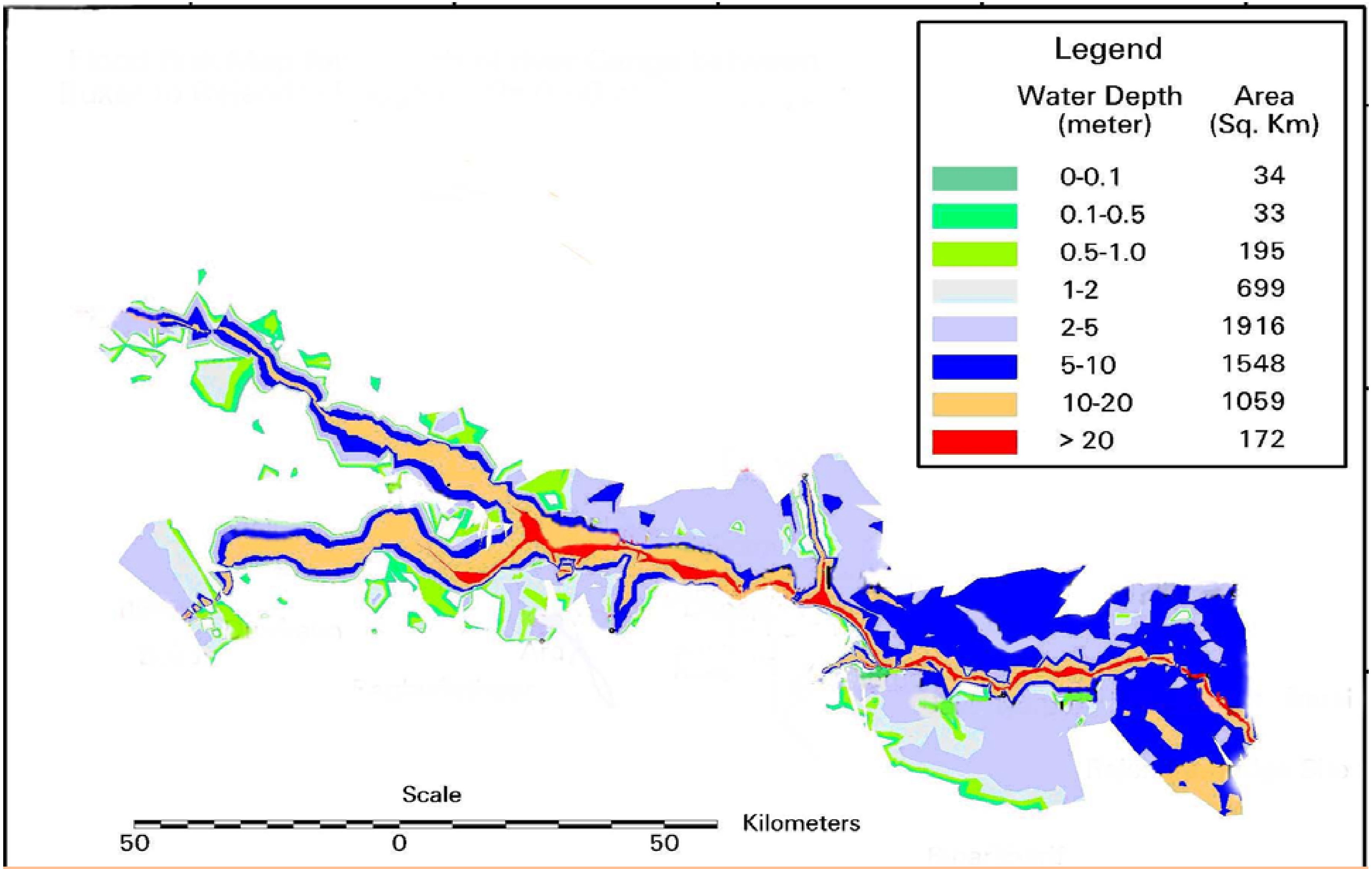


Fig. Flood inundated area and depth of flooding for 100 year return period.

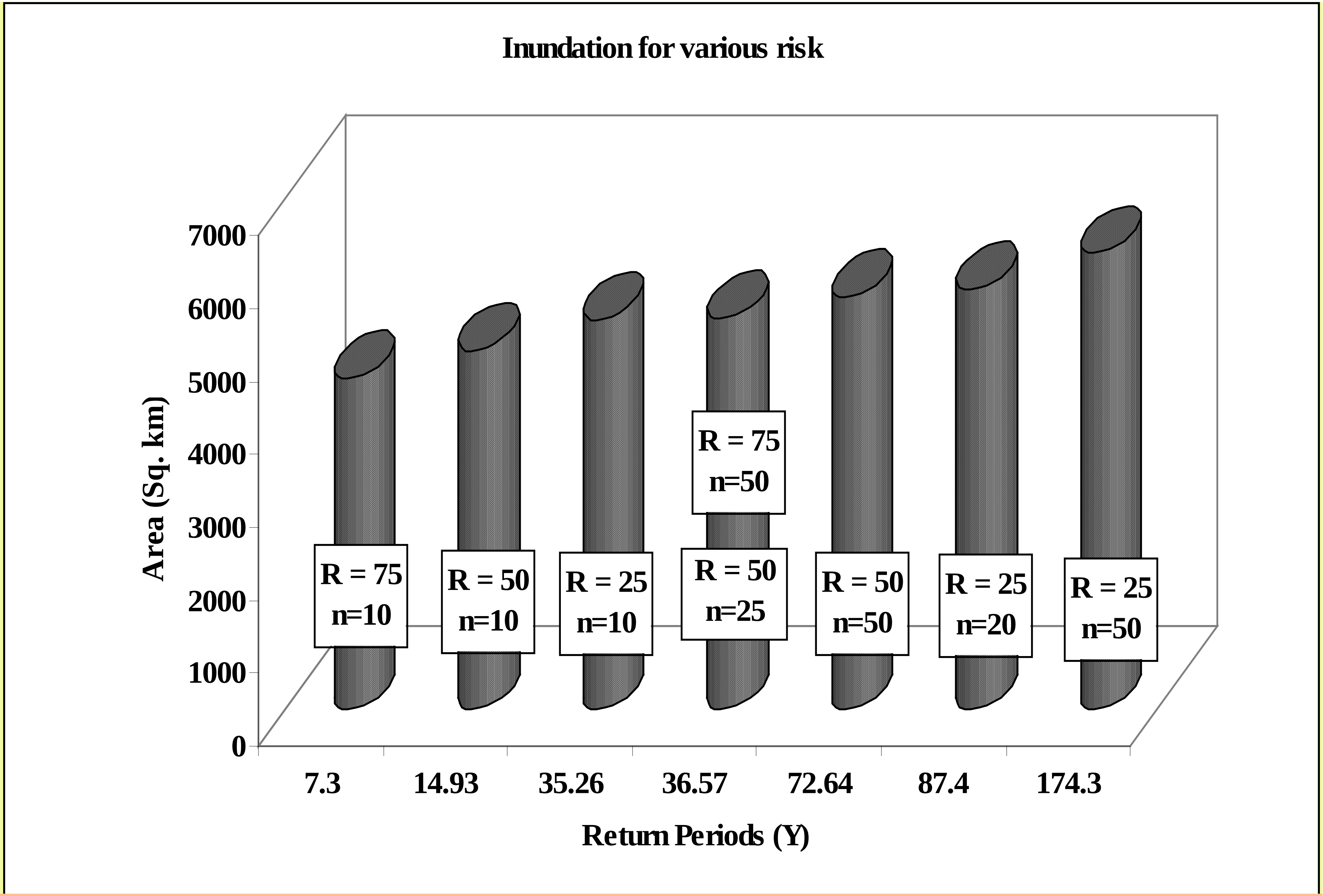


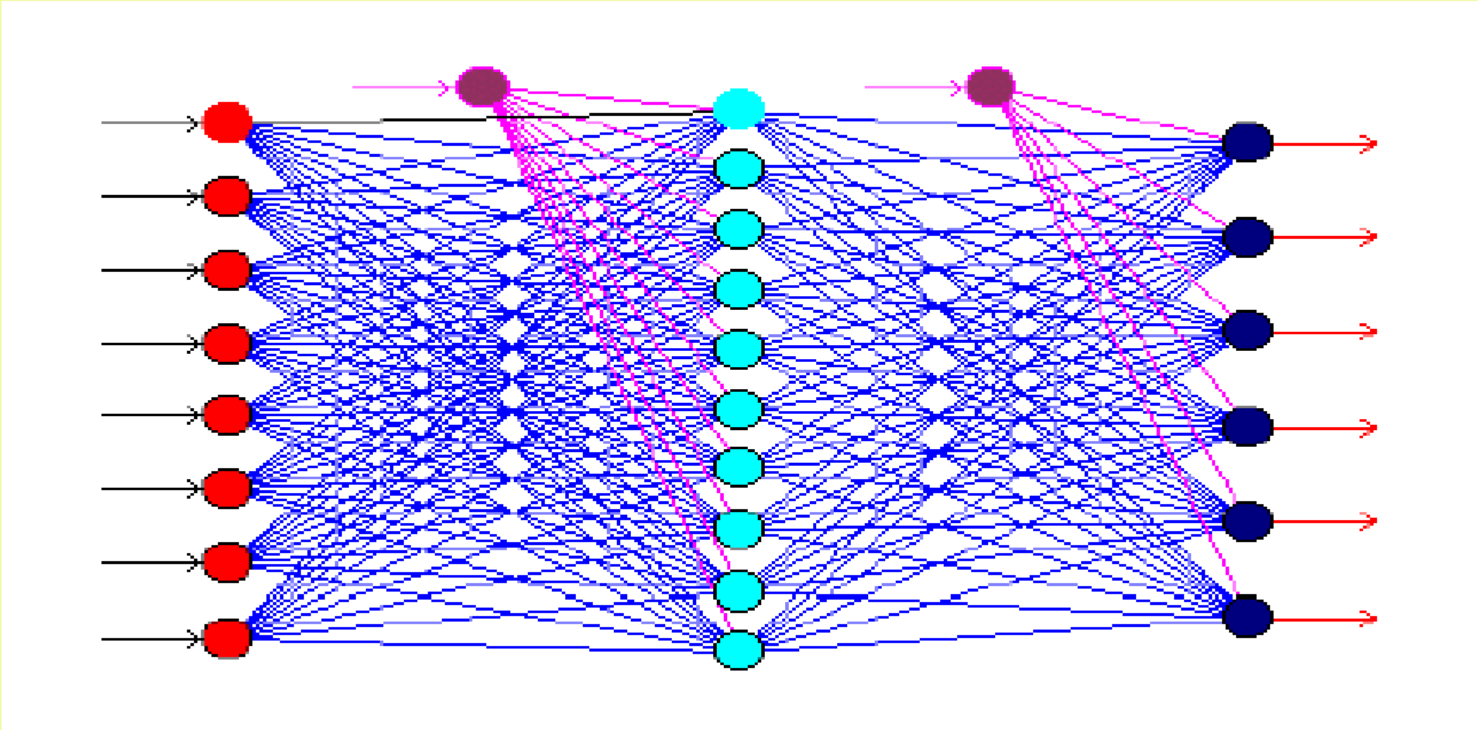
Fig. Area inundated for various levels of risk of flooding.

METHODS FOR FORMULATING REAL TIME FLOOD FORECASTS

- Statistical Methods
- Stochastic Methods
- Deterministic Methods
- Soft Computing Techniques

REAL TIME FLOOD FORECASTING USING ARTIFICIAL NEURAL NETWORK

Structure Of A Multi-Layer Feed Forward Artificial Neural Network Model



Input Nodes

Hidden Layer Nodes

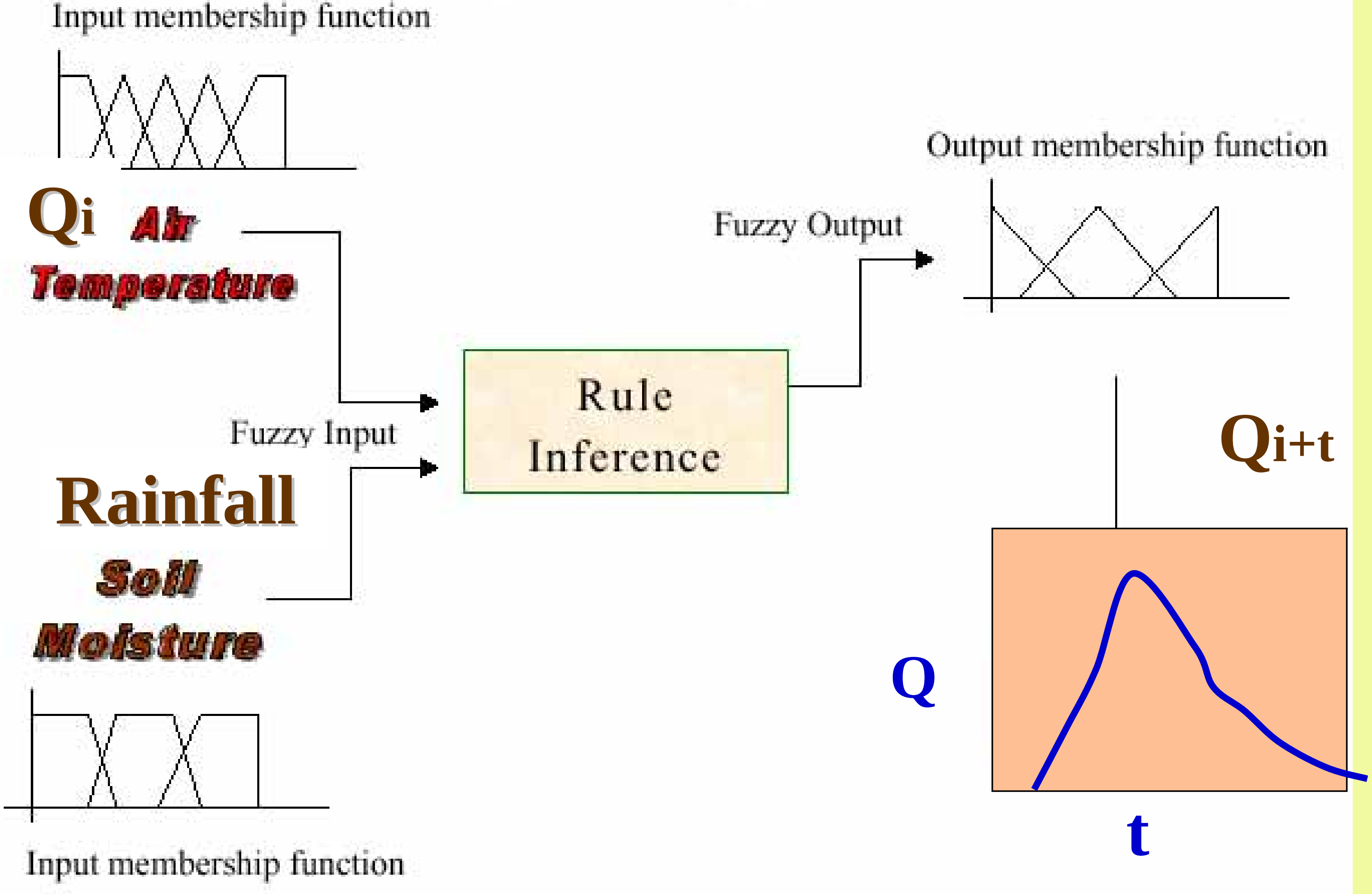
Output Nodes

REAL TIME FLOOD FORECASTING USING ARTIFICIAL NEURAL NETWORKS AND FUZZY LOGIC

- **To develop a fuzzy logic based model for flood forecasting**

- **To apply the developed model on a river gauging site**

Example for Flood Forecasting System



CAUSES OF RECENT URBAN FLOODING

- **Heavy intense rainfall within short duration**
- **For example on July 26, 2005 Mumbai received 944 mm rainfall in 24 hours while there were high sea tides**
- **Inappropriate town planning**
- **Inadequate drainage system**
- **Rapid development eliminating holding lakes & ponds**
- **Increased runoff due to faster impervious surfaces**
- **Slum encroachments over existing nalla banks have reduced the waterways**
- **Land reclamation and misuse of no-development zones**

URBAN FLOODING MITIGATION

- **Strengthening and Enhancement of Flood Response Mechanism Institutional Mechanisms**
- **Upgraded Emergency Control Room**
- **Development of Rain Gauge Network**
- **Message Alert Systems**
- **An Early Warning System for Mitigating Urban Flooding**
- **Fire Brigade Control Rooms**
- **Search and Rescue Mechanisms**
- **Equipment up-gradation**

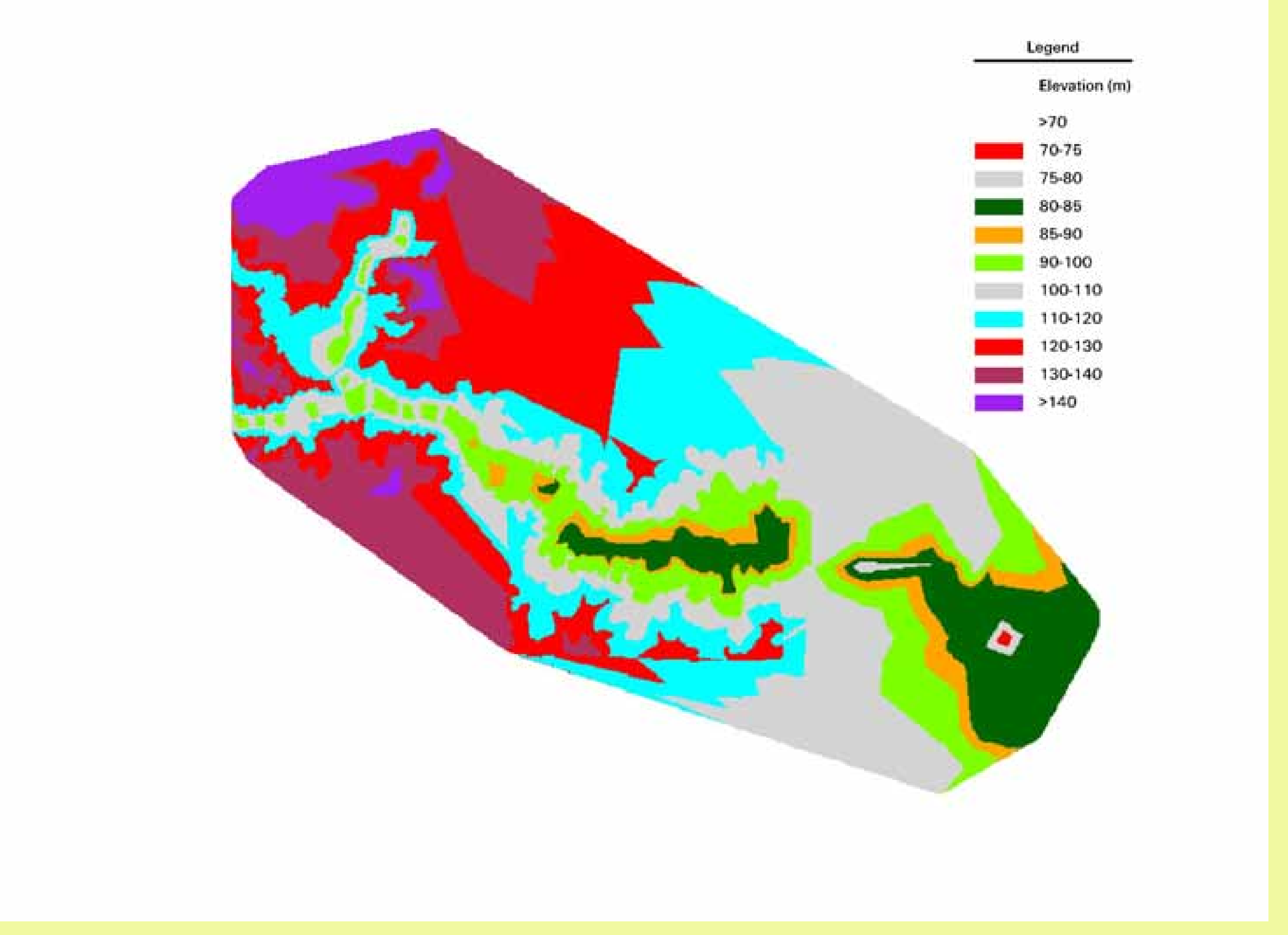
URBAN FLOOD MITIGATION Contd…

- Additional electricity transformers
- Desilting of Drains/nallas
- Emergency Parking
- Voluntary Organizations to be involved
- Additional pumps
- Hospital Arrangements
- Pumping may reduce local flooding

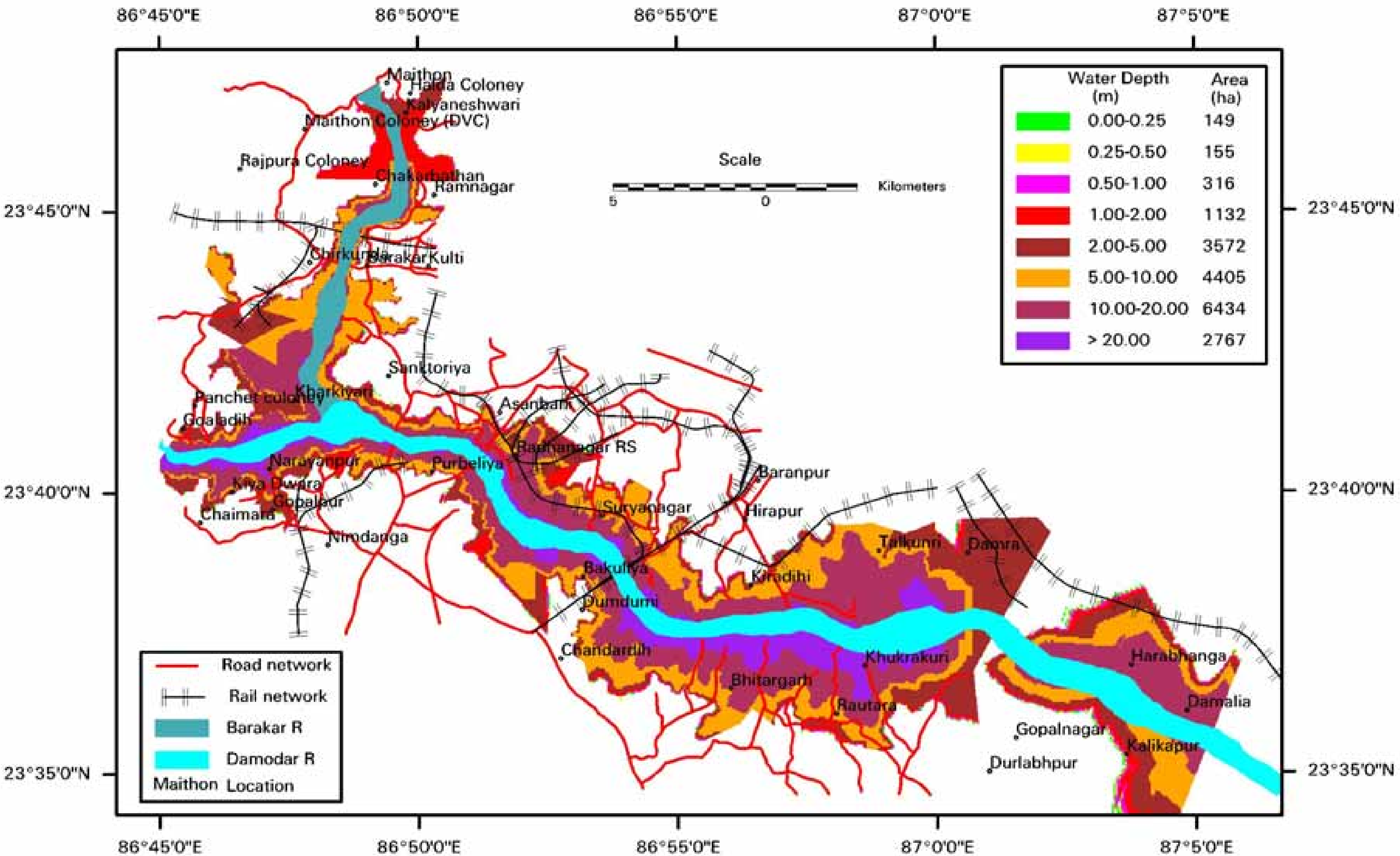
FLOODING DUE TO BREAKING OF DAMS

- **Dams are subject to decay and as a result they may in time become dangerous and can fail.**
- **The term "failure" is used in a general sense referring to the entire range from supplementary construction to total failure of the project.**
- **It may span structural failure to overtopping due to inadequate spillway design or inaccurate design flood estimation to rapid release of stored water within safe limits.**
- **Breaching of the Dam - opening formed in the dam during its failure .**

INUNDATION MAPPING



MAITHON & PANCHET DAM



Flood inundation map when both the dams fail under PMF - Case A3

FLOOD RESPONSE

- Response system
- Institutionalisation
- Evacuation plan
- Estimation of the severity of the flood
- Flood management plan
- Search and Rescue teams
- Emergency relief
- Emergency medical relief

DECISION SUPPORT SYSTEM

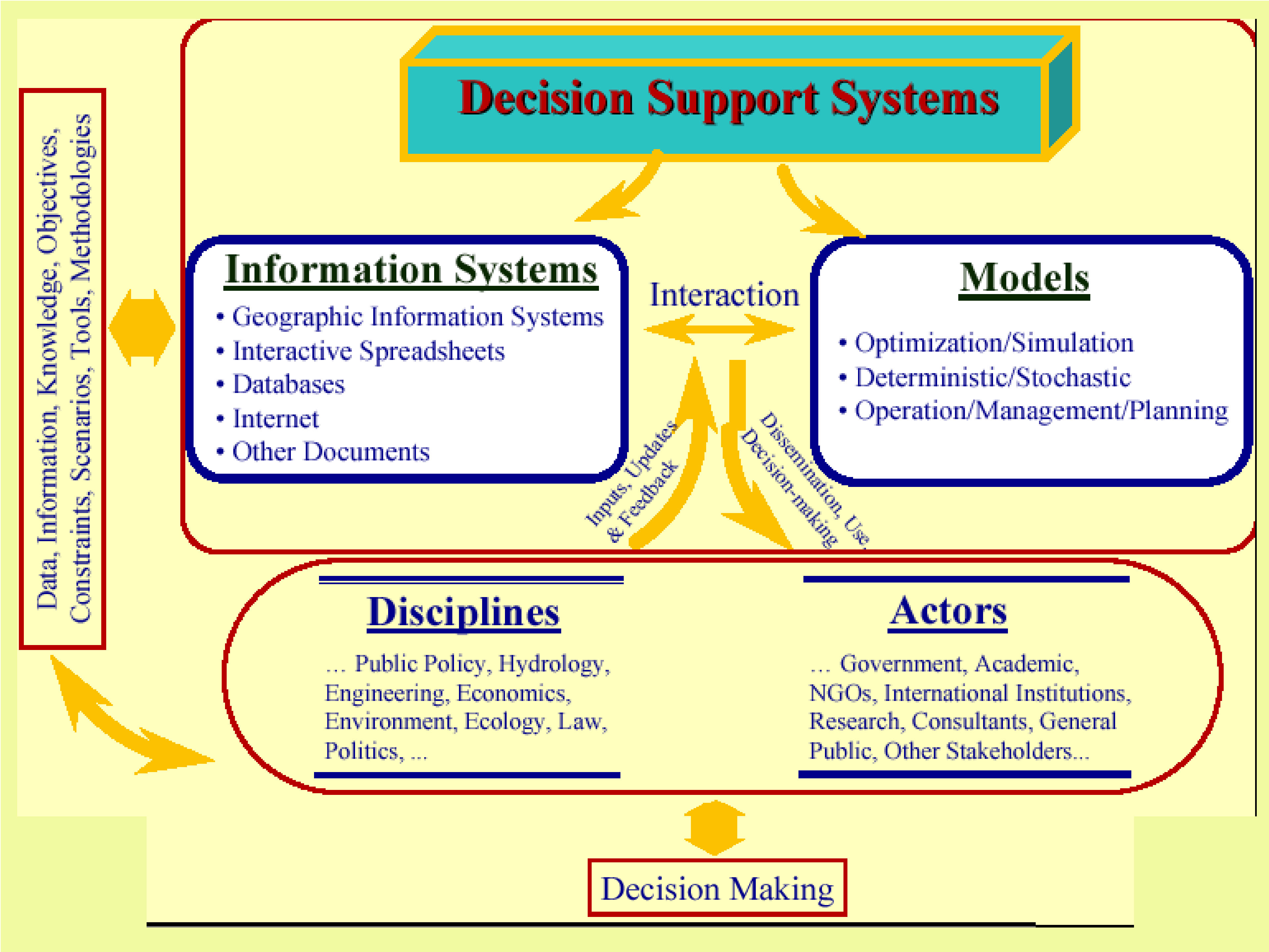
- Using a DSS, a person responsible for the actual project is able to make rational use of the system without an in-depth knowledge of modelling techniques.

Why a DSS?

- Communicate result to a larger audience
- Open and unbiased working
- Scenario analysis

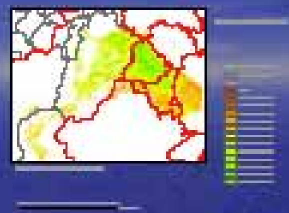
DECISION SUPPORT SYSTEM DEFINITION

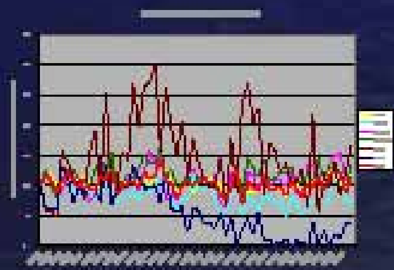
- **Computer based models together with their interactive interfaces are typically called decision support systems (DSSs)**
- **DSS does not take decisions**
- **Provides timely information**
- **Easy comprehension of abstract information**


Decision Support Systems
Data, Information, Knowledge, Objectives, Constraints, Scenarios, Tools, Methodologies
Information Systems
• Geographic Information Systems
• Interactive Spreadsheets
• Databases
• Internet
• Other Documents
Interaction
Models
• Optimization/Simulation
• Deterministic/Stochastic
• Operation/Management/Planning
Inputs, Updates & Feedback
Dissemination, Use, Decision-making
Disciplines
… Public Policy, Hydrology, Engineering, Economics, Environment, Ecology, Law, Politics, ...
Actors
… Government, Academic, NGOs, International Institutions, Research, Consultants, General Public, Other Stakeholders...
Decision Making

Modern Spatial Toolkit

- GIS
- GPS / Modern Survey Tools
- Remote Sensing
- Modern Hardware
- Modern Software
- Modern Platforms (www)
- Modern Applications/DSS
- and most important... Skilled Staff with multi-sectoral perspectives





...along with all the old-fashioned insights, knowledge, expertise

DECISION SUPPORT SYSTEM (PLANNING) FOR IWRDM

- Surface water planning
- Integrated operation of reservoirs
- Conjunctive surface water and ground water planning
- Drought Monitoring, assessment and management
- Water Quality

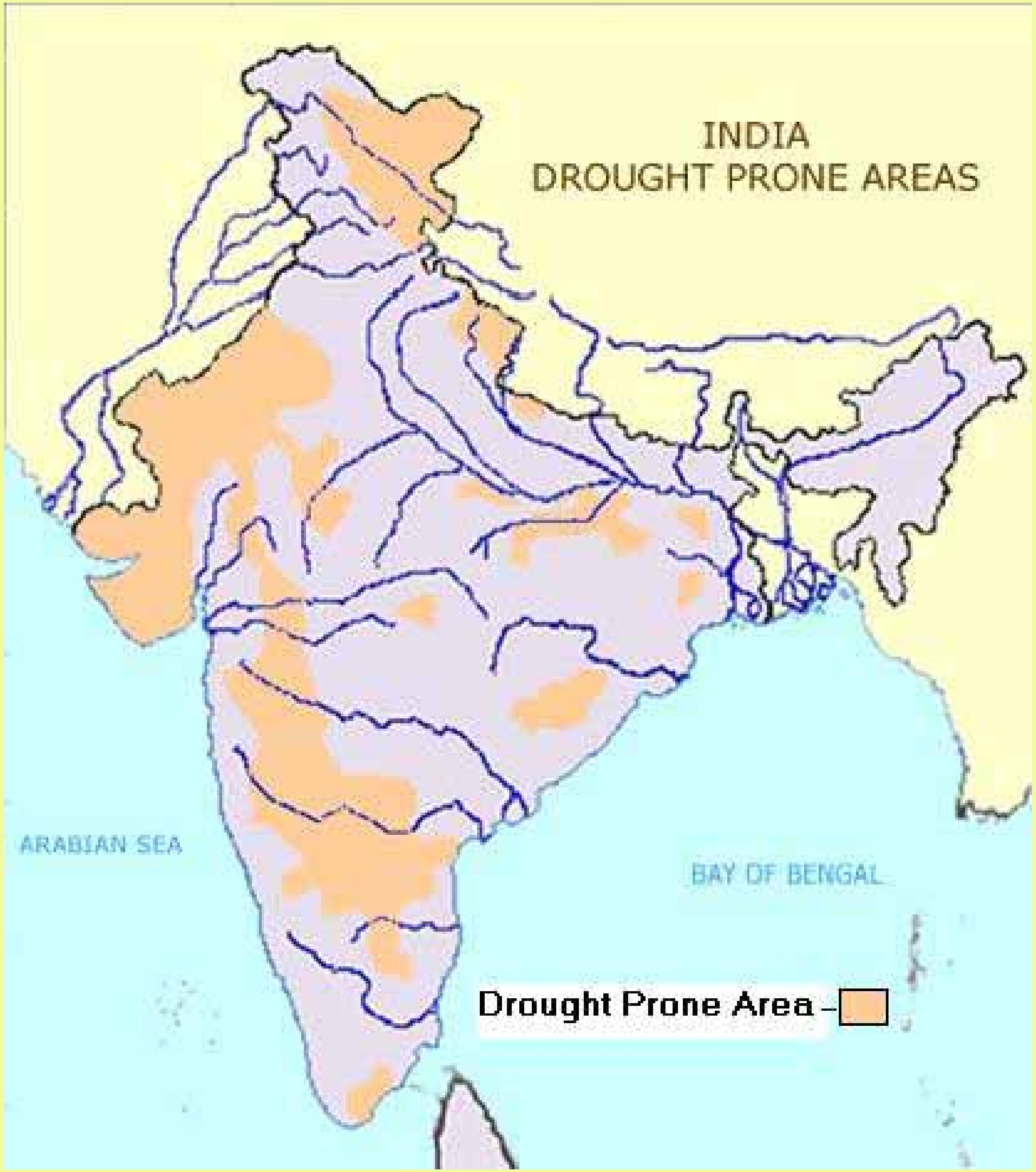
DROUGHT

Efforts to Combat Desertification

- More than 1/3 of the total land area of globe is prone to the hazards of desertification

- In India arid zone covers about 12% of country's geographical area.

  - Rajasthan- 62%
  - Gujarat - 19%
  - Punjab & Haryana - 9%
  - Andhra Pradesh & Karnataka - 10%


INDIA
DROUGHT PRONE AREAS
ARABIAN SEA
BAY OF BENGAL
Drought Prone Area -

DROUGHT MANAGEMENT

- Drought have Low priority
- Drought Planning & Management schemes

  -after persistence drought
- After normal rainfall rapid

  -decrease in drought planning schemes
- DSS at basin scale

  -outputs at Administrative scales
- People participation
- Publication campaign

  -Electronic & Print Media

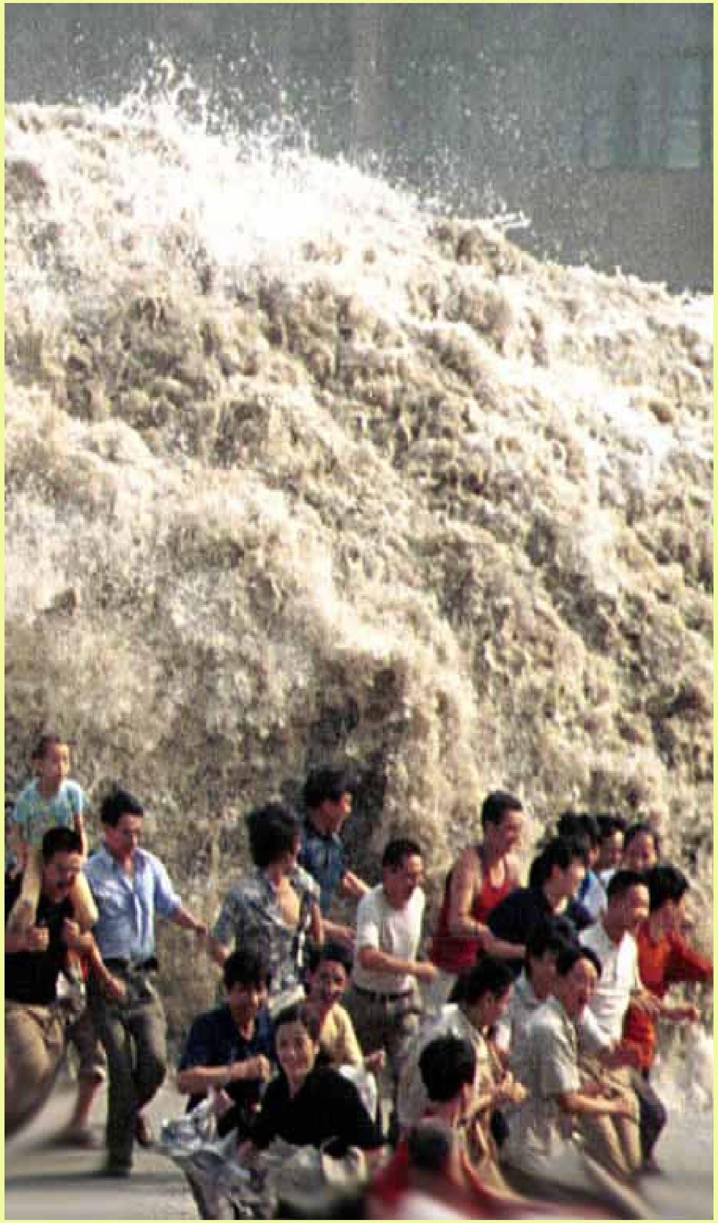
CYCLONE

- India has a long coast line of 8,000 kms. On an average, about five to six tropical cyclones form in the Bay of Bengal and Arabian Sea every year, out of which two to three are severe.

- There are two distinct cyclone seasons: pre-monsoon (May-June) and post-monsoon (October-November).
- Analysis of cyclone events during the last 100 years period from 1891 to 1991 reveals that as against 117 cyclones of varied intensities formed in the Arabian Sea, 442 cyclones were formed in the Bay of Bengal.
- The impact of these cyclones is confined to the coastal districts, the maximum destruction being within 100 Km. from the centre of the cyclones and on either side of the storm track. Strong winds, torrential rains and high tidal waves causes most of the casualties and coastal inundation during these cyclones.

TSUNAMI

- **A tsunami is a natural phenomenon consisting of a series of waves generated when water in the sea is rapidly displaced on a massive scale. Earthquakes, landslides, volcanic eruptions and large meteorite impacts all have the potential to generate a tsunami.**
- **The effect of a tsunami can range from unnoticeable to devastating.**
- **India has experienced a devastating tsunami in 2004.**



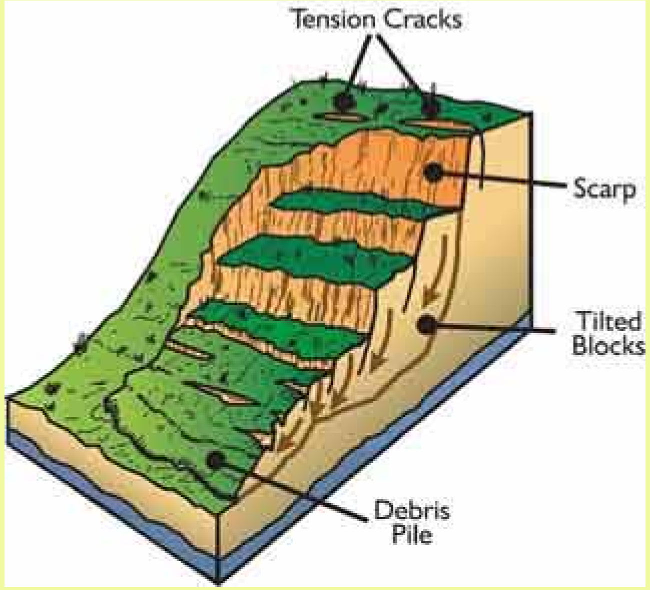
LANDSLIDES

- The Himalayan, the north-east hill ranges and the Western Ghats experience considerable landslide activities of varying intensities.

- The rocks and the debris carried by the rivers like Kosi originating in the Himalayas cause enormous landslides in the valleys.

- The seismic activity in the Himalayan region also results in considerable landslide movement.

- The heavy monsoon rainfall, often in association with cyclonic disturbances, results in considerable landslide activity on the slopes of the Western Ghats



AVALANCHES

- Avalanches constitute a major hazard in the higher reaches of the Himalayas.

- Heavy losses of life and property have been reported due to avalanches.

- Parts of the Himalayas receive snowfall round the year and adventure sports are in abundance in such locations.

- Severe snow avalanches are observed during and after snowfalls in Jammu & Kashmir, Himachal Pradesh and the Hills of Uttranchal.

CONCLUSIONS

- **Water related disasters lead to immense tangible and intangible losses, loss of life and miseries to society.**
- **The calibrated and validated hydrologic models should be coupled with distributed rainfall-runoff models.**
- **For this purpose, antecedent rainfall forecasts based on radar, satellite based instrumentation and high resolution Numerical Weather Prediction (NWP) models and may be used for simulation of flood inundation, depth of flooding and risk associated with the flooding in real time for flood mitigation and management.**
- **Presently, there are many uncertainties in forecasting heavy rainfall and the uncertainty should be minimised, quantified and presented as an integral part of the forecast.**
- **It would help in providing improved flood hazard warning and lead to better flood management and flood damage reduction.**

- **Flood inundation maps, flood hazard maps and flood risk zone maps should be developed for various flood prone river reaches.**

- **These maps may be used for land use planning, flood insurance purposes and flood damage reduction.**

- **The existing hydro-meteorological data networks need to be strengthened through the establishment of state-of-art equipment. Web-enabled data base management systems for data archiving, storage, and retrieval need to be developed by employing advanced information technology.**

- **Sharing of knowledge and dissemination of technology through the participatory approach and capacity building programs utilizing the modern means of communications needs to be encouraged for mitigation and management of the water related disasters.**


THANK YOU