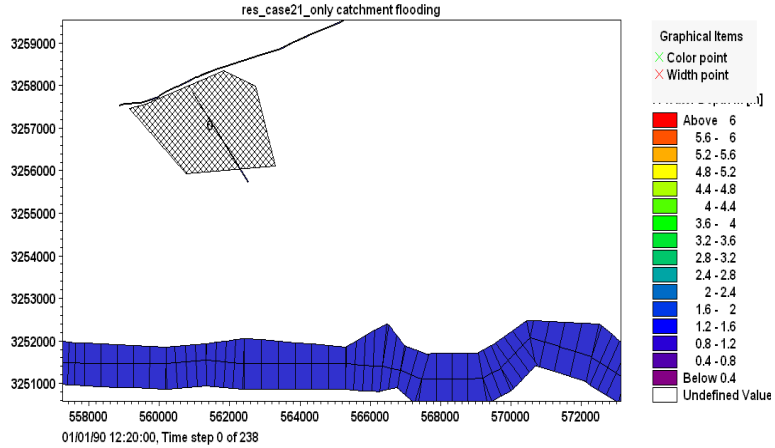
CLIMATE CHANGE ADAPTATION AND WATER NEXUS WITH SPECIAL REFERENCE TO INDIA



Dr Rakesh Kumar
NATIONAL INSTITUTE OF HYDROLOGY
ROORKEE - INDIA

India – A Comparison with the World

India's Land Resources	2% of the World
India's Freshwater Resource	4% of the World
India's Population	16% of the World
India's Cattle Population	10% of the World

India's Land Resources

Geographical Area	**329 mha**
Non-cultivated Area	7%
Barren/Waste Land	23%
Forested Area	23%
Cultivated Area (CA)	47%
Irrigated Area (produces 55%)	37% of CA
Rainfed Area (produces 45%)	63% of CA

Annual Water Availability in India

Total precipitation	4000 BCM
Annual water availability	1869 BCM
Utilizable water	1123 BCM
- Surface water	690 BCM
- Ground water	433 BCM

Rainfall Patterns in India

Long-term average annual rainfall is 1160 mm.

Highly Variable in space (about 11,690 mm at Mousinram near Cherrapunji in Meghalaya and 150 mm at Jaisalmer)

Highly Variable in time (Three-quarters of the rain in less than 120 days during June to September)

Average number of rainy days in a year is 40


Impact of Climate Change
Temperature increase
Change in Monsoon Pattern
Increase in Rain Fall Intensity
Decrease in No. of Rainy Days
Decrease in Snow Fall
Increase in Glacier retreat
Increase in Evaporation rate
Change in Runoff Pattern
Change in Ground water Recharge
Increase in Extreme Events
Sea Level Rise
Change in water quality

Importance of Weather, Water and Climate

A large part of the economy of the country is weather sensitive.

Various sectors such as Agriculture, Energy, Tourism, Health, Food, Water Security and Environment, water related disasters are all related to Weather and Climate.

The Science of Meteorology, Hydrology and Climatology will advance rapidly requiring strengthening of linkage among the disciplines of Weather, Water and Climate Prediction.

Weather and Climate information for water Management

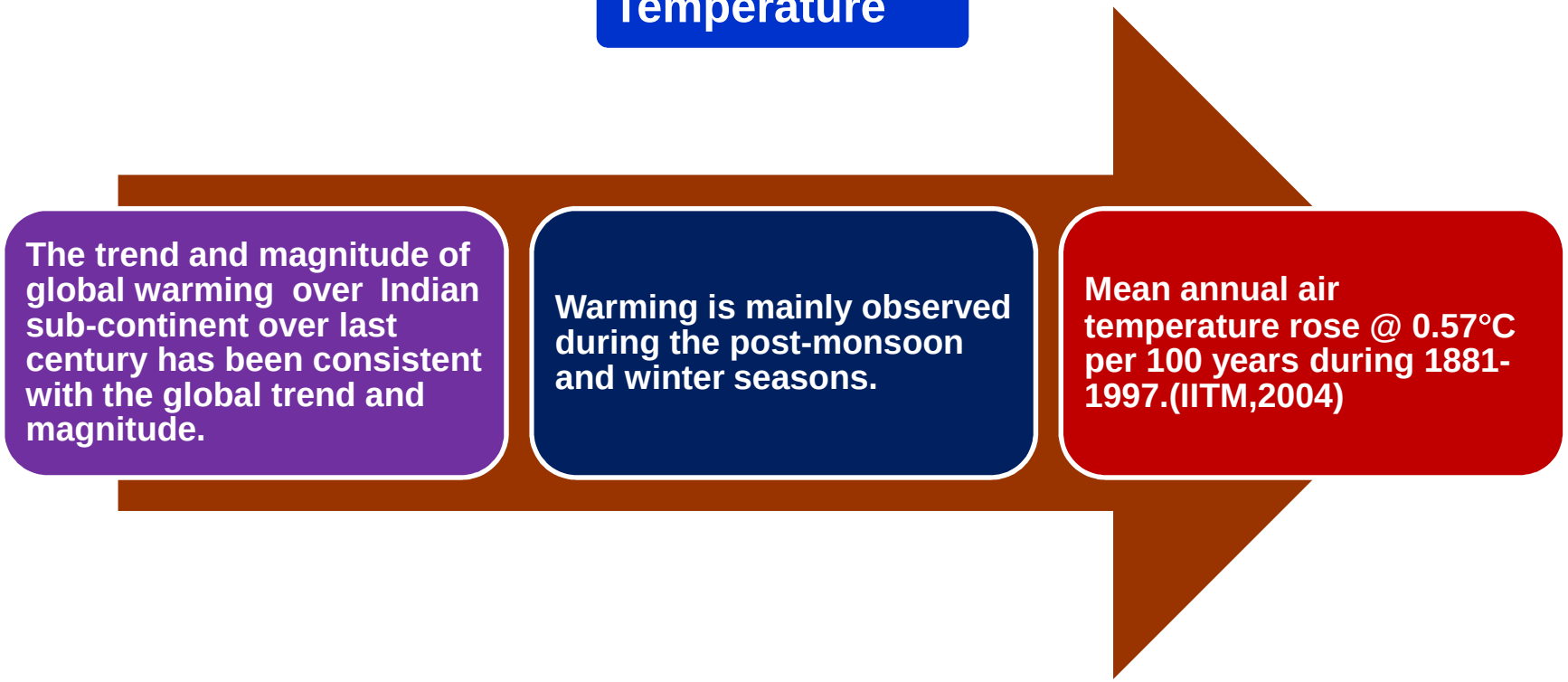
- **Water Related disasters on human livelihood are constantly increasing (aggravated by Climate Change)**
- **Increasingly serious economic impacts of water related disasters**
- **90% of natural disasters are weather and climate related**
- **The death toll from these hydro-meteorological disasters account for nearly 70% of all deaths due to natural disasters**

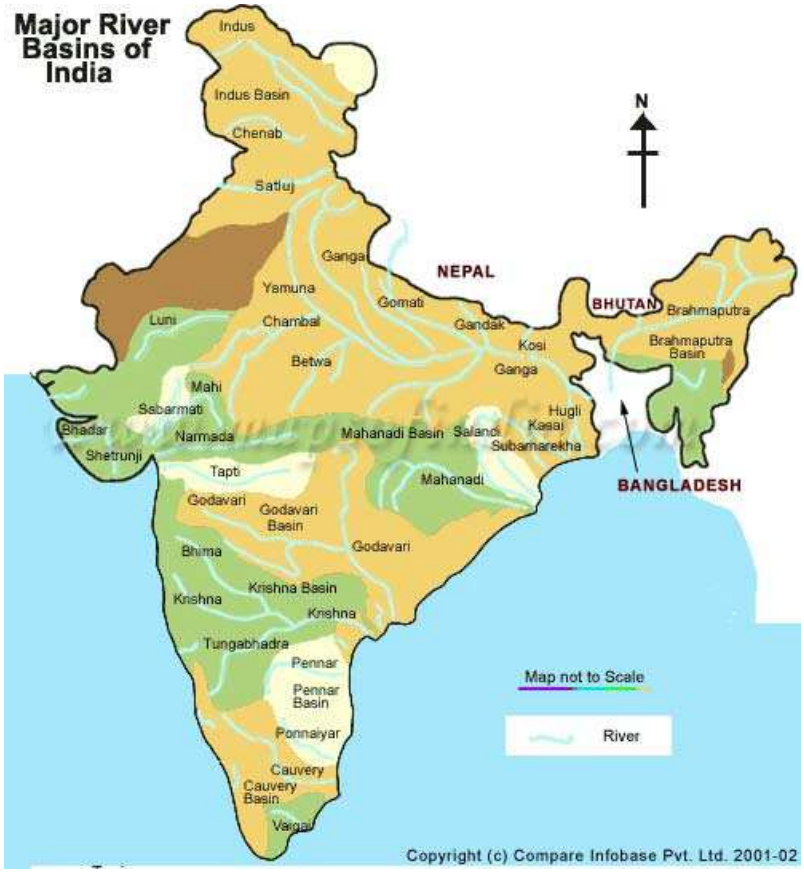
Challenges

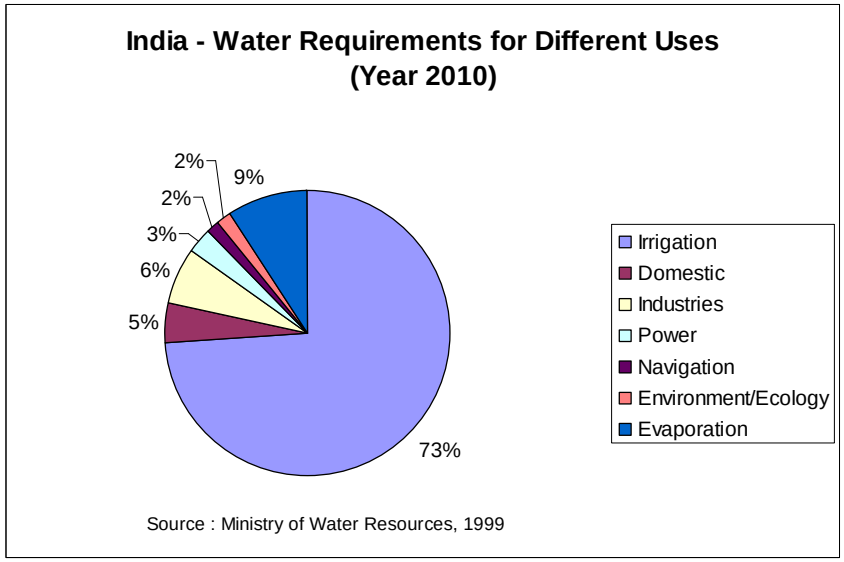
- **Climate change is likely to impact climate variability, making extreme events more severe and more frequent.**
- **Increasing world population, economic growth, urbanization lead to intense use of water and land resources and increasing potential for damage due to extreme events.**
- **There is widespread expectation that technological and scientific advances should ensure greater protection against these extreme events.**

TRENDS OF CLIMATE CHANGE IN INDIA

Temperature







National Issues of Interest

Water availability

- How do water fluxes vary on catchment scale in response to global climate events?
- Impacts on Water Quality

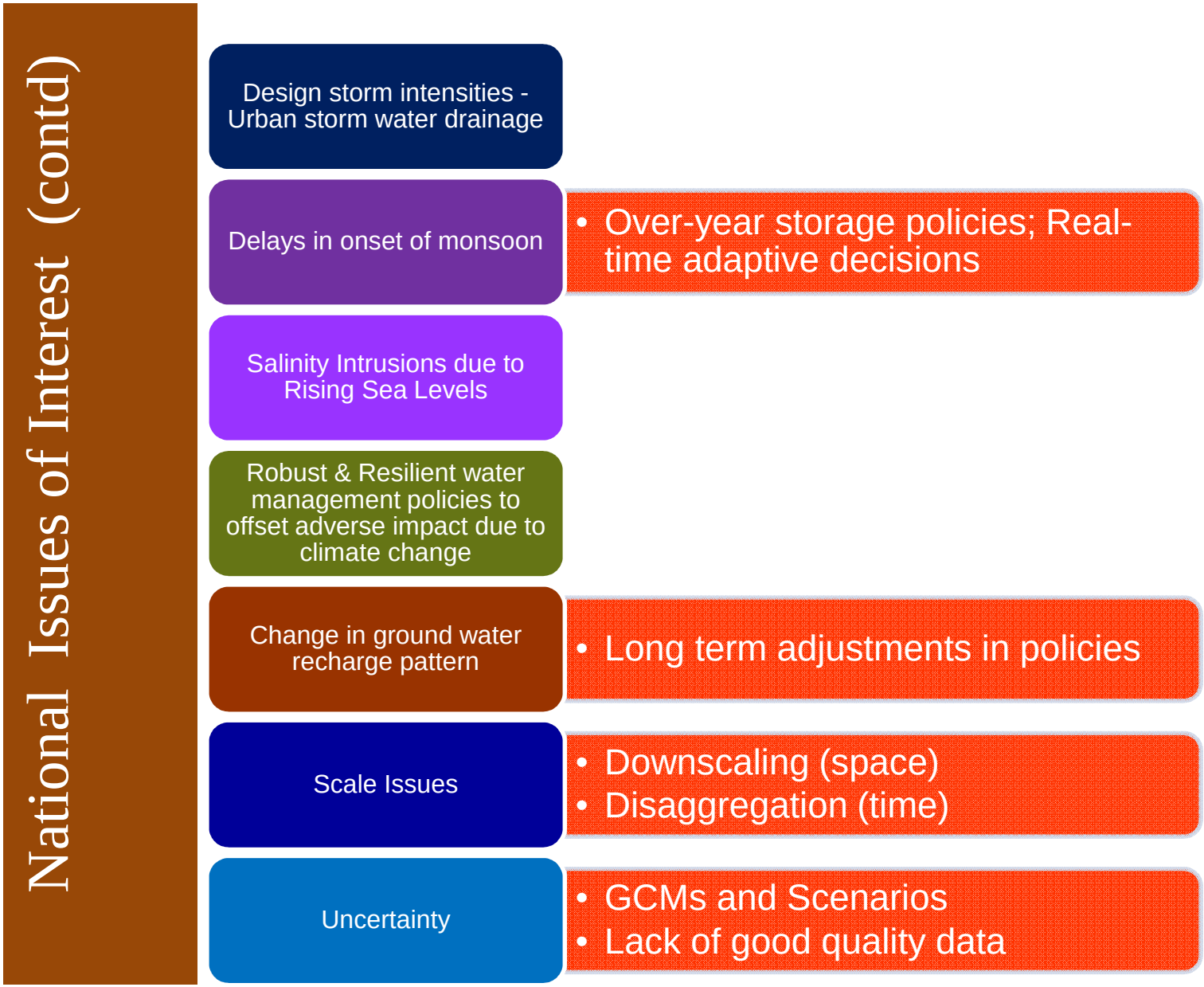
Water Demands

- Crop Evapo-transpiration

Association of Hydrologic Extremes of Floods and Droughts with Large Scale Global Climate Events

- Change in Frequency and Magnitude of extreme events ;
- Impact of year to year variations of the Monsoon will continue to be dominant even in the presence of global warming

National Issues of Interest (contd)



Eight National Missions

- National Solar Mission
- National Mission for Enhanced Energy Efficiency
- National Mission on Sustainable Habitat
- **National Water Mission**
- National Mission on Sustaining the Himalayan Ecosystem
- National Mission for a Green India
- National Mission for Sustainable Agriculture
- National Mission on Strategic Knowledge for Climate Change

Strategy 0.3

Setting up of Climate Change Cells in various organizations in MoWR (NIH, CWC, BB, CGWB)

Strategy 1.2

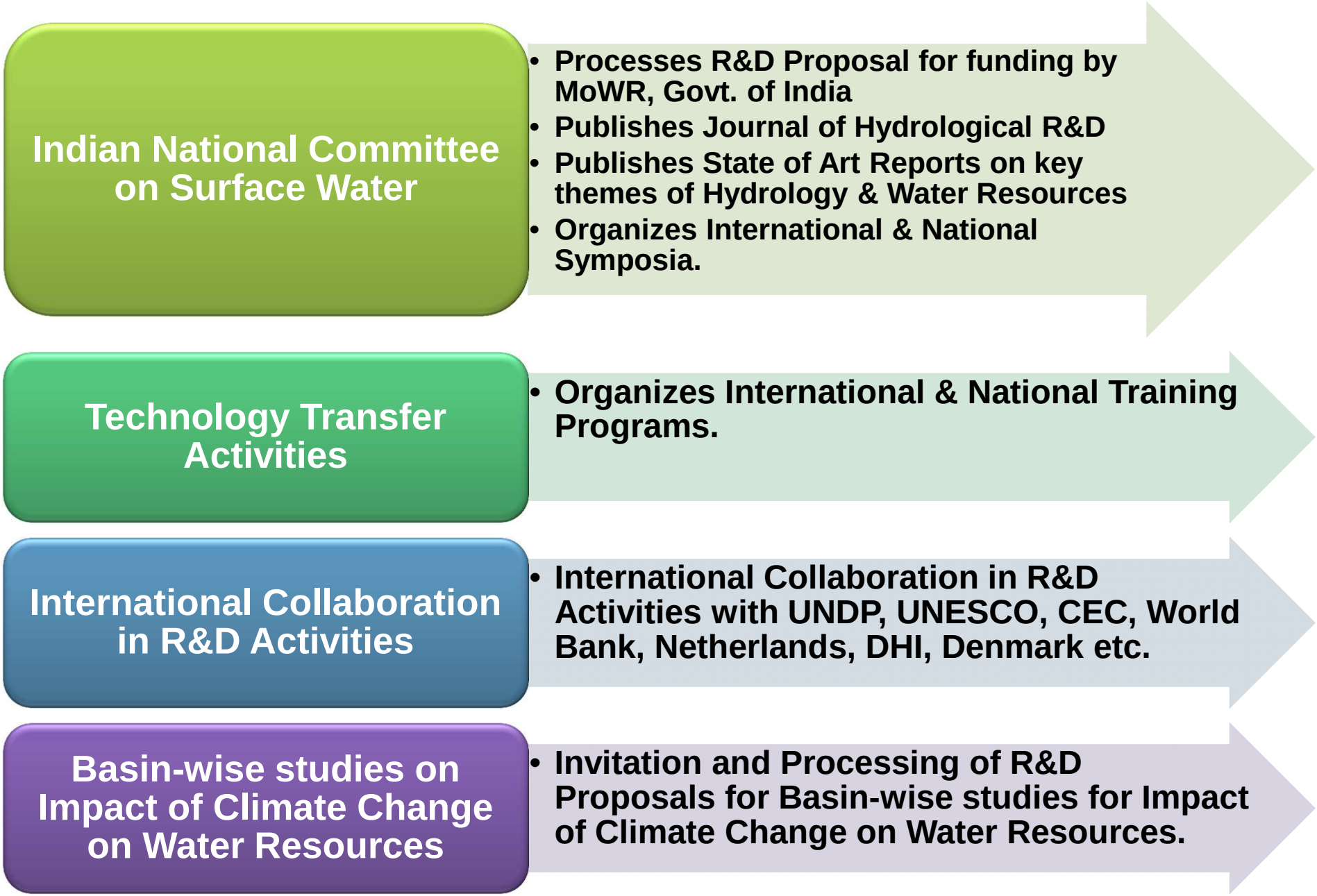
Development/implementation of modern technology for measurement of various data. (CWC, NIH)

Strategy 1.5

Research and studies on all aspects related to impact of climate change on water resources including quality aspects of water resources with active collaboration of all research organizations working in the area of climate change (NIH, CWC, CGWB, BB and Research Stations)

Strategy 1.7

Projection of the impact of climate change on water resources (CWC & NIH)


Indian National Committee on Surface Water
• Processes R&D Proposal for funding by MoWR, Govt. of India
• Publishes Journal of Hydrological R&D
• Publishes State of Art Reports on key themes of Hydrology & Water Resources
• Organizes International & National Symposia.
Technology Transfer Activities
• Organizes International & National Training Programs.
International Collaboration in R&D Activities
• International Collaboration in R&D Activities with UNDP, UNESCO, CEC, World Bank, Netherlands, DHI, Denmark etc.
Basin-wise studies on Impact of Climate Change on Water Resources
• Invitation and Processing of R&D Proposals for Basin-wise studies for Impact of Climate Change on Water Resources.

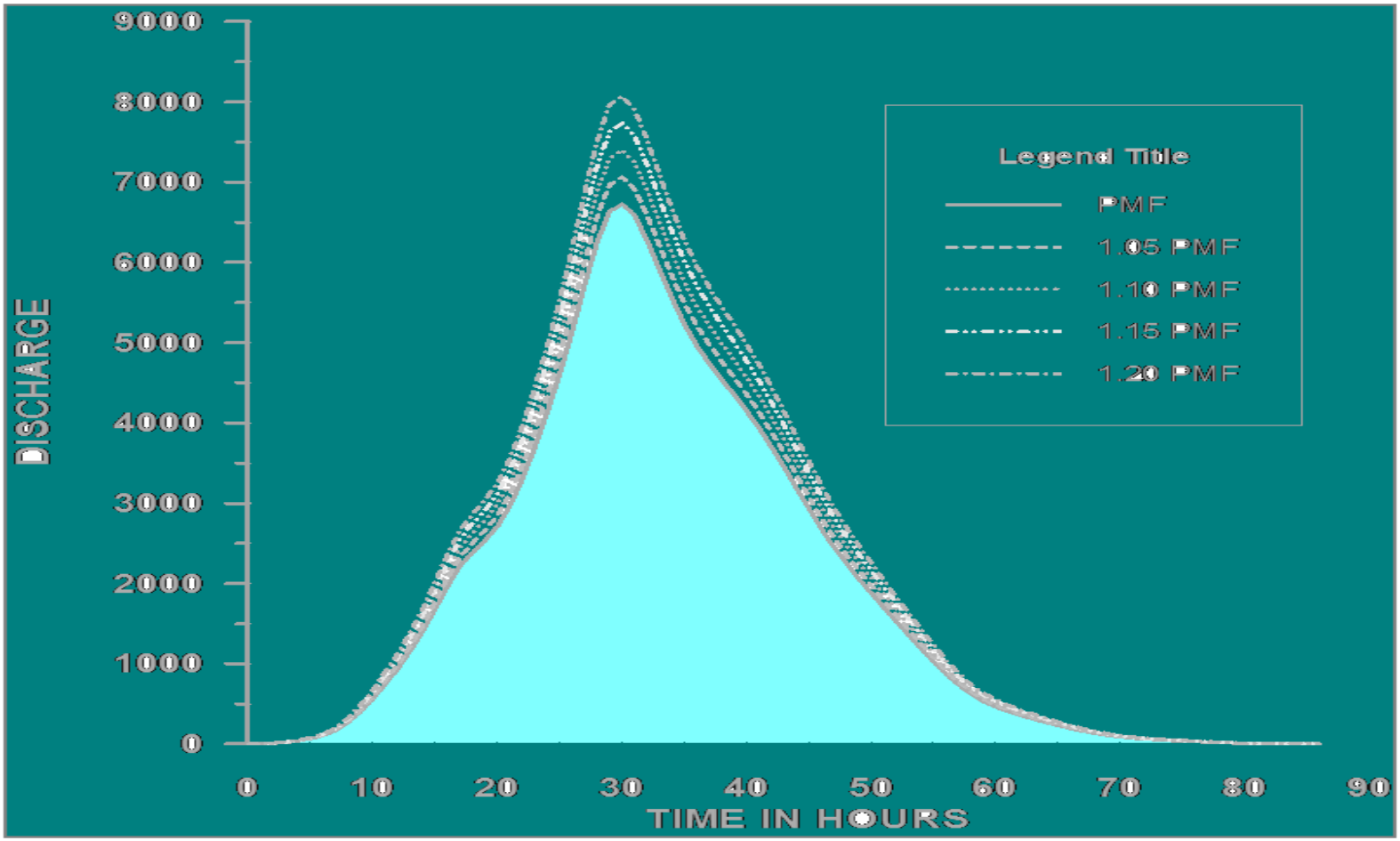
Sensitivity Analysis for Estimation of floods of various return periods using L-moments for different Scenarios (m^3/s)

Return Periods	25	50	100	1000
Scenario 1	8978	10418	12042	19208
Scenario 4	9403	11049	12945	21676
Scenario 5	9408	11025	12868	21186
Scenario 6	10603	12896	15657	29802
Scenario 7	10685	12842	15358	27317

% Deviations in floods of various return periods for different Scenarios

Return Periods	25	50	100	1000
Scenario 4	4.73	6.05	7.50	12.85
Scenario 5	4.78	5.83	6.86	10.30
Scenario 6	18.0	23.8	30.0	55.2
Scenario 7	19.0	23.3	27.5	42.2

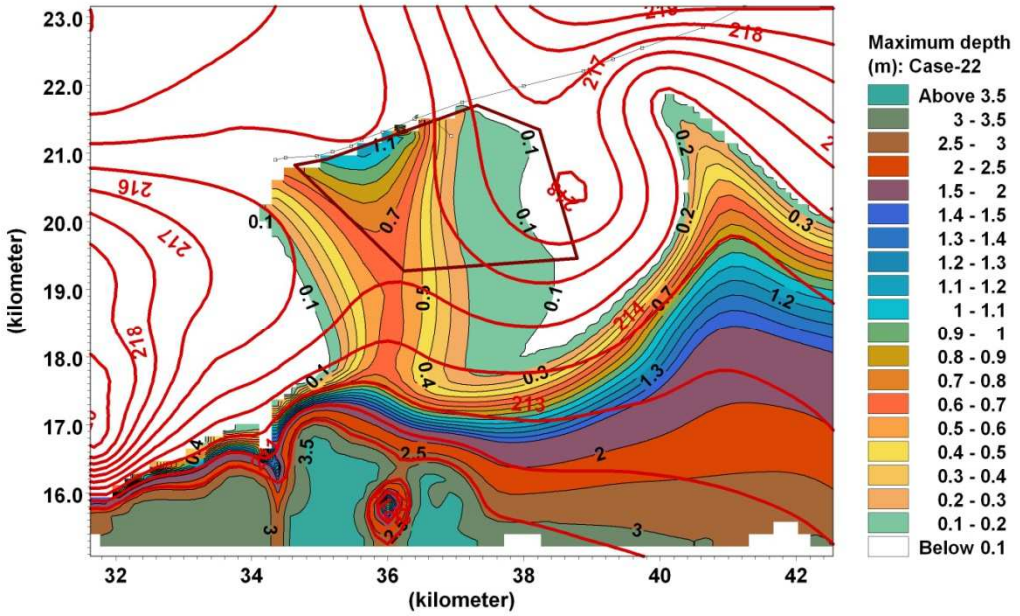
PMF 6842 m3/s	1.05 PMP	1.10 PMP	1.15 PMP	1.20 PMP
	Peak of PMF			
	7064	7401	7737	8073
	% Deviation in PMF			
	3	8	13	18



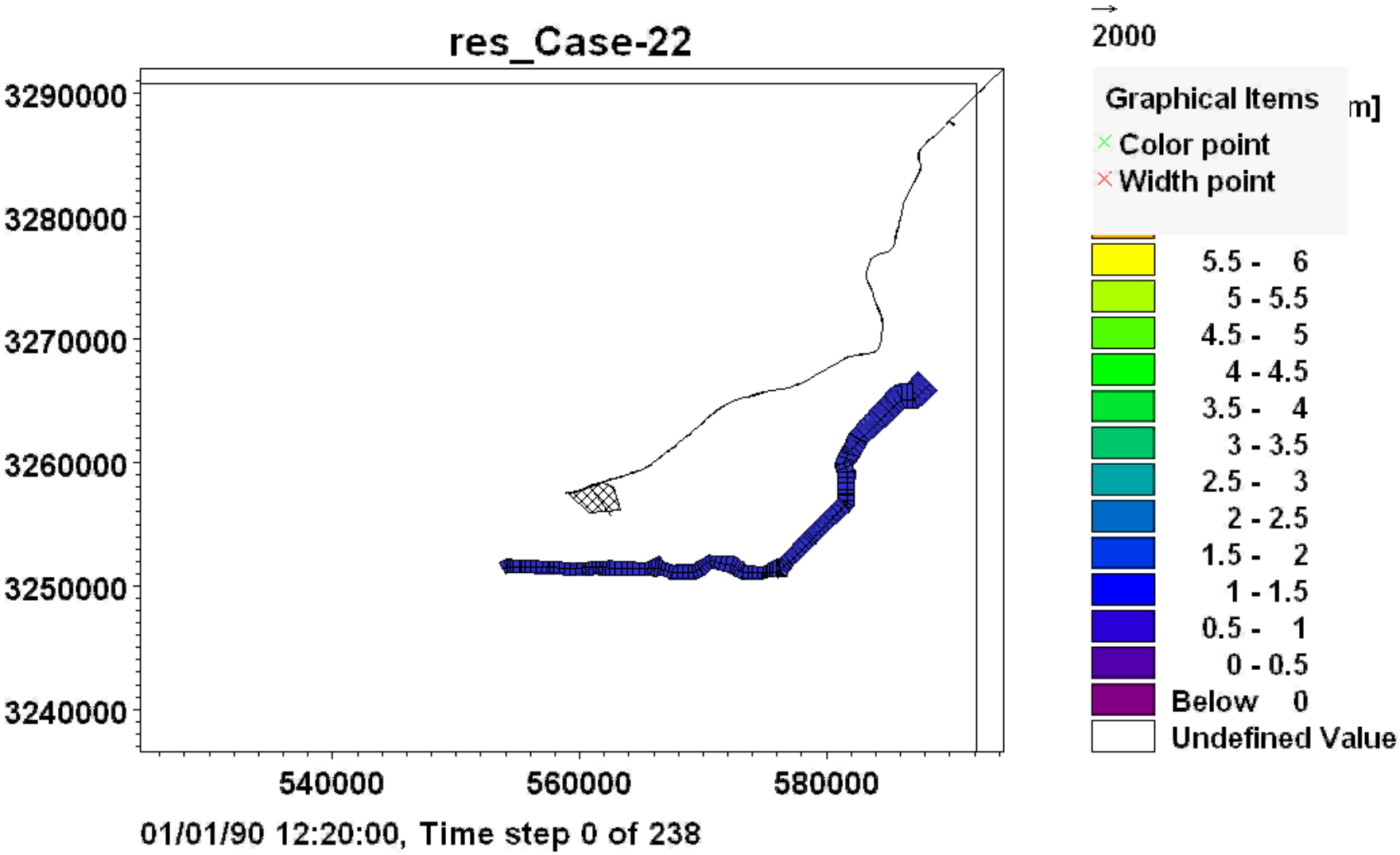
Estimation of Safe Grade Elevation for the Design Flood

Future climate change scenario

- Rainfall estimate is increased by 15% to account for the future climate change
- This makes case-22, the flooding scenario when bank full FBC flow is fully diverted towards plant site, local rain is 1000 yr + σ + 15% increase & catchment is flooded with 1000 yr + σ+15% increased rain
- Max flood depth = 1.17 m
- Max flood elevation = 218.25 m, increase of 0.1 m



FLOW MOVEMENT ANIMATION



Case-22

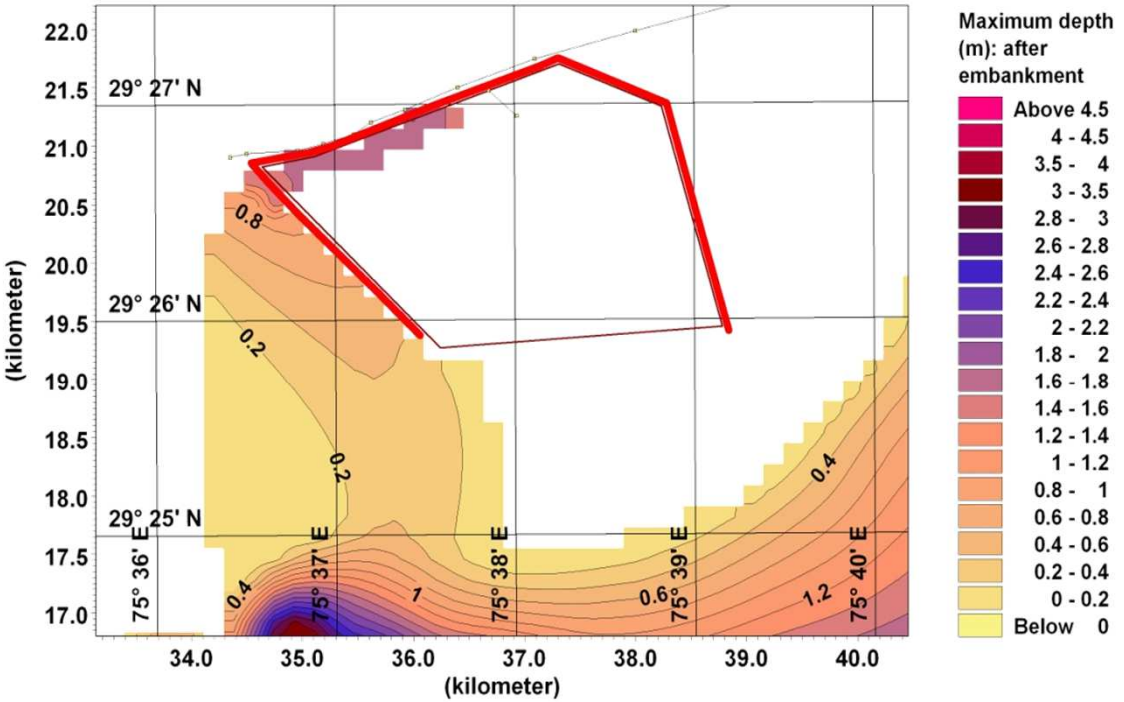
Catchment flooding – 1000+σ+15%increase, local site rainfall – 1000+ σ +15%increase,
Full flow divert from FBC & BML

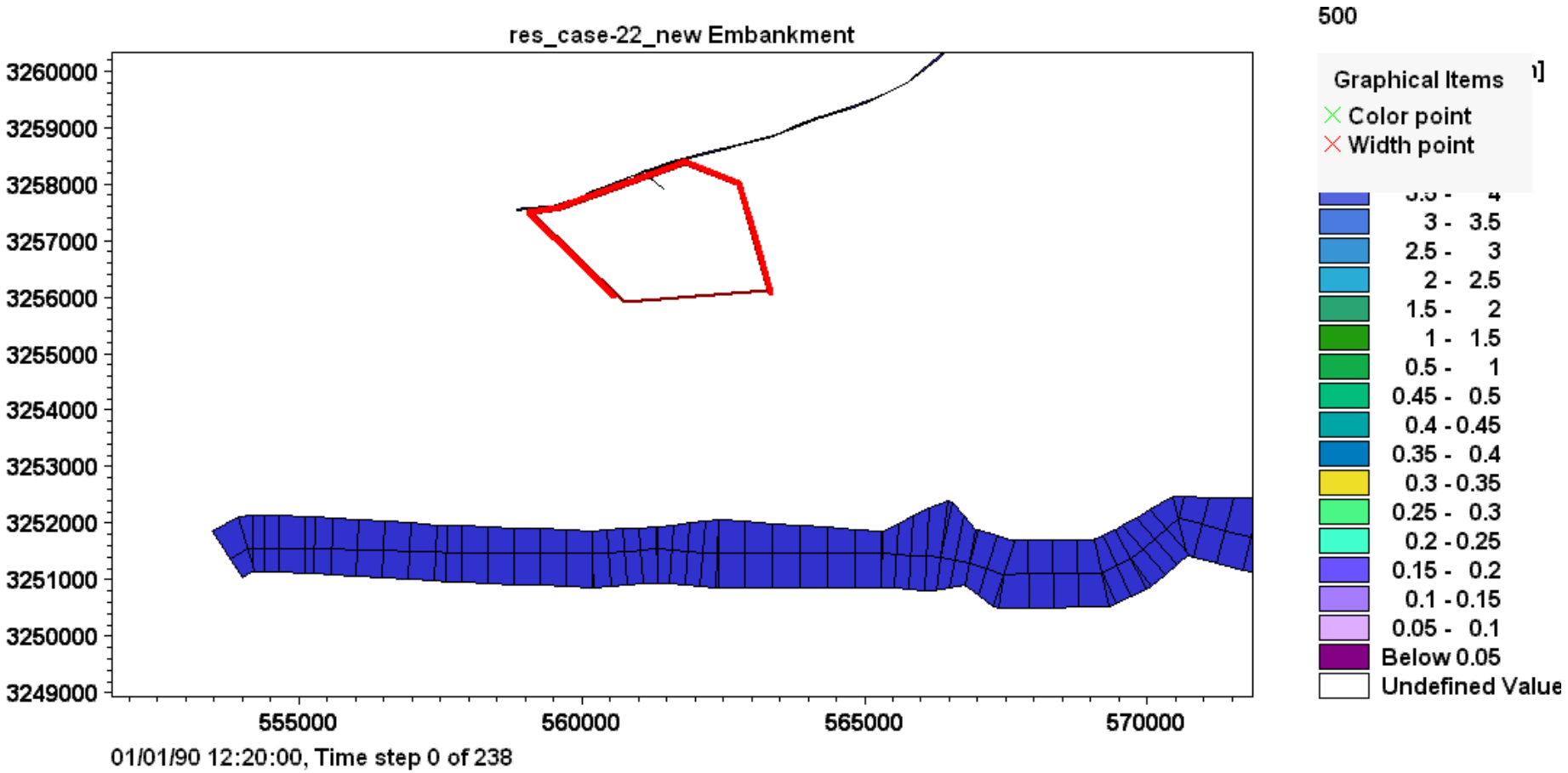
FLOOD PROTECTION MEASURE

Alternative-I:

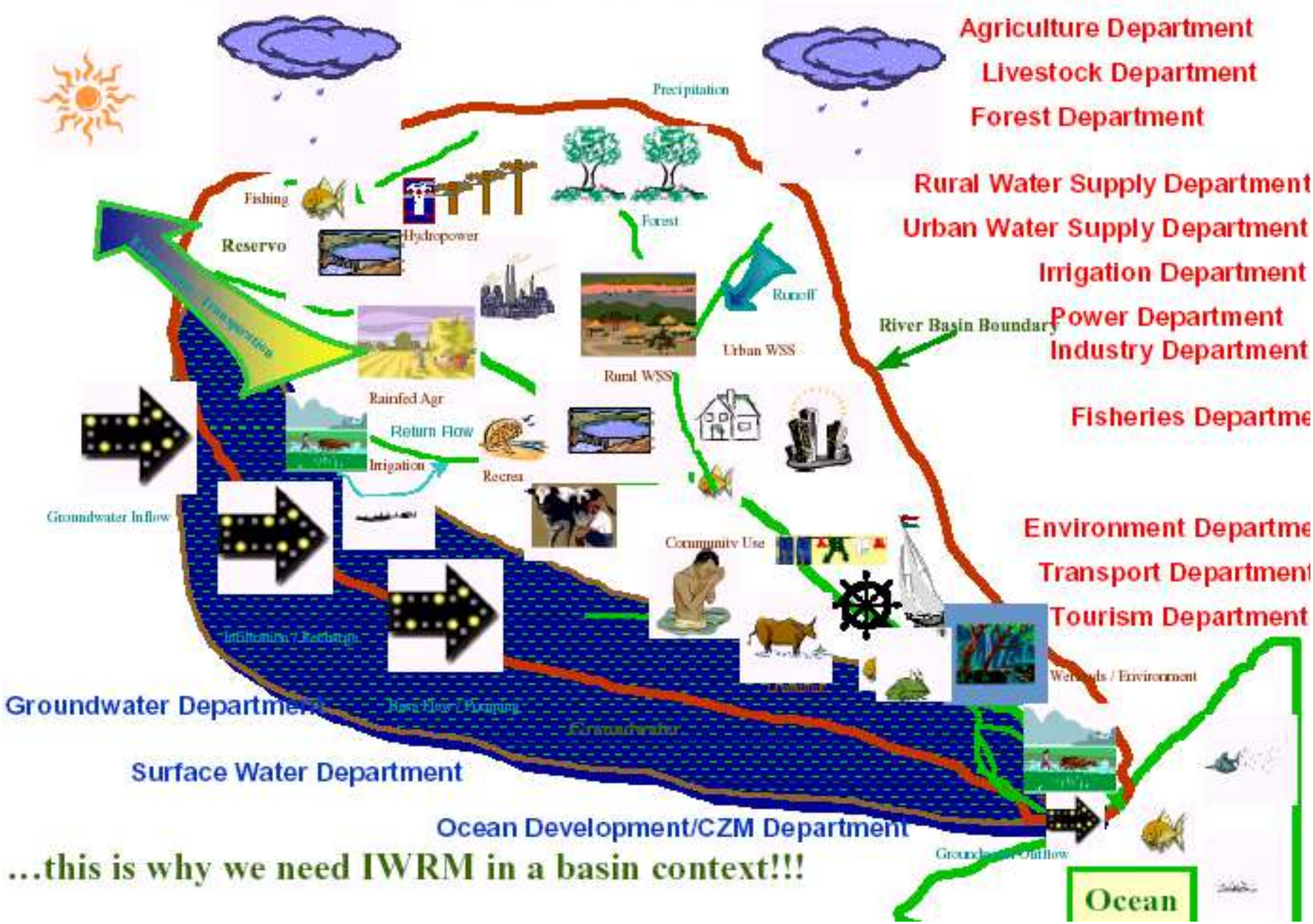
A flood protection embankment with top elevation of RL 219.3 m and plinth level of structures at RL 219.1 m

(local 1000 yr rainfall with 15% increase for CC and 1 .0 m free board)




res_case-22_new Embankment
3260000
3259000
3258000
3257000
3256000
3255000
3254000
3253000
3252000
3251000
3250000
3249000
555000
560000
565000
570000
01/01/90 12:20:00, Time step 0 of 238
500
Graphical Items
Color point
Width point
3 - 3.5
2.5 - 3
2 - 2.5
1.5 - 2
1 - 1.5
0.5 - 1
0.45 - 0.5
0.4 - 0.45
0.35 - 0.4
0.3 - 0.35
0.25 - 0.3
0.2 - 0.25
0.15 - 0.2
0.1 - 0.15
0.05 - 0.1
Below 0.05
Undefined Value

Why Integrated Water Resources Management?



…this is why we need IWRM in a basin context!!!

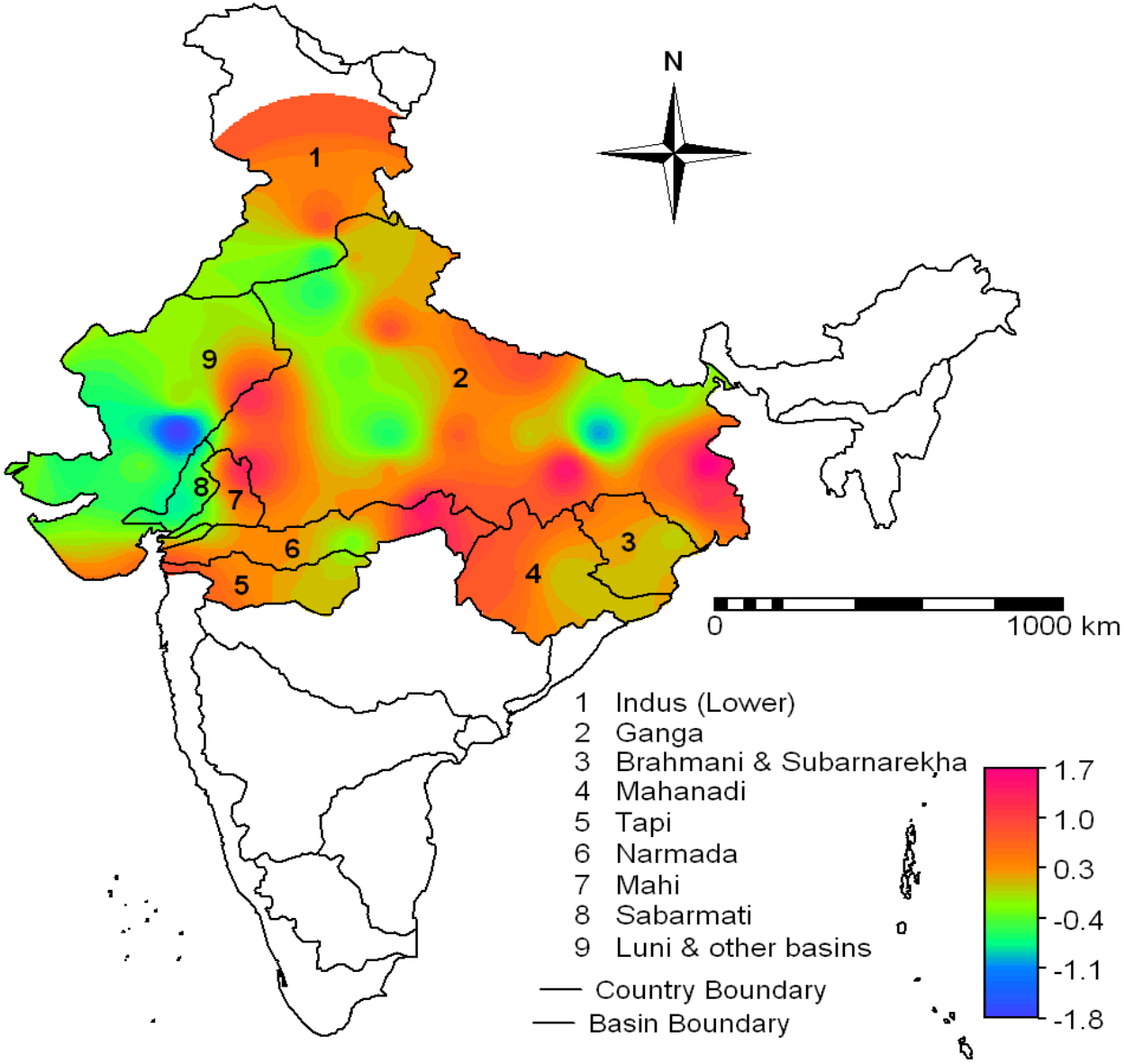


Figure 1: Spatial patterns of linear trends in annual mean temperature (oC/100 years) for different river basins during last Century (1901-2000).

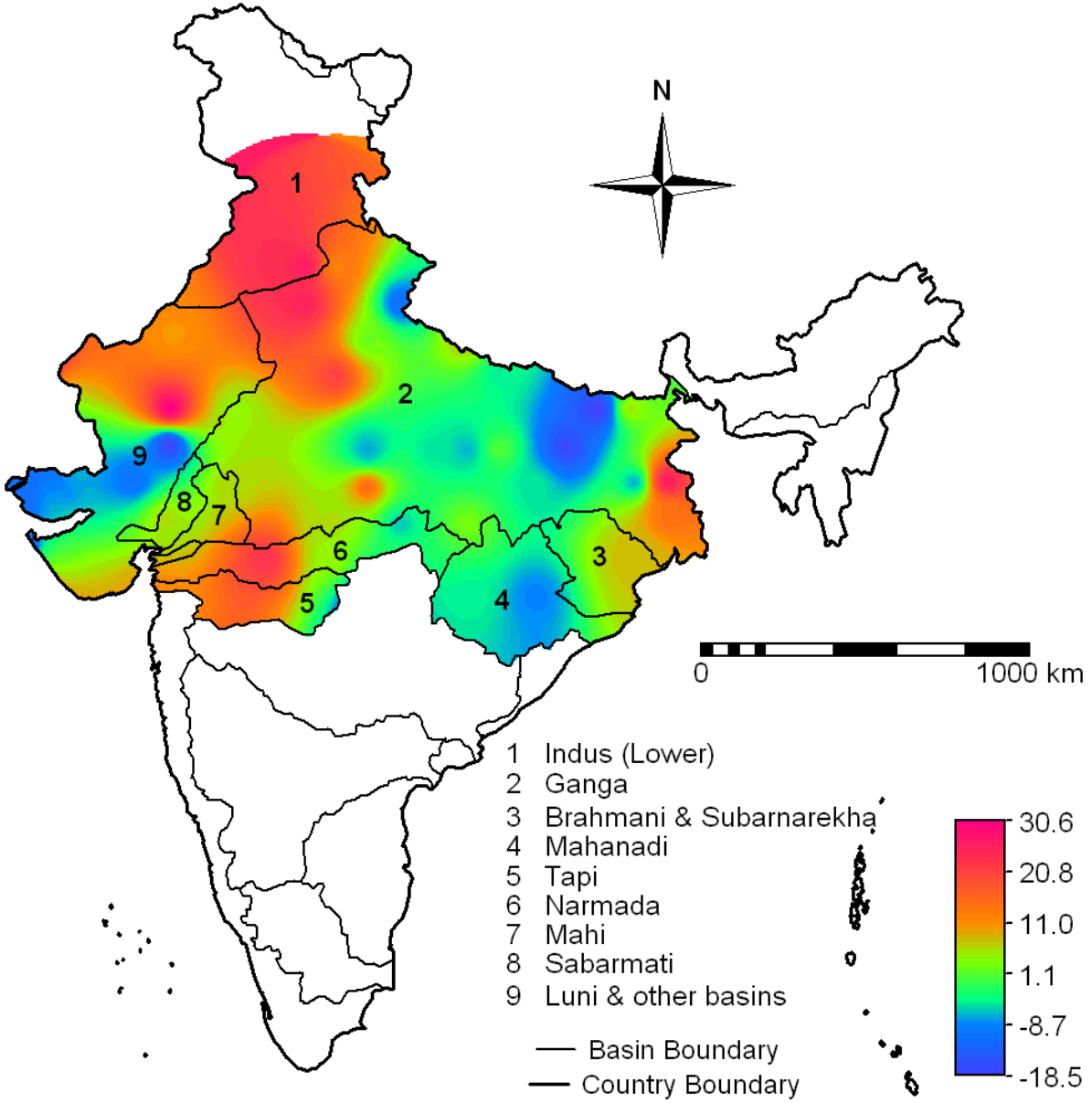
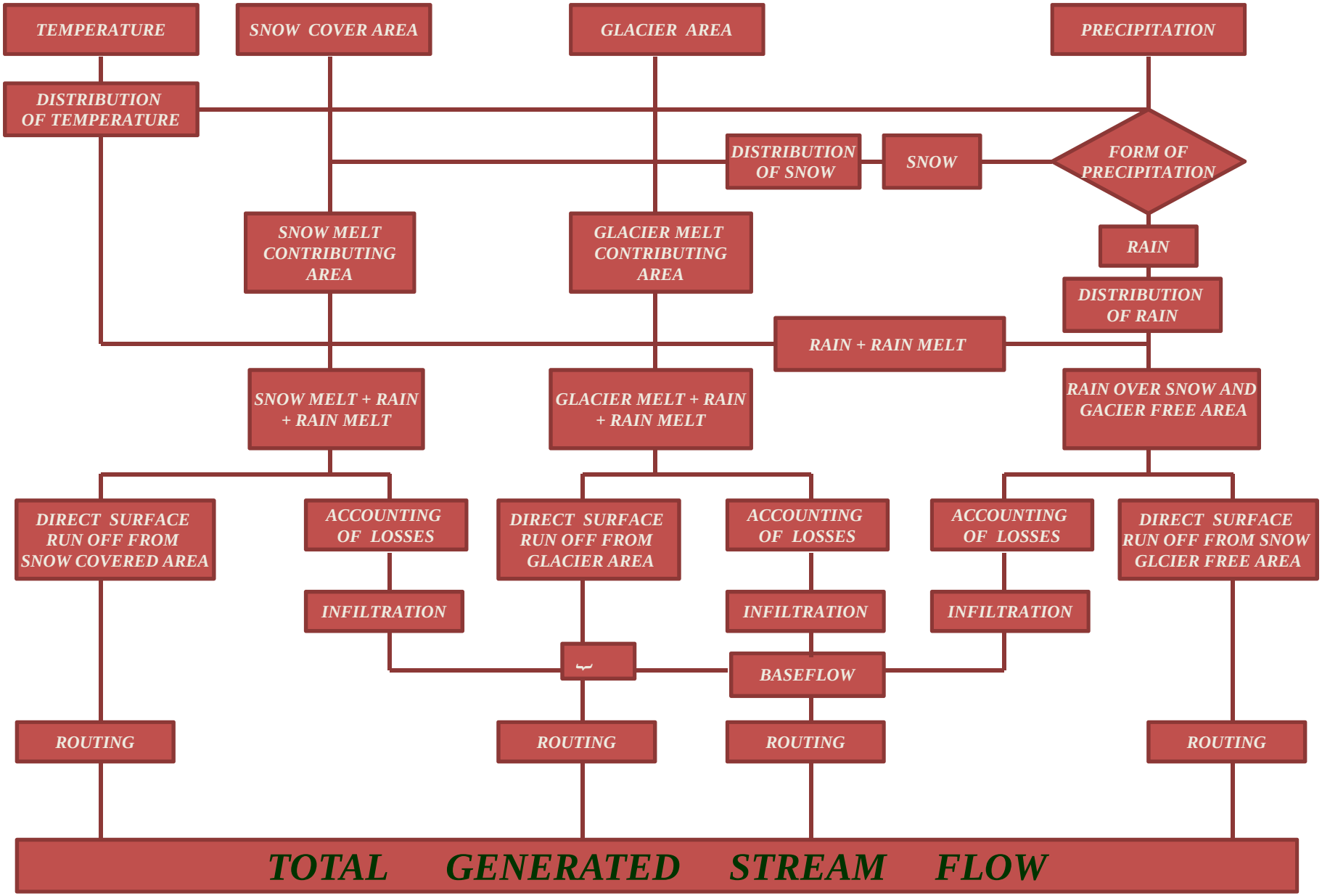


Figure 2: Spatial patterns of linear trends in annual rainfall (% of mean /100 years) for different river basins during last Century (1901-2000).



Flow chart of the snowmelt model (SNOWMOD)

Climate variability analysis for Satluj Basin

- *Basin Area (Indian part) : 22,275 km^2*
- *Elevation Range: 500-7000 m.*
- *Snow covered area : About 65% after winter*
- *Glacierized area : About 10%*
- *Important hydropower scheme: Bhakra Dam*

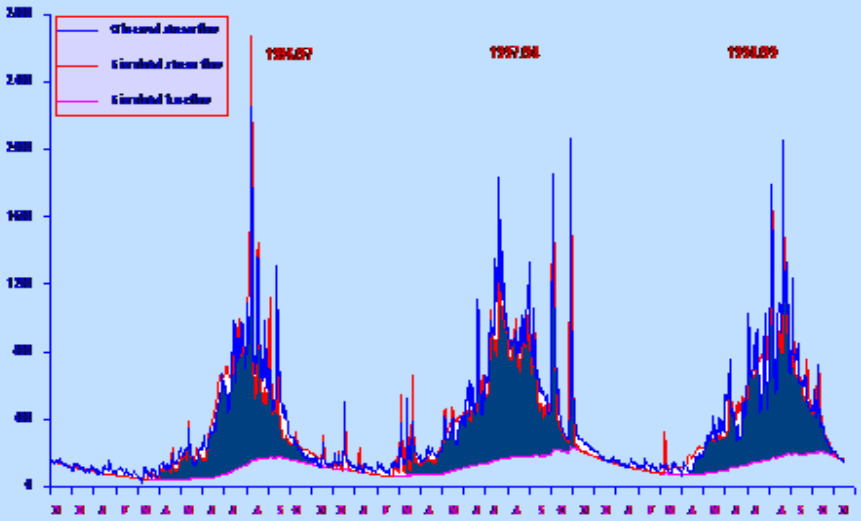
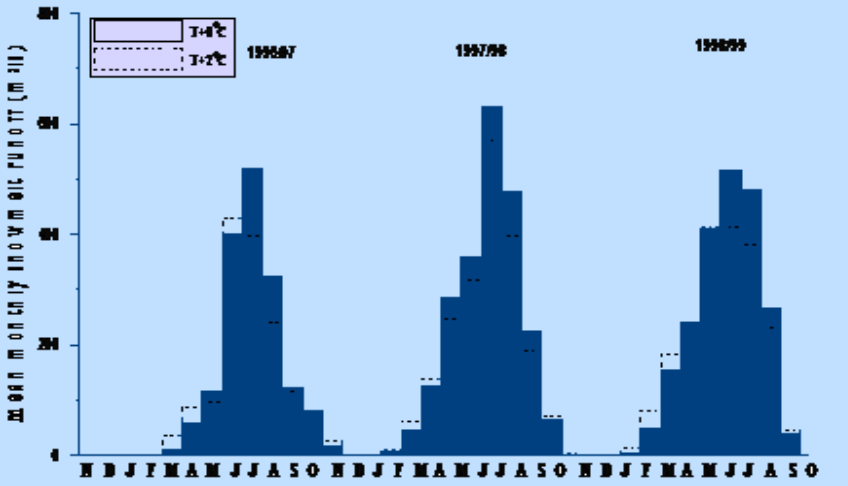


Figure 4: Observed and simulated daily streamflow for the Satluj River at Bhakra for a period of 3 years (1996/97–1998/99).



Effect of increase in temperature on mean monthly snow melt runoff for a period of 3 years (1996/97-1998/99) in the Sutlej River Basin.

Climate Change and Adaptation

Assessment of projected water demands for irrigation, drinking water supply, industrial water supply , environmental requirements etc. based on climate change, demography, economic development and spatial planning

Assessment of projected water availability from the analysis of Hydrological and Hydro-meteorological data taking in to account impact of climate change

Optimal allocation of projected available water for future scenarios considering projected water demands using river basin simulation model

Review of hydrological design practices – Existing methodologies for computations of SPS, PMP, design storms, basin response and other design parameters are required to be reviewed.

Adaptation Strategies for Climate Change

In case of imbalance between projected demands and supply, design water resources management strategies (logical and/or promising combinations of structural and non-structural measures, allocation rules and water sharing options) to improve the situation

Assessment of the performance of the strategies, in terms of impacts on the water resources system, the socio-economic system and the environment.

Contd…

Adaptation Strategies for Climate Change

Flood Management Strategies – Long-term flood management strategies should be re-examined and accordingly actions may be planned.

Drought Management Strategies - Measures to augment supplies and decrease demands in the drought prone areas are needed.

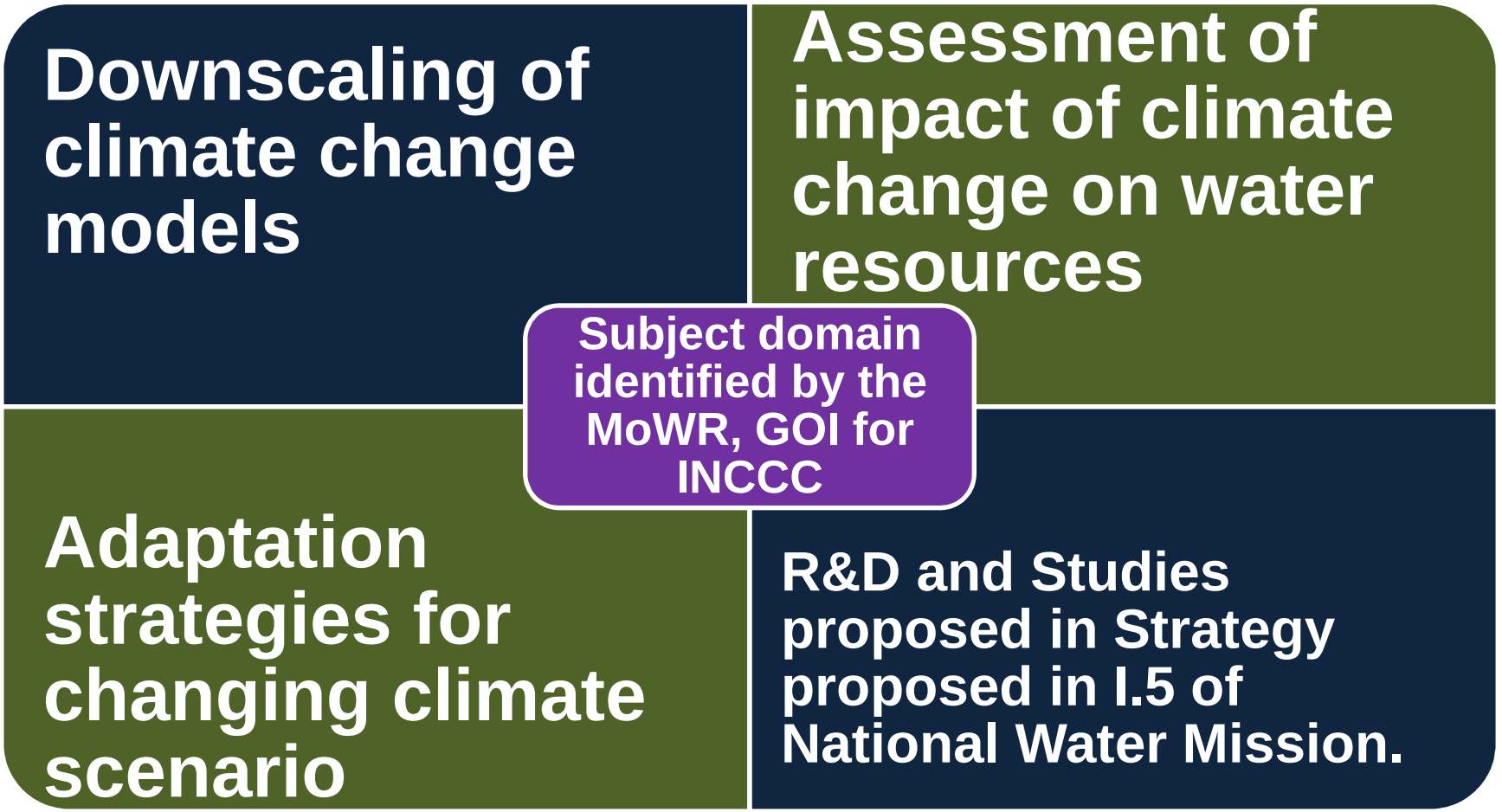
Temporal and spatial assessment of water for Irrigation - Conjunctive use of surface water and groundwater needs to be encouraged.

Land Use and Cropping Pattern - Need to understand the possible coping strategies by different sections and different categories of farmers.

Prediction of Impact of Climate Change and Management Water Resources

- Downscaling of GCM Outputs for use in Hydrological Modeling on basin scale
- Applications of distributed Hydrological Model for making future predictions considering all the processes of land phase of hydrological cycle
- IWRDM, Development of DSS (Planning), DSS (Real Time), Policy & Operational Approaches to Manage Water Resources in in Medium to Long Term
- Training on the developed software and techniques.

Thrust areas of INCCC as per R&D guidelines




THANKS!