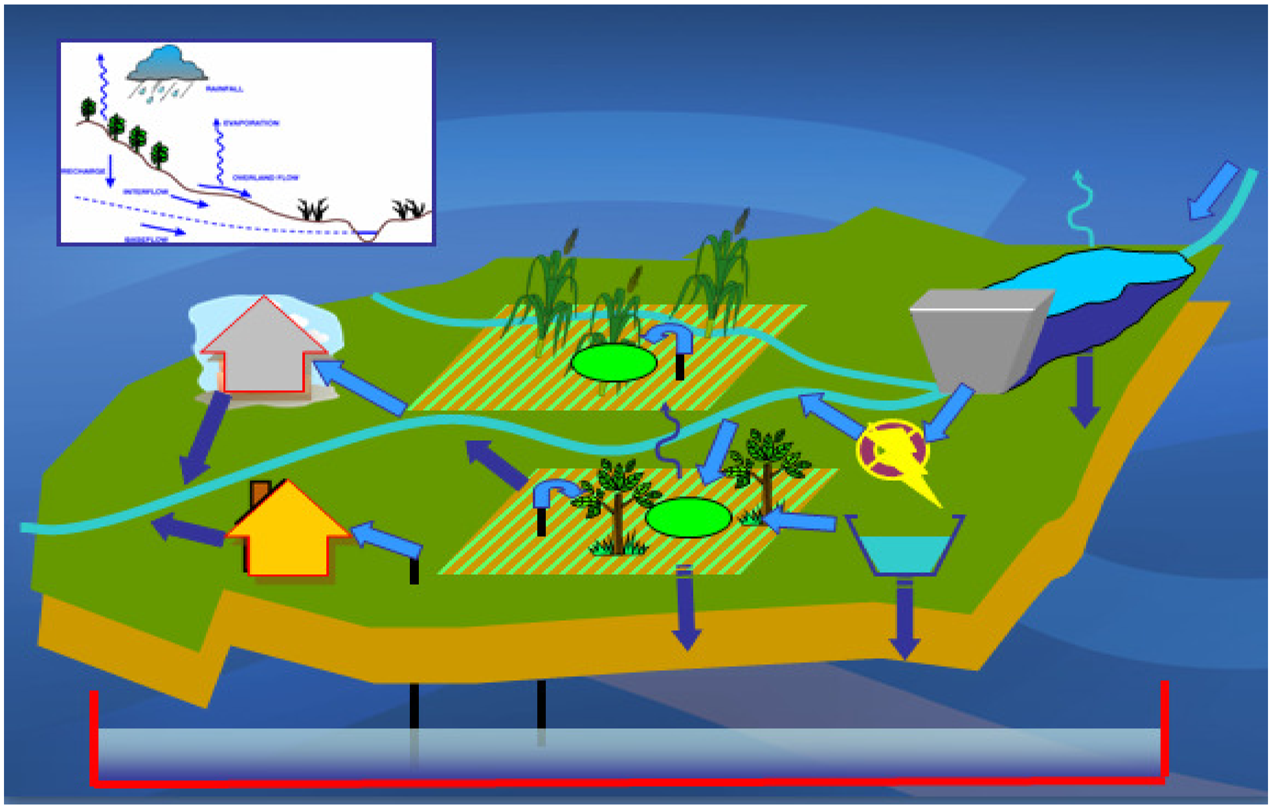
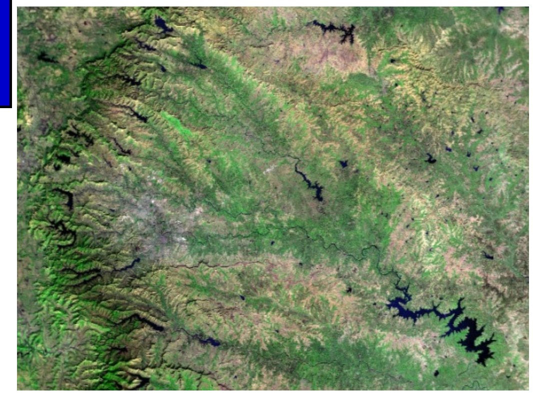
Integrated Water Resources Development and Management for Upper Bhima River Basin of India

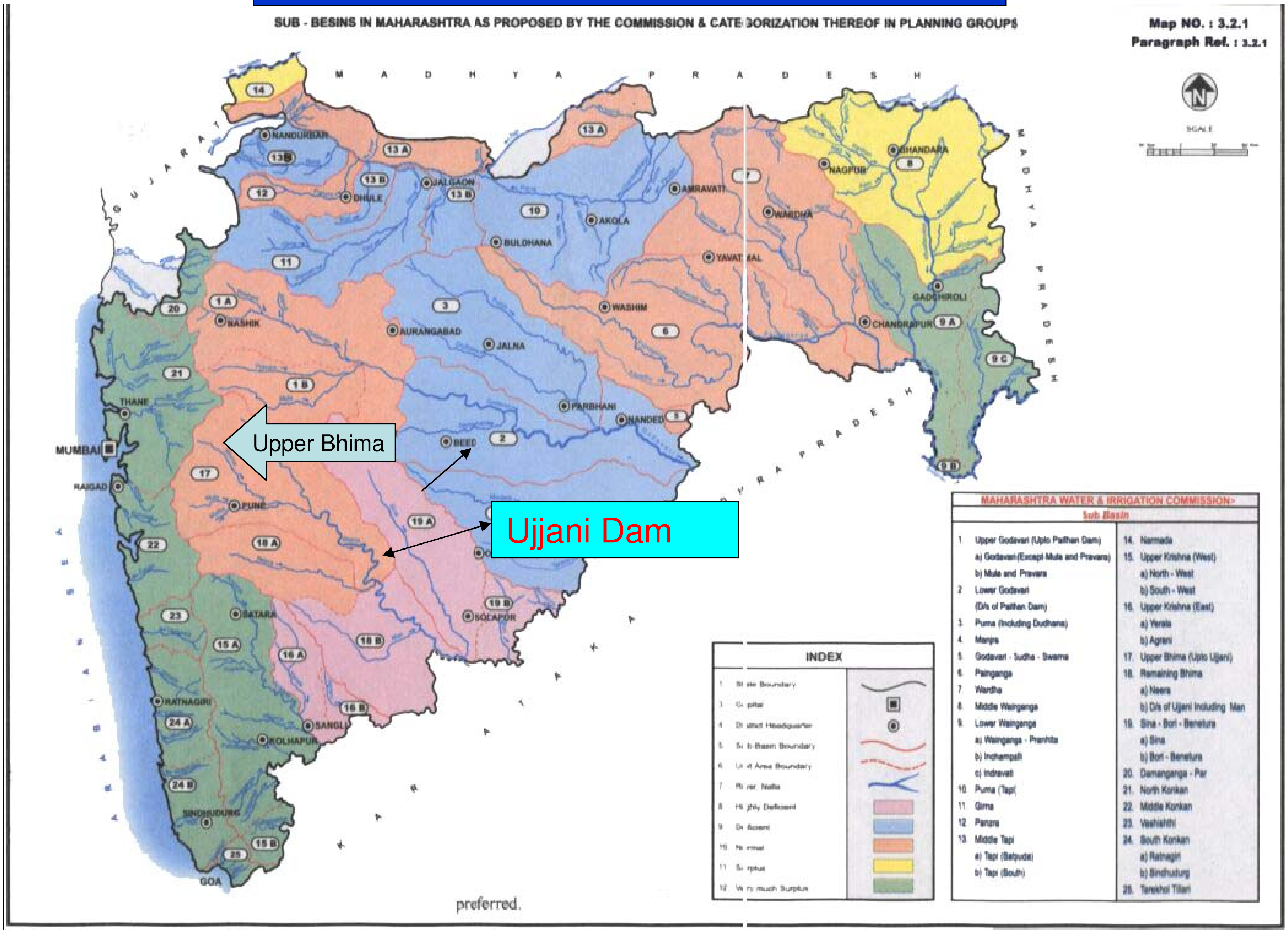




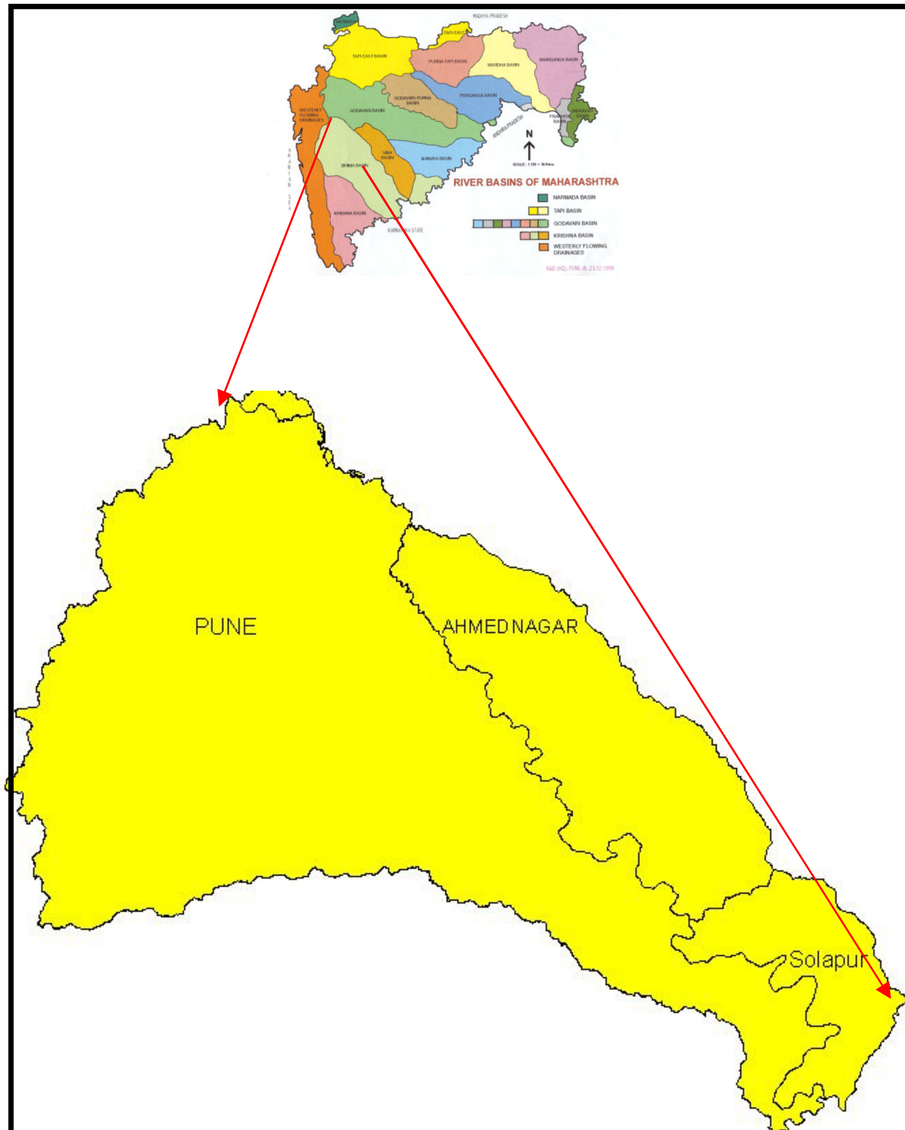
Rakesh Kumar
National Institute of Hydrology
Roorkee, India

Upper Bhima River Basin

Map of Sub Basins in Maharashtra

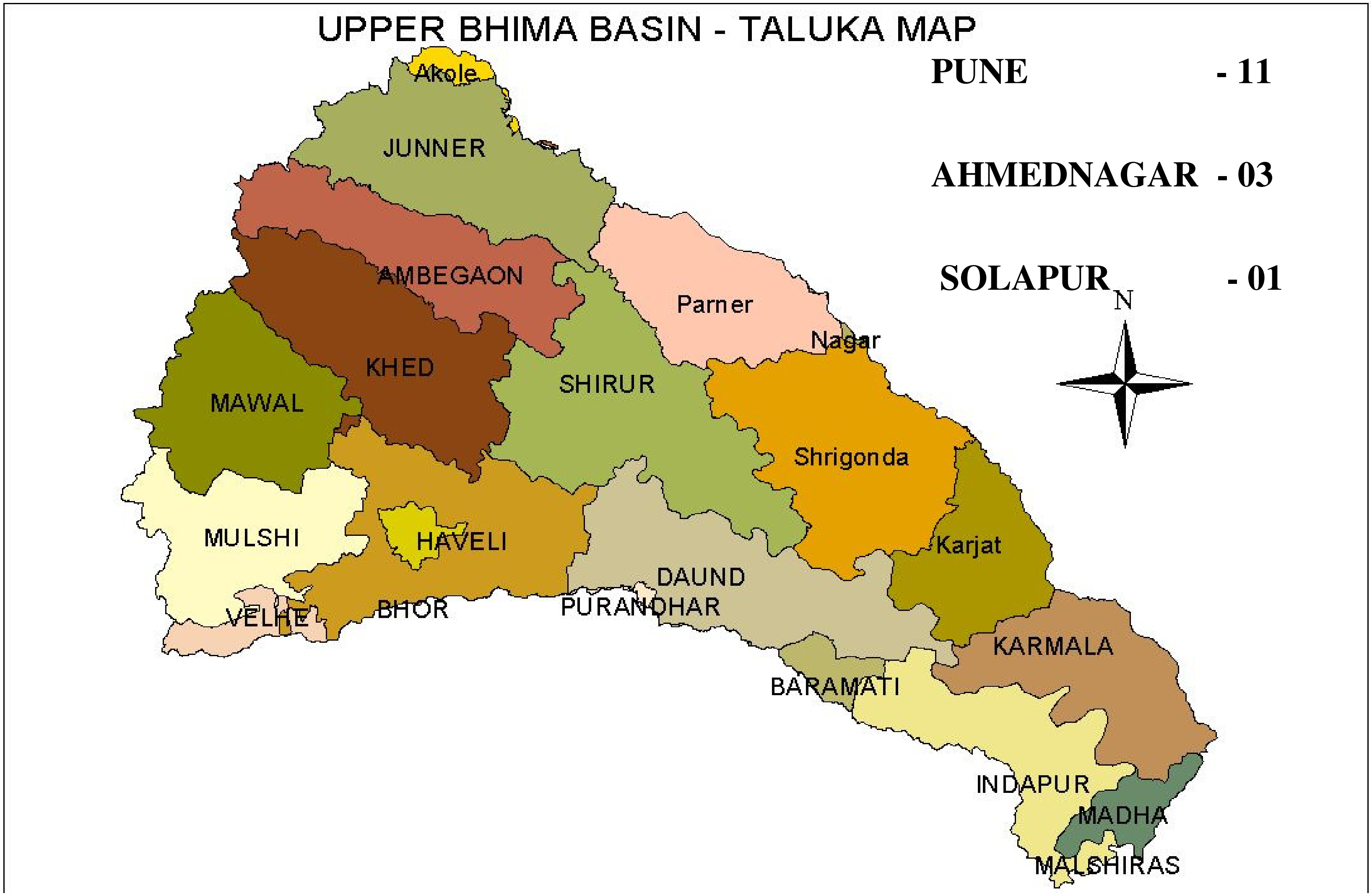


LOCATION MAP OF UPPER BHIMA BASIN



- **18^0 3' to 19^0 24' North Latitude**
- **73^0 20' to 75^0 18' East Longitude**
- **Covers an area of 14712 sq. km.**
- **The basin covers area of Pune, Solapur and Ahmednagar district of Maharashtra**

TALUKA MAP OF UPPER BHIMA BASIN



Average Annual Rainfall

Sr. No.	District	Taluka	Average annual rainfall (mm)	Area
1	Pune	Haveli	692	In Sq.Km
2		Dound	471	1290
3		Indapur	519	893
4		Shirur	499	1557
5		Junnar	626	416
6		Baramati	483	110
7		Khed	681	1400
8		Maval	440	1131
9		Mulshi	1576	1039
10		Ambegaon	1197	1043

Populaion in Bhima Basin & Growth Rate

Sr.No.	District	Taluka	Population		Growth Rate %
			2001	1991	
1	Pune	Ambegaon	213842	186809	14.47
		Junner	369806	303951	21.67
		Khed	343214	283504	21.06
		Haveli	4048961	2889195	40.14
		Maval	305083	242490	25.81
		Daund	341388	263994	29.32
		Baramati	372852	310442	20.10
		Velhe	55874	53968	3.53
		Shirur	310590	239405	29.73
		Mulshi	127385	123326	3.29
		Indapur	348413	287753	21.08
2	Solapur	Karmala	233316	205000	13.81
3	Ahmednaga	Shrigonda	277356	235706	17.67
		Karjat	205674	184331	11.58
		Parner	246552	214064	15.18
	Total		7800306	6023938	29.49

Geological Formation:

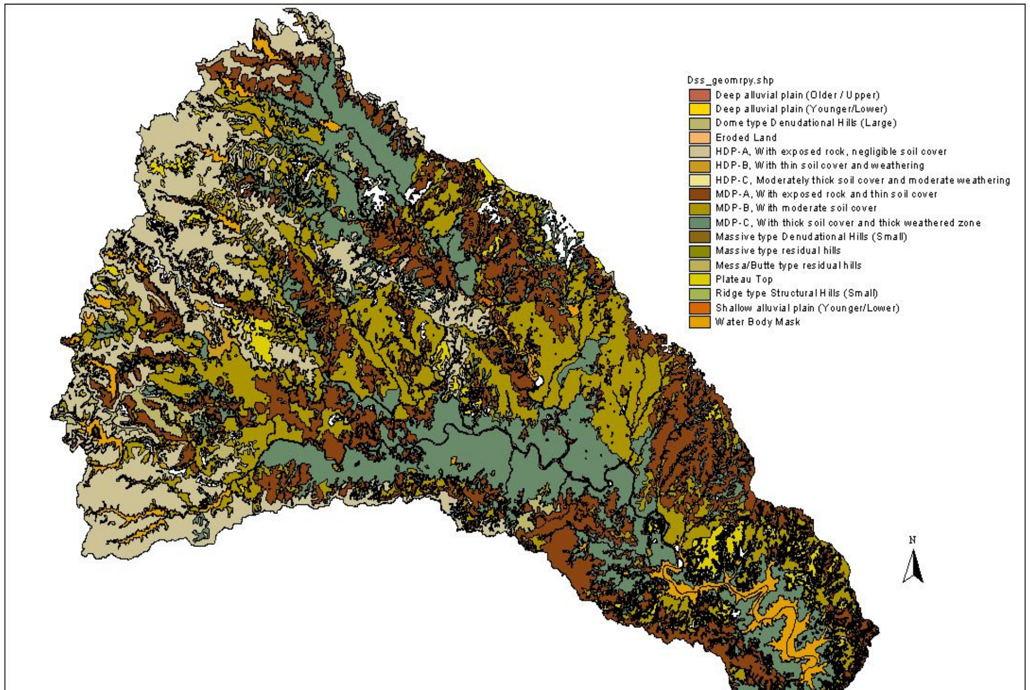
Geomorphology:

About 25% of the area in the Sub-basin is hilly & highly dissected, 5% is plateau & 20% plain & valley filled. There are 68 GSDA-designated watersheds in this Sub-basin.

Geology:

The Sub-basin is predominantly covered by multi-layered Deccan Trap formation formed of lava flows. It is overlain with recently formed alluvium mainly along the banks of Bhima, Ghod, Mula & Mutha Rivers.

GEOMORPHOLOGICAL MAP OF UPPER BHIMA BASIN



GEOMORPHOLOGICAL MAP OF THE UPPER BHIMA BASIN

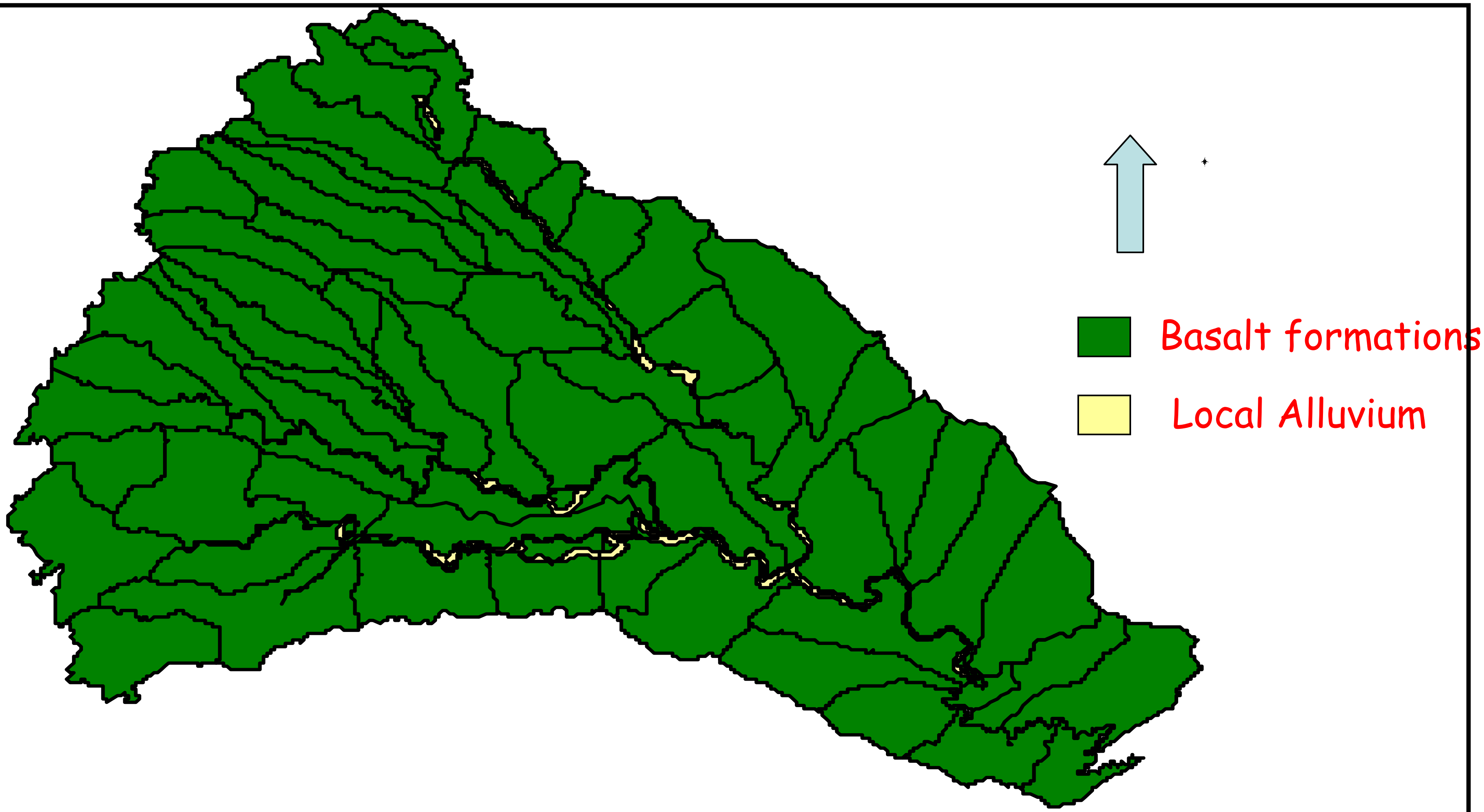
Basin can be roughly divided into three zones

The western zone : zone consists of the main Sahyadri hills which run along the entire western border of the basin. The terrain is characterised with steep slopes, clear cut ridges. These hills have height of between 700 to 1300 metres.

The eastern zone: In this zone the hills sink slowly into the plain, the tablelands become lower and more broken often little more than rolling uplands and the broader and more level valleys are stripped of bare soil less plateaus.

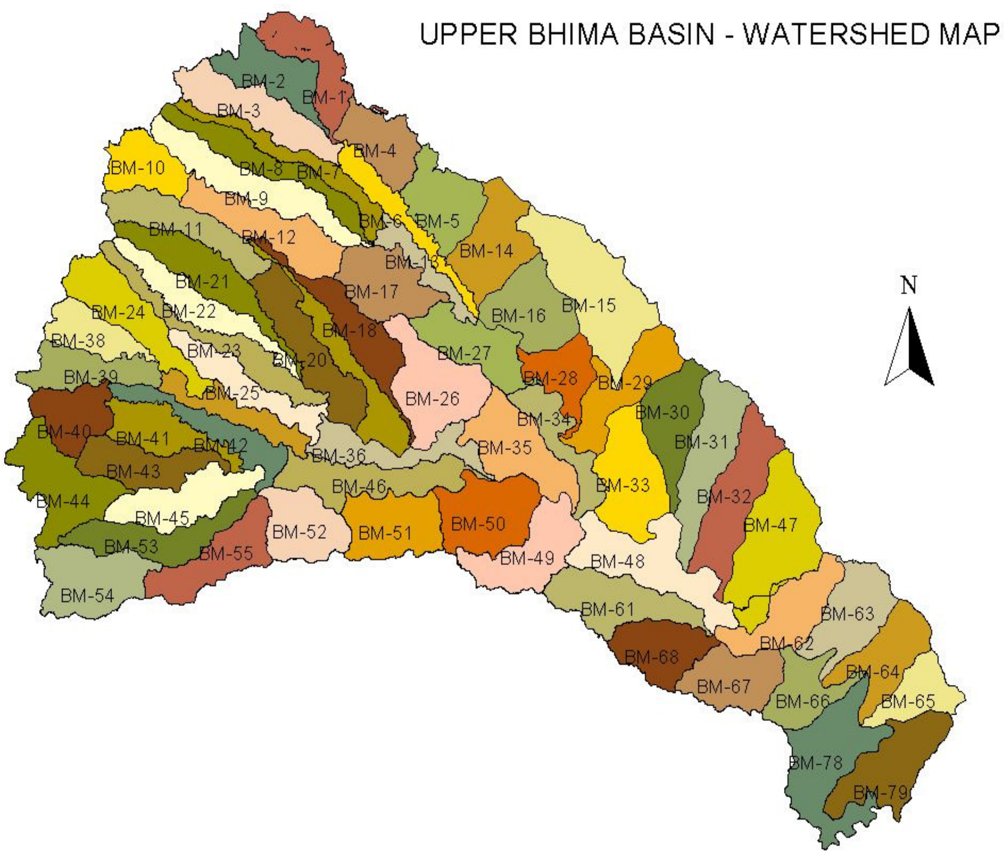
The central zone : This zone shows smaller chains of hills sink into the plains. This region has a moderate but certain and seasonal rainfall.

GEOLOGICAL MAP OF UPPER BHIMA BASIN



The Sub-basin is predominantly covered by multi-layered Deccan Trap formation formed of lava flows. It is overlain with recently formed alluvium mainly along the banks of Bhima, Ghod, Mula & Mutha Rivers

ELEMENTARY WATERSHED MAP OF UPPER BHIMA BASIN



District	No of WS
Pune	50
Ahmednagar	11
Solapur	3
Total	64

CLIMATE & RAINFALL

Climate

- The climate of the basin is generally dry.
- The year may be divided into three seasons.
- The cold season is from November to February
- The monsoon season from June to October.
- The hot season from March to May
- Average annual rainfall is 700 mm. The rainfall generally decreases from west to east.

Rainfall

- On the basis of Rainfall Characteristics the basin is divided in three regions.
- The extreme western region - heavy rainfall (2300mm)
- The foot hill region- moderate rainfall (800 to 1000 mm)
- The central & eastern region - lowest rainfall. (400 to 600mm)

Surface Hydrology and Water Storages

- Important tributaries of Bhima River in the upper region include the Mula, Indrayani, Mutha, and Ghod Rivers.
- This basin is advanced as far as industrialization and urbanization are concerned. It has a terminal storage at Ujjani.
- Upstream of the Ujjani Reservoir, 18 projects exist with gross storage greater than 17.4 MCM.

Surface Hydrology and Water Storages cont…

- The original purpose of these projects was to catch the runoff from the Western Ghats to be used for irrigation during the non-monsoon period.
- Since the development of these projects, municipal and industrial demands have since accounted for much of this supply of water as has the need for flood protection.
- Six hydropower projects have a total installed capacity of 318MW.
- The Khadakwasla and Ujjani Reservoirs service large commands areas.

Bhima Basin Land Use

No	Particulars	Area ('000 Ha)	Percentage with geographical area
1	Geographical area	1471	100
2	Area with the Forest Department.	149	10.1
3	Non-arable area a)Barren land b)Land under non-agricultural uses	132 68	9 4.6
4	Culturable fallow land	31	2.1
5	Permanent pastures & grazing lands	63	4.3
6	Land under miscellaneous trees & shrubs	2	0.1
7	Current fallow land	34	2.3
8	Other fallow lands	39	2.7
9	Net sown area	953	64.8
10	Culturable area (4+5+6+7+8+9)	1122	76.30
11	Area sown twice	164	-
12	Total cropped area (9+11)	1117	-
13	Cropping intensity (12÷9 x 100)	117 %	-

Soils

Soils in the basin range from reddish brown on sloping land (basalt 38%),Coarse shalow soils (12%), medium black soils (26%), and Deep black soil (24%)

Data Availability for CCAA Study

No. of obs. Sites	In the basin
Daily Rainfall (1970-2004)	18
Daily Temperature (1969-2004)	1
Discharge (1969-2007)	2

Hydrological Problems

- 20% of the area is hilly, comes under high rainfall and falls in Run-off zone . Hence groundwater storage is for short duration.

- 22% of the project area falls under Chronically drought affected category. In this zone repetitive failure of rainfall is a major problem.

- 9% of the project area is under surface water irrigation and due to heavy usage of chemical fertilizers, groundwater is qualitatively affected. This is further aggravated due to industrial development.

- Large quantity of domestic and industrial water requirement for the Cities of Pune, Pimpri, Chinchwad, and Solapur has to be met through surface water in the Temghar and Pawana Reservoirs that was earlier earmarked for irrigation.

Hydrological Problems cont…

- There are a number of major and medium dams constructed upstream of Ujjani Reservoir. The integrated operation of reservoirs is, therefore, necessary during the floods as well as during the drought.

- Similarly threat to the City of Pune by releases from Panshet, Khadakwasala, War-sagaon, Temghar, and Pawana Reservoirs is critical.

- The pollution brought in through the entire drainage area will be going to be an important issue of planning and regulation in the context of this reservoir.

- Indiscriminate groundwater withdrawal through irrigation bore wells is going on a large scale leading to over exploitation of groundwater.

Hydrological Problems cont…

Large quantity of domestic water requirement for Pune city has to be met through surface water, earlier earmarked for irrigation.

Community has tendency to construct irrigational bore wells, which has created a problem of over exploitation of groundwater in the area.

Water Recourses Management Practices

- **Traditional Irrigation is practiced in most of the areas.**
- **Modern irrigational practices are adopted in about 5 % irrigated areas.**
- **Indiscriminate groundwater withdrawal through irrigational bore wells is going on a large scale.**
- **Transfer ownership of irrigation projects to WUAs has recently started.**
- **Community based drinking water supply management is adopted in the entire State.**
- **Under MWSIP project User Centered Aquifer Management is being piloted**
- **Under *Shivkalin Pani purvata yojana* sustainability of drinking water sources through community management is being practiced.**

Design flood estimation under hypothetical climate change scenarios

- **Objectives**
  - Effect of climate change on floods of various return periods
  - Effect of climate change on PMF

- **Various scenarios for estimation of floods of various return periods**
  I. Using Annual Maximum Peak Flood Series (AFS) data of 98 years of a snow and rain-fed catchment
  II. Using earlier 49 years of the AFS data
  III. Using later 49 years of the AFS
  IV. Increasing the highest 20% values of the AFS by 5%
  V. Increasing the highest 20% values of the AFS by 5% and decreasing the lowest 20% values of the AFS by 5%
  VI. Increasing the highest 20% values of the AFS by 20% and
  VII. Increasing the highest 20% values of the AFS by 20% and decreasing the lowest 20% values of the AFS by 20% are considered.

- **Various scenarios for estimation of PMF**
  I. Increasing PMP values by 5%, 10%, 15% and 20%
  II. Changes in sequencing of rainfall
  III. Increase in peak of the unit hydrograph
  IV. Changes of temporal distribution pattern of design storm and
  V. Changes of loss rate have been studied.

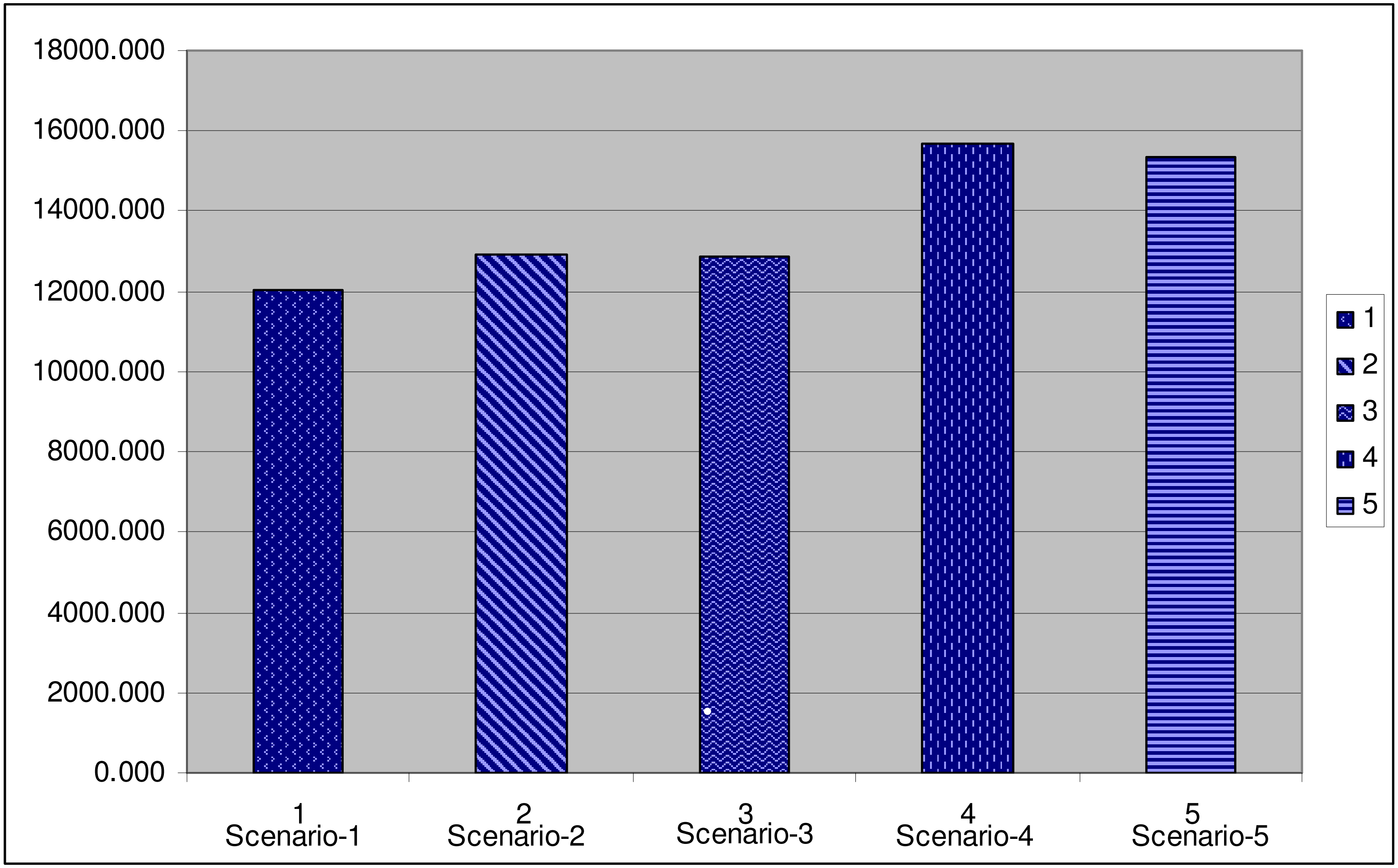
Floods of various return periods for different Scenarios

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

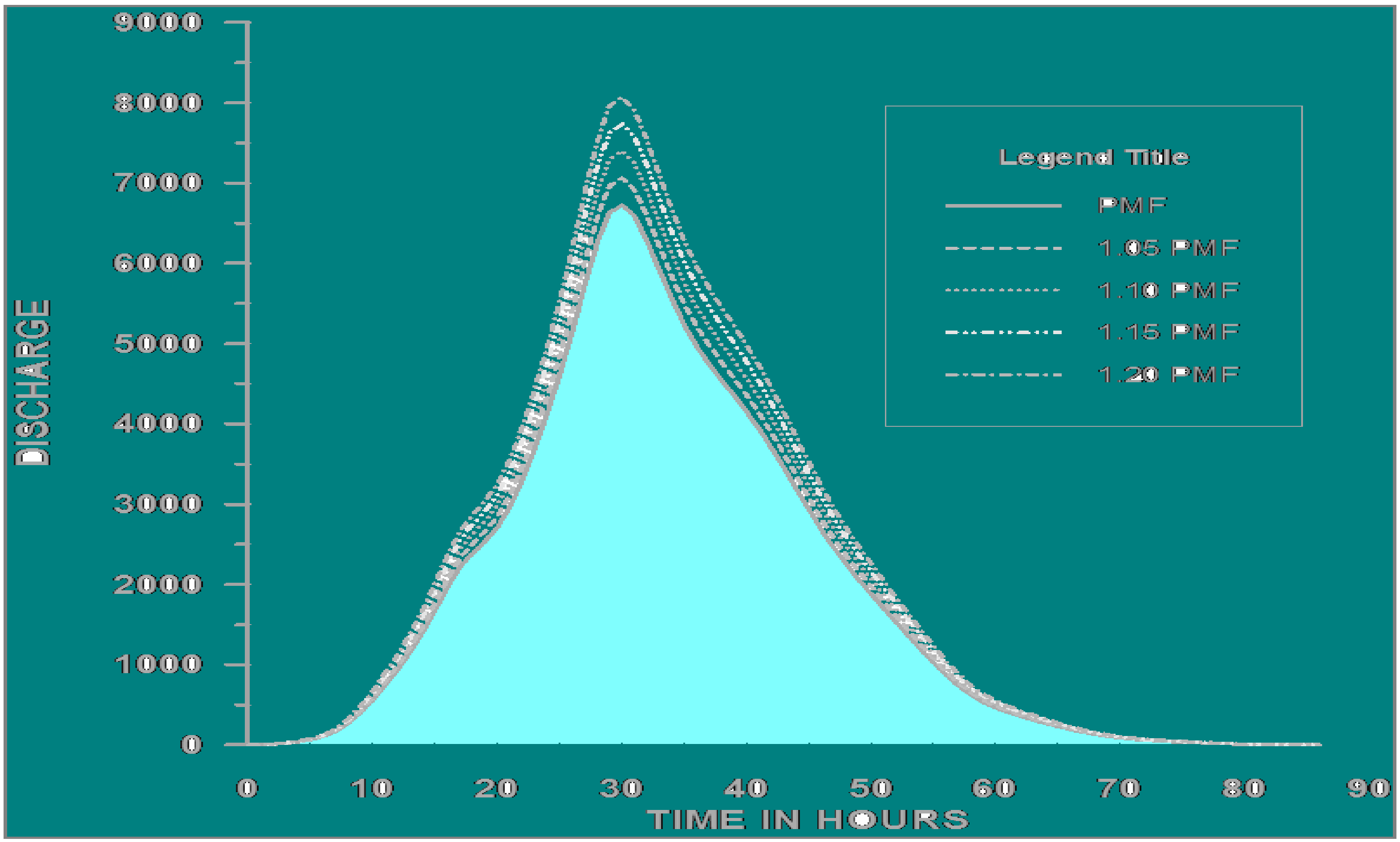
% Deviations in floods of various return periods for different Scenarios

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

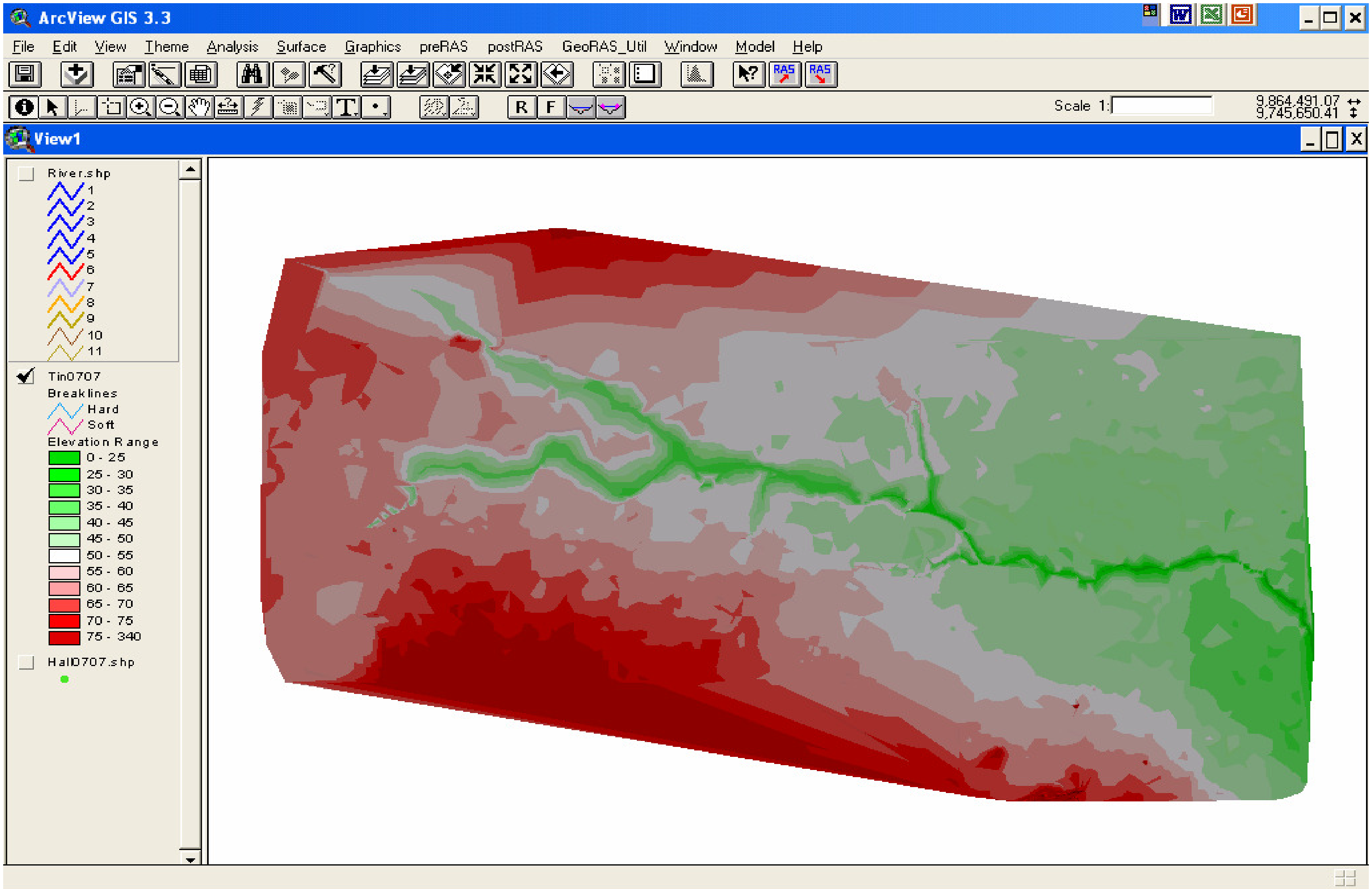
Return Period 100 year



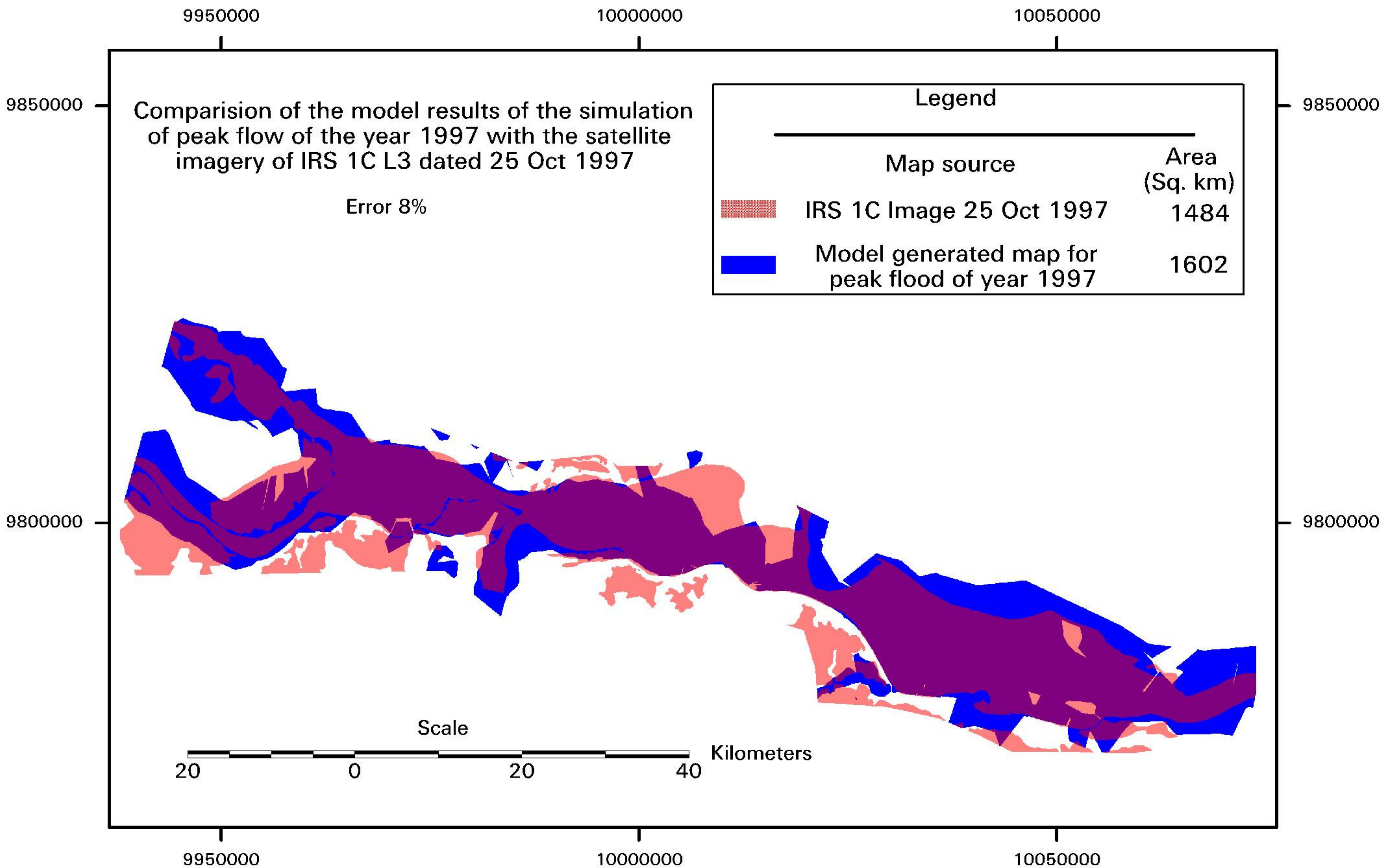
PMF 6842	1.05 PMP	1.10 PMP	1.15 PMP	1.20 PMP
	Peak of PMF			
	7064	7401	7737	8073
	% Deviation in PMF			
	3	8	13	18



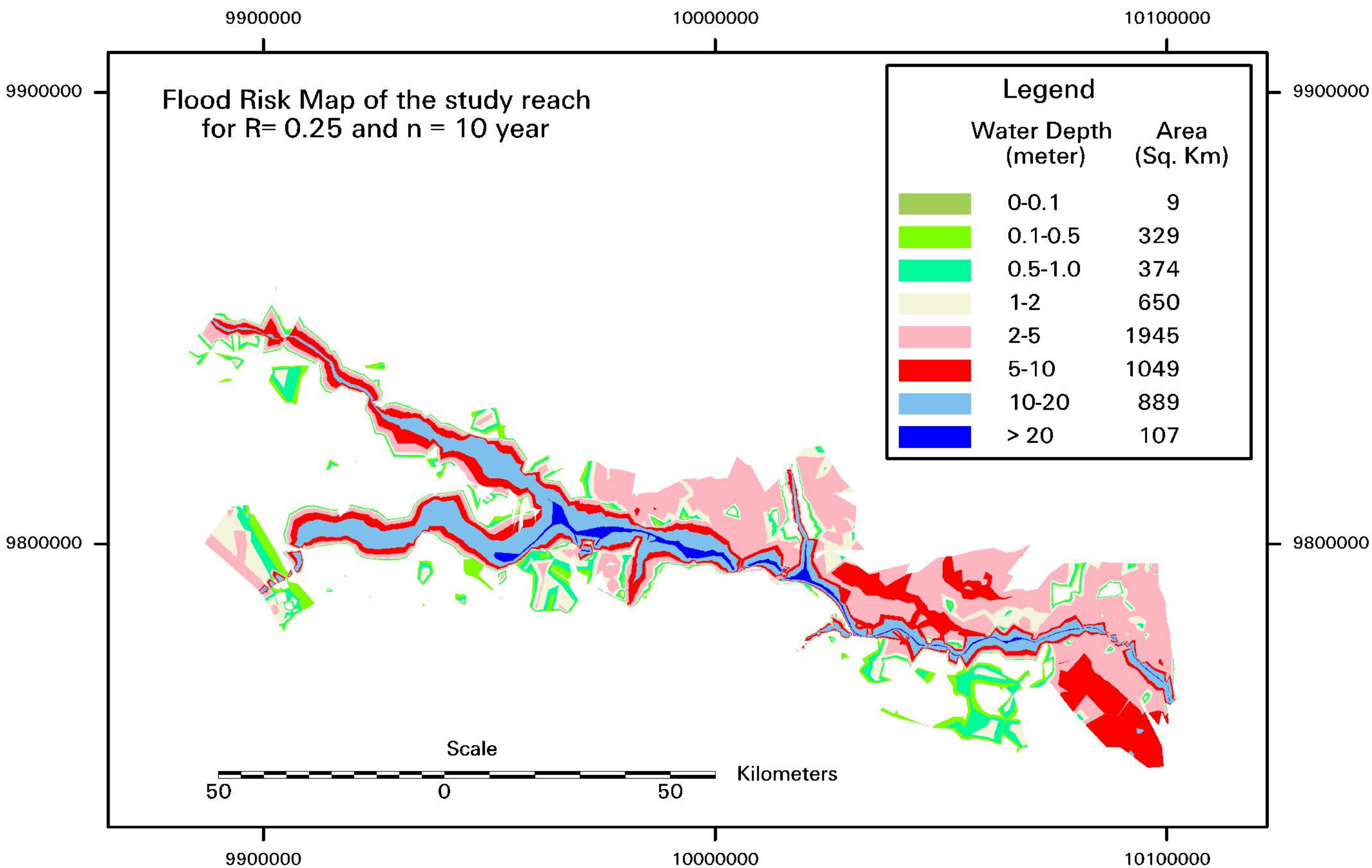
Flood Inundation Modeling for various Return Periods



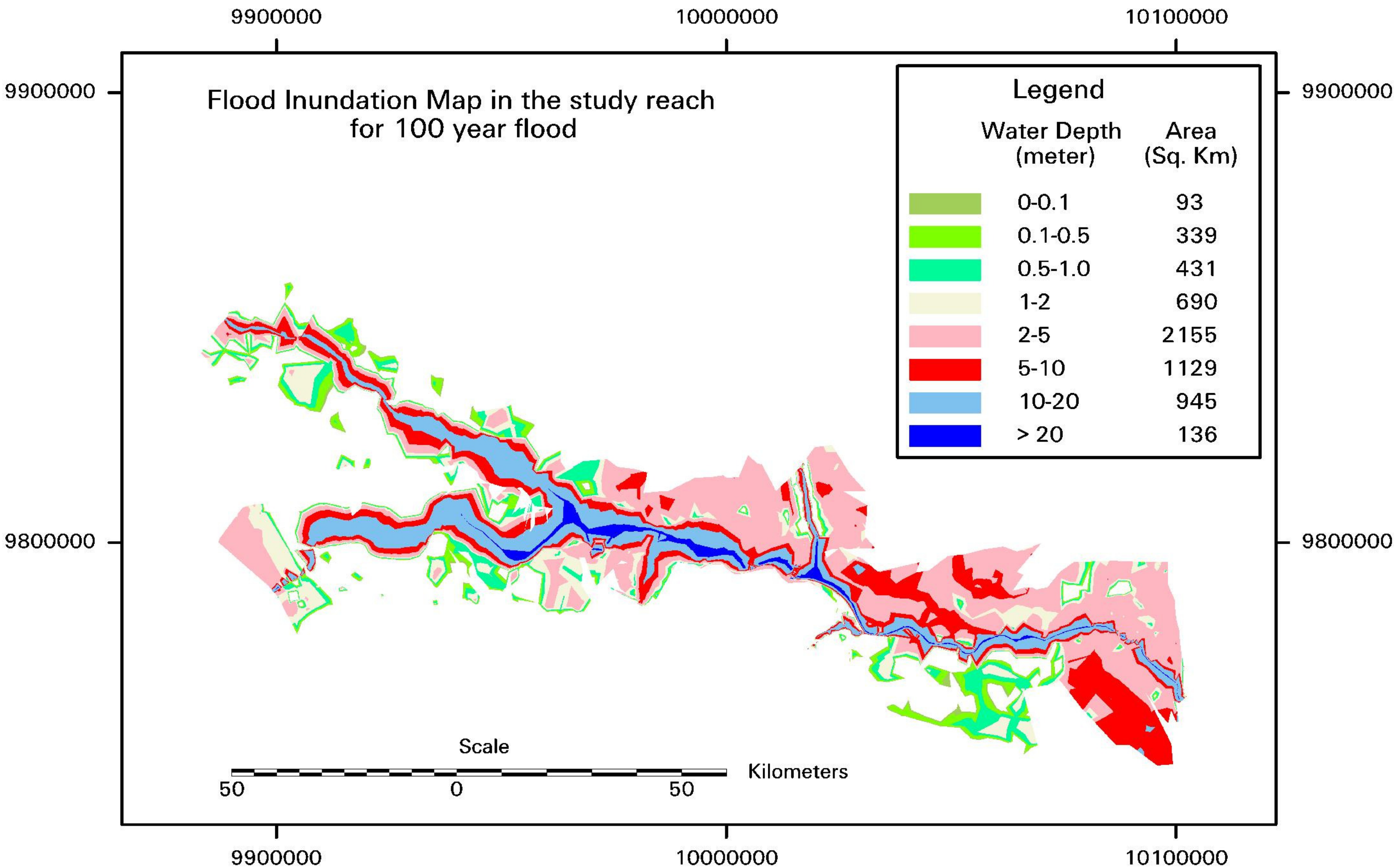
Digital Elevation Model (DEM) of the Study Area



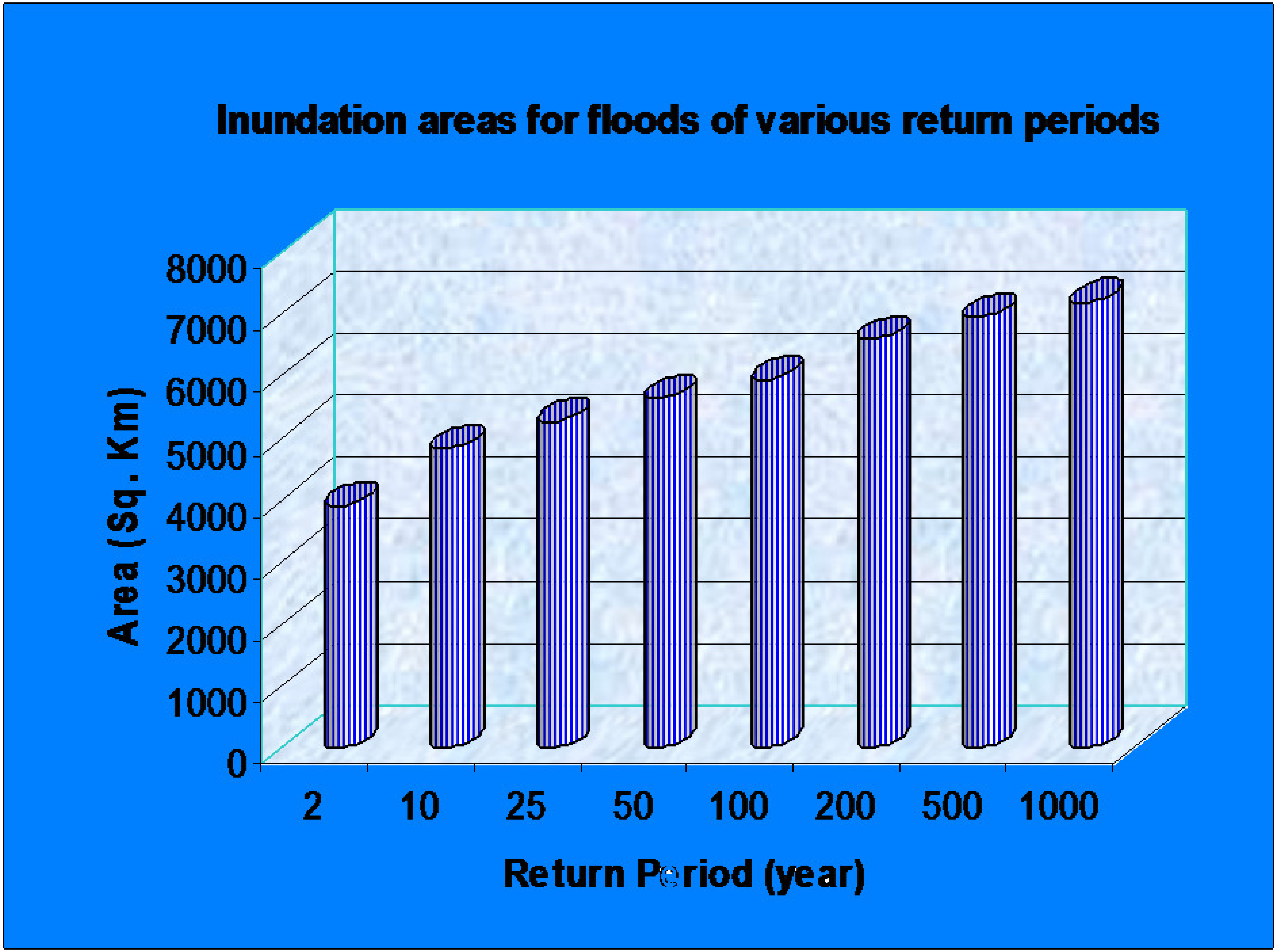
Comparison of Inundated area computed by hydraulic modeling and Inundated area mapped by satellite data for the year 1997

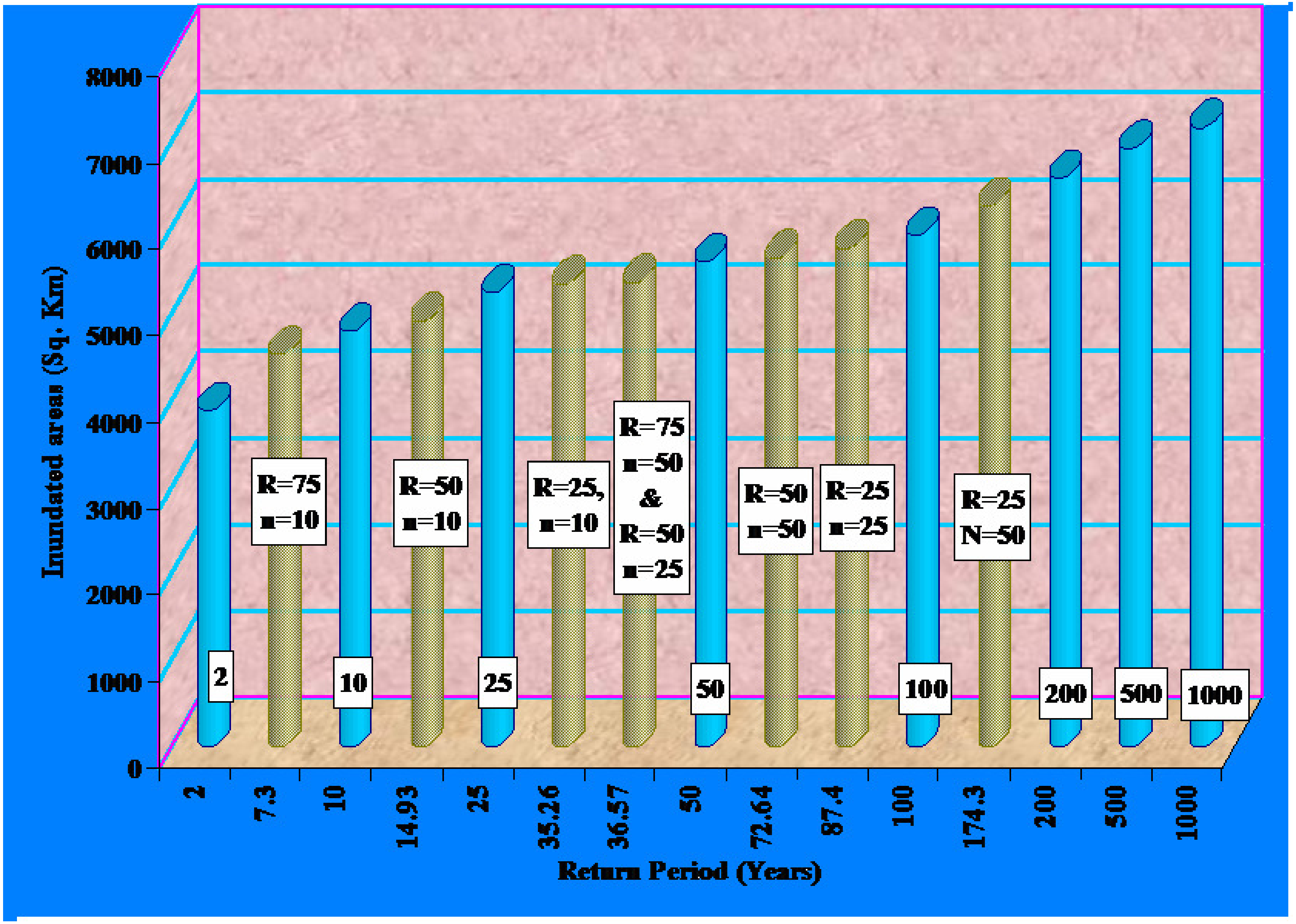


Flood risk zone map for a risk of 25% over a period of 25 years

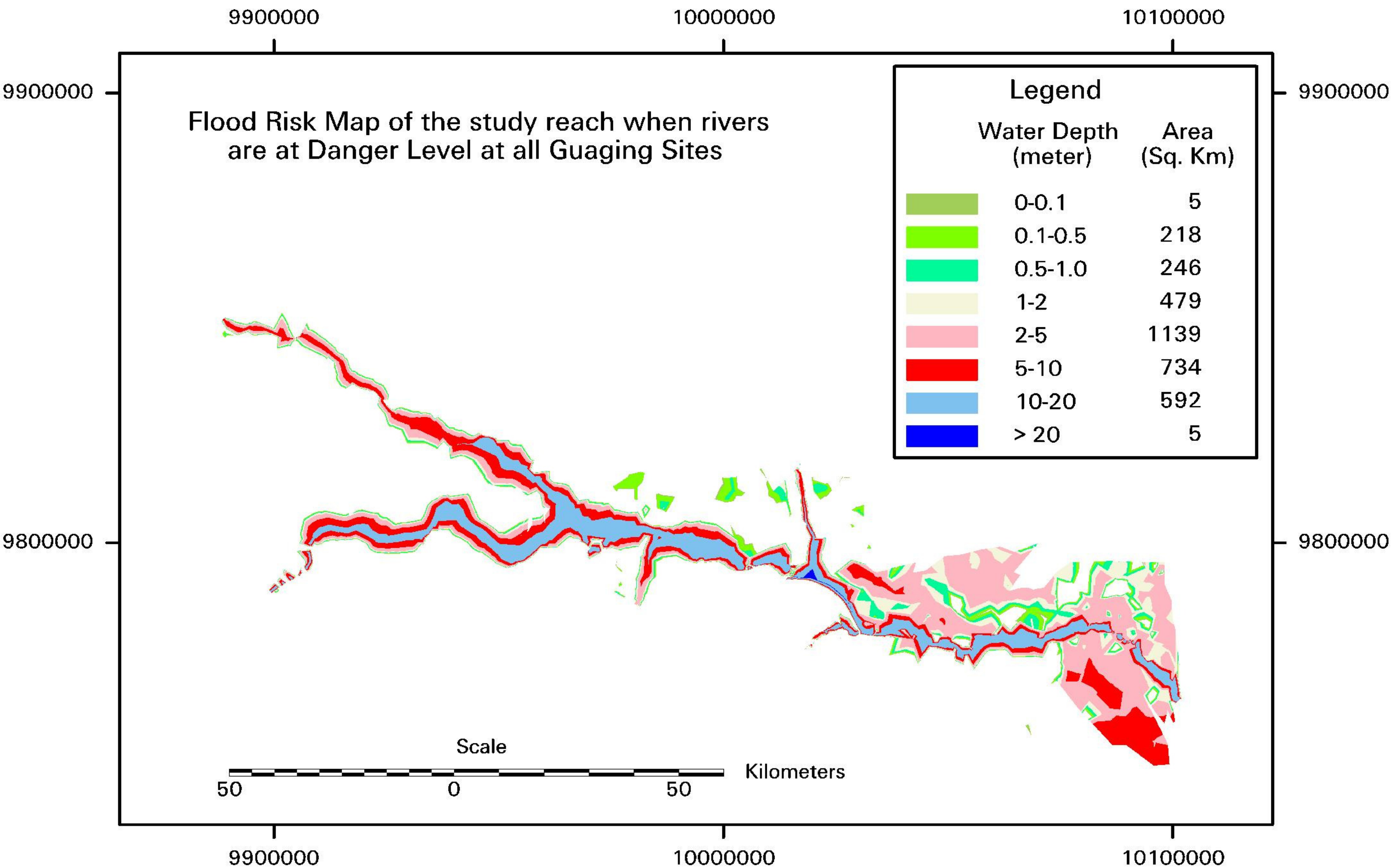


Flood Inundation map for 100 year return period

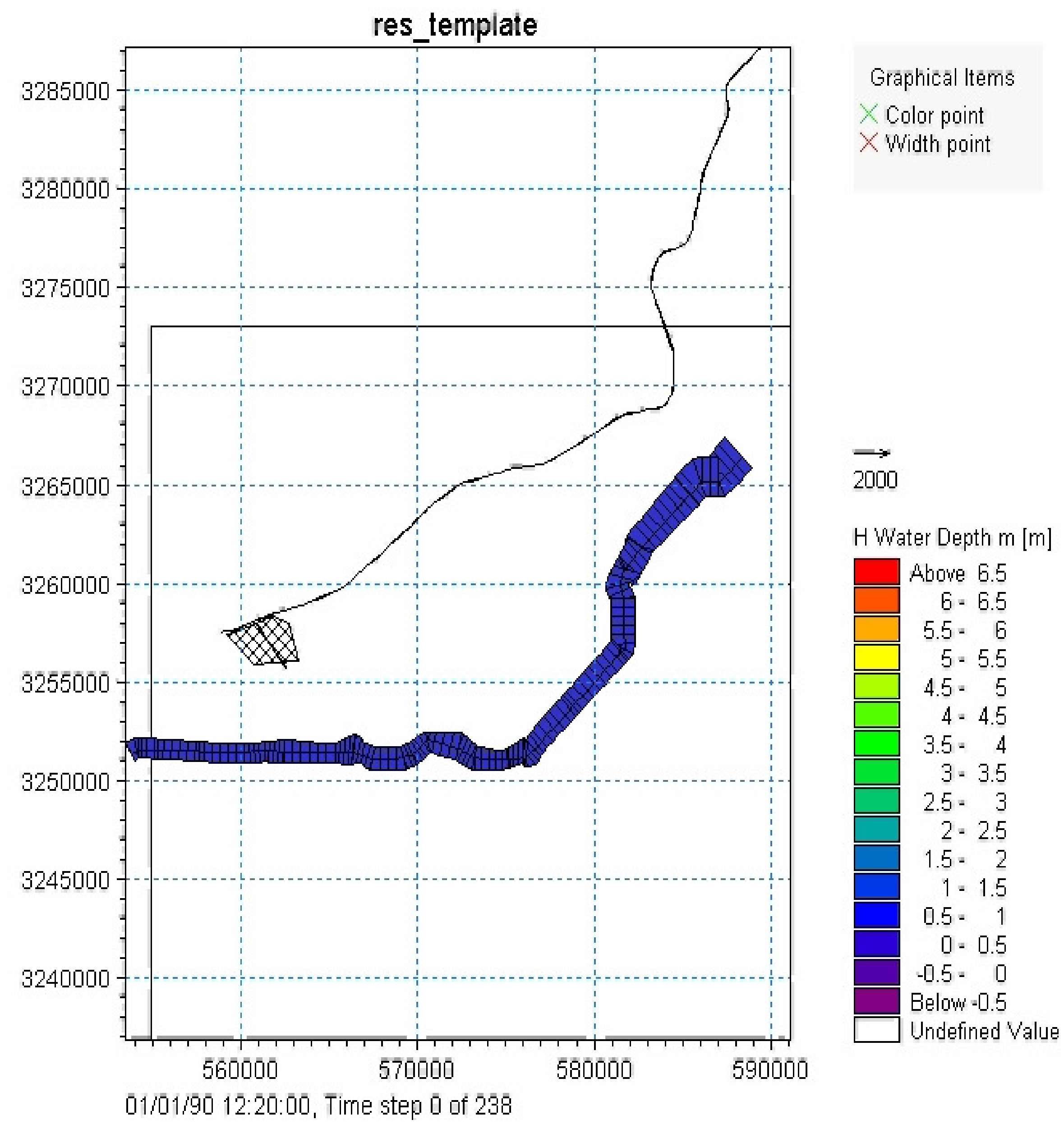

Inundation areas for floods of various return periods
8000
7000
6000
5000
4000
3000
2000
1000
0
Area (Sq. Km)
2
10
25
50
100
200
500
1000
Return Period (year)



Inundated area for floods of various return periods and hydrological risk



Flood Inundation map when the water level is at danger level at all the gauging sites



res_template
3285000
3280000
3275000
3270000
3265000
3260000
3255000
3250000
3245000
3240000
560000
570000
580000
590000
01/01/90 12:20:00, Time step 0 of 238
Graphical Items
Color point
Width point
2000
H Water Depth m [m]
Above 6.5
6 - 6.5
5.5 - 6
5 - 5.5
4.5 - 5
4 - 4.5
3.5 - 4
3 - 3.5
2.5 - 3
2 - 2.5
1.5 - 2
1 - 1.5
0.5 - 1
0 - 0.5
-0.5 - 0
Below -0.5
Undefined Value

Climate variability analysis of North Central Indian basins

Objectives:

- Basin-wise assessment of temperature variability and trends in the northwest and central India, and
- Changes in rainfall in river basins in northwest and central India.

Conclusions:

The majority of basins (7 river basins) have shown increasing trend in mean annual temperature in the range of 0.40 to 0.64 °C per 100 years, while 2 basins have shown cooling trend varying between –0.15 to -0.44 °C per 100 years.

The Narmada river basin has experienced maximum warming and Sabarmati river basin has shown highest cooling trend.

The Indus (lower) basin experienced the maximum increase(19%). Ganga, Sabarmati, Brahmani and Subarnarekha river basins experienced a stable annual rainfall.

For the entire northwest and central India, the annual rainfall increased by 5% per 100 years.

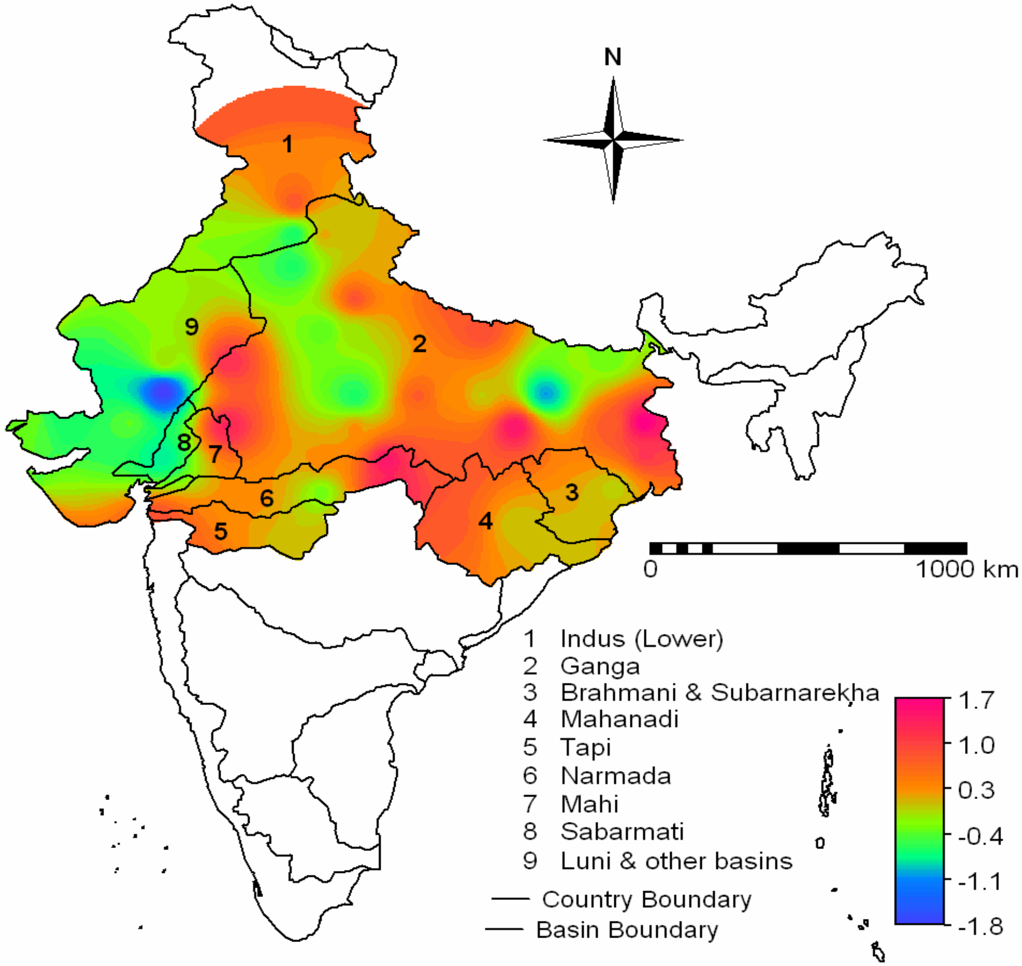


Figure 1: Spatial patterns of linear trends in annual mean temperature (oC/100 years) for different river basins during last Century (1901-2000).

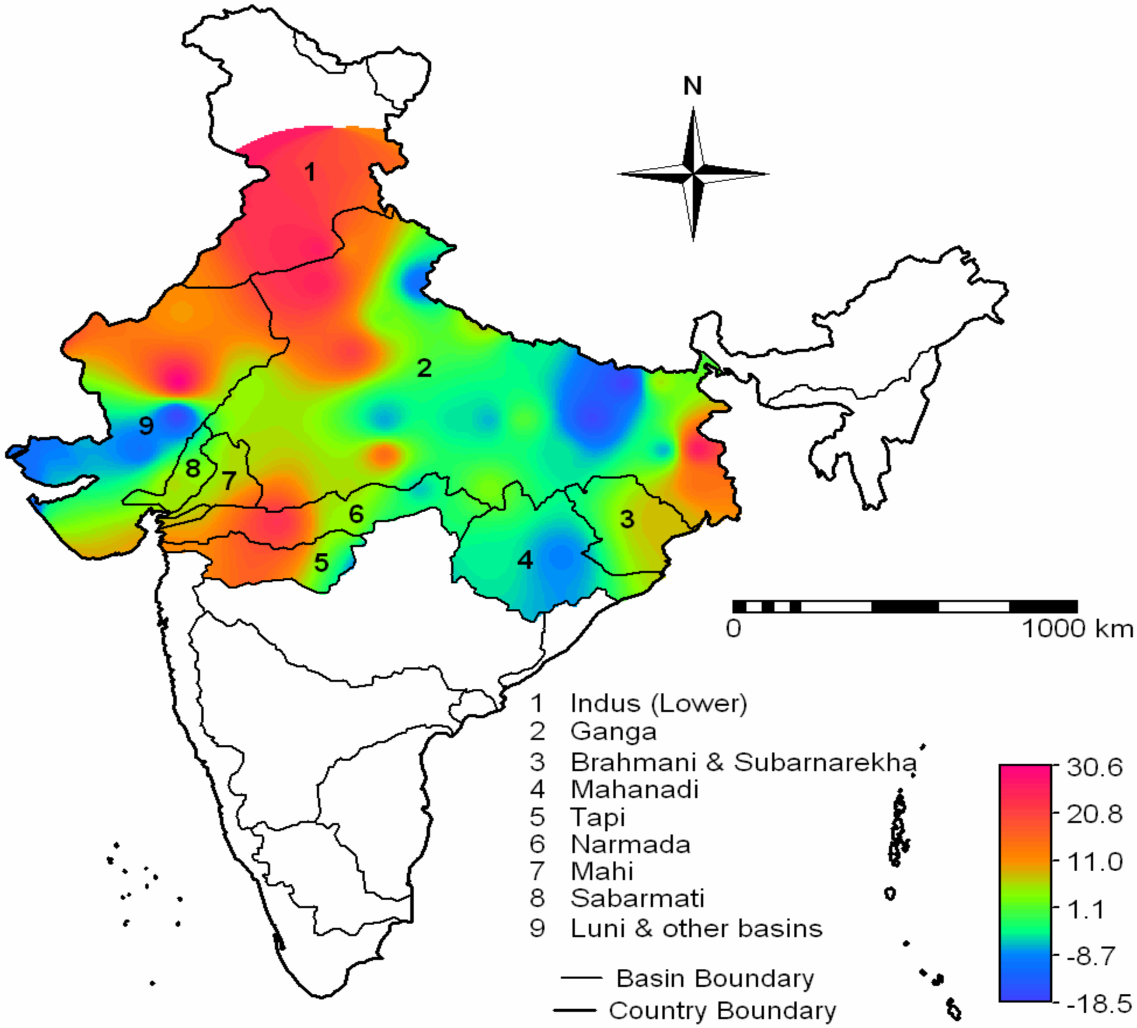


Figure 2: Spatial patterns of linear trends in annual rainfall (% of mean /100 years) for different river basins during last Century (1901-2000).

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

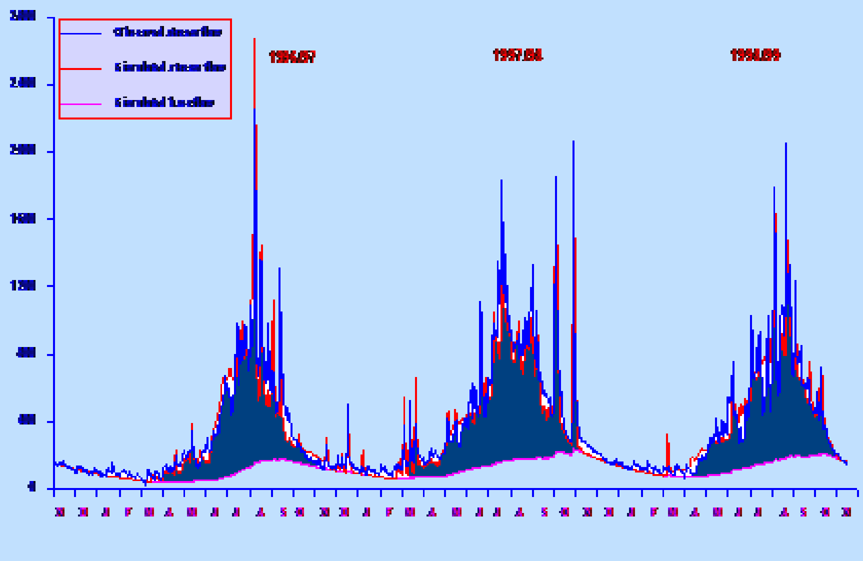
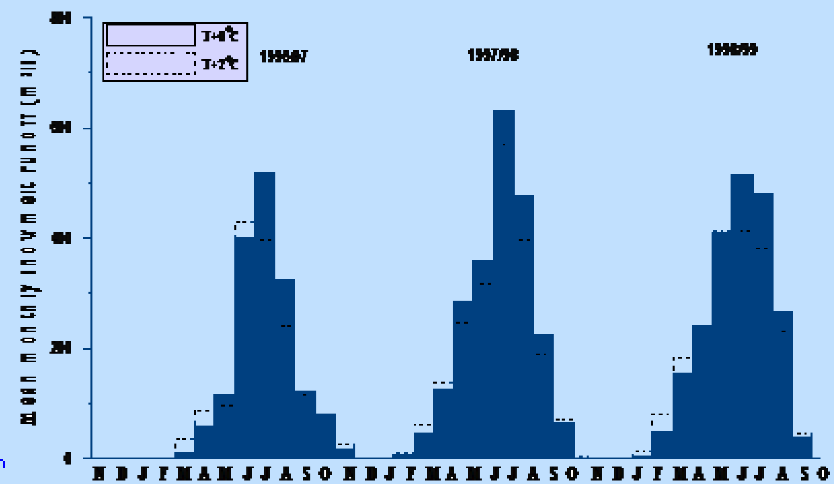


Figure 4: Observed and simulated daily streamflow for the Satluj River at Bhakra for a period of 3 years (1996/97 - 1998/99).



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 variability analysis for Satluj Basin

Objective

To study the impact of warming on the snowmelt runoff and total streamflow

Conclusions

Changes in distribution of melt runoff were more pronounced in summer showing a decrease of about 10% for a temperature increase by 2℃.

Considering only the lower and middle part of the basin, where snow disappears in summer, the reduction in snow melt runoff is about 27%.

High altitude zones containing permanent snowfields/ glaciers throughout the ablation period produce higher melt under warmer climate.

On basin scale, reduction in melt from lower zones is counterbalanced by the increase in melt from upper zones.

Expectations from Project

- Water resources assessment including allocation to different users, impact on future water resources development, agricultural planning, hydrological analysis under climate change scenarios.

- Design Flood Estimation & Forecast of Floods under climate change scenarios.

- Identification of different types of droughts for determining the onset and severity of drought, areas prone to drought, and ways to mitigate the impacts

- Water resources management practices under climate change scenarios.

- Quantification of the impacts and vulnerabilities and assessment of adaptation strategies with combination of climate projections and integrated assessment models by utilizing comprehensive data of climate water cycle and resources for integrated water resources development and management.


THANK YOU !
7.82.net