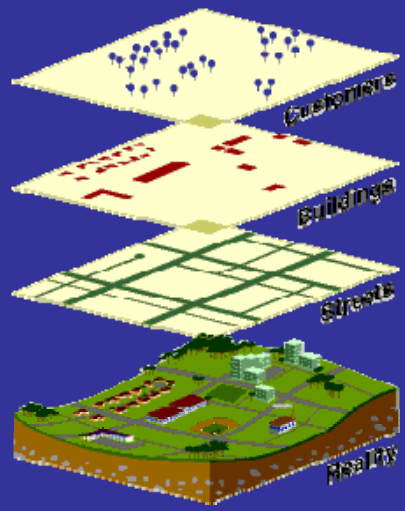
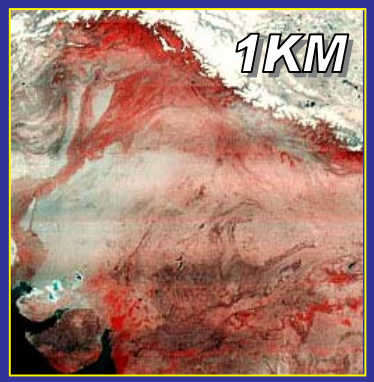
UNOOSA Symposium on
Space Systems-Protecting and Restoring Water Resources
(September 13-16,2005)
Graz,Austria



Dr V Madhava Rao
National Institute of Rural Development
(Ministry of Rural Development, Government of India)
Hyderabad, India
http://www.nird.org.in

Imaging Capability: Km to Sub-metre

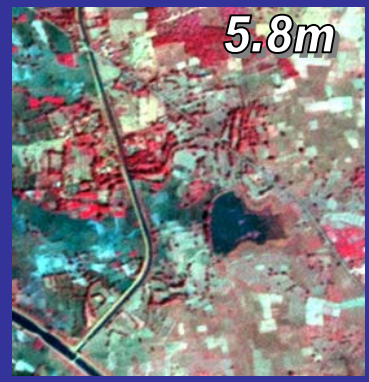
NOAA



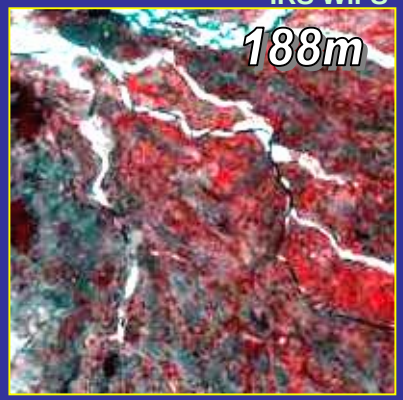
QUICKBIRD

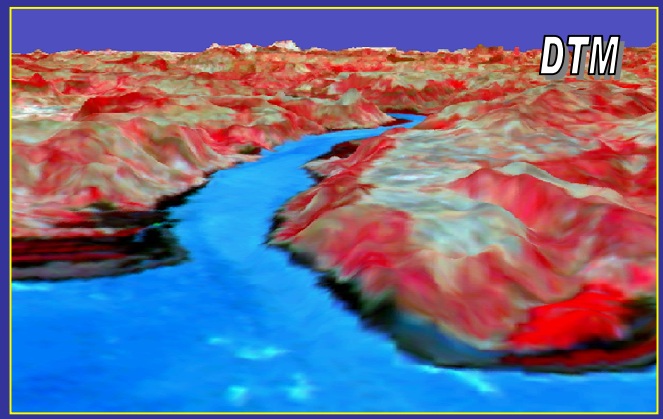
QUICKBIRD

IRS LISS IV



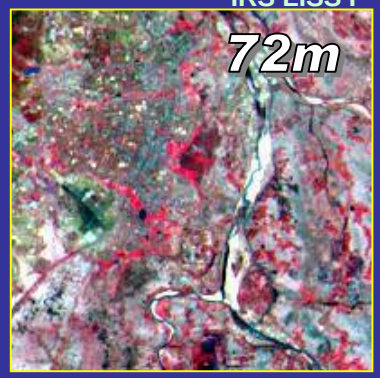
IRS WiFS





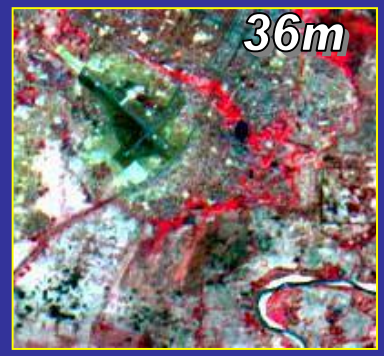
IRS LISS III

IRS LISS I



IRS AWiFS

IRS LISS II



Sensors or satellites that produce images suitable for Water Resources

Purpose	SPOT	IRS	TM	MSS	AVHRR	ERS-SAR	Radarsat	ERS-ALT	ATSR	Meteosat	GOES	GMS	JERS-SAR
Cartographic Information	✡	✡											
Irrigated Area	✡	✡	✡	✡	✡								
Cropping Pattern		✡	✡			✡	✡						✡
Land cover			✡	✡	✡								
Leaf area index	✡	✡	✡	✡	✡								
Crop coefficient	✡	✡	✡	✡									
Transpiration coefficient	✡	✡	✡	✡	✡								
Surface roughness						✡		✡					✡
Crop yield	✡	✡	✡	✡	✡		✡						
Potential evapotranspiration			✡		✡				✡	✡	✡	✡	
Actual evapotranspiration			✡		✡				✡				
Surface moisture			✡			✡							✡
Root-zone moisture					✡				✡				
Soil salinity			✡			✡							✡
Water logging	✡	✡	✡	✡		✡							✡
River discharge						✡		✡					✡
Precipitation										✡	✡	✡	

Initiatives got institutionalized in India by use of Satellite Remote Sensing Applications

»Agricultural drought assessment and monitoring
»Near real-time nationwide flood monitoring, flood risk zone mapping
»Cyclone damage assessment
»Snow cover mapping and snowmelt run-off forecast
»Monitoring and performance evaluation of canal/tank irrigation system
»Surface water mapping
»Reservoir sedimentation and drainage congestion studies
»Evaluation of Command Area Development (CAD) programme
»Improve the diagnosis of regional scale practices
»Evaluate the success of organizational, socio-economic and technical interventions on
»irrigation system performance
»Establish water accounts methods to determine water use and scarcity at basin level
»identify strategies to increase the productivity of water.

Water Resources Exploration, Assessment & Exploitation related Technology

Remote Sensing/Geophysical Exploitation of Alternative Resources
Yield very good results.

Water Scarcity Reduction and related Technology Development

Water saving irrigation/industry/reuse and recycling/tap leakage detection and prevention by using remote sensing and GIS.

Technology for Water Quality Enhancement for Rural Areas

Remote Sensing widely used for water quality surveillance and for development of Water Quality enhancement under Rajiv Gandhi National Drinking Water Mission.

Watershed Development

√National Programme under the Department of Land Resources, Ministry of Rural Development, Government of India

√GIS and Remote Sensing technologies for delineation and resource inventorying, deciding appropriate structures for water conservation and improving levels of water irrigation wells for productive use of soil and land for micro or mini watersheds

√Maximisation of water conservation and minimisation of environmental degradation like erosion, sedimentation, etc. forms important part of geomatics application at grass root level

√Conjunctive use of water resources through water rights, judicious use of water, alternative cropping pattern and augmenting various sources of water namely rain water harvesting structures using GIS, GPS and Satellite Remote Sensing technologies

Rajiv Gandhi National Drinking Water Mission, Department of Drinking Water Supply, Ministry of Rural Development, Government of India

Innovative and direct way of applying space science in drinking water sector

Each tube well identified and monitored and this helped timely decisions and upkeep of functionality of tube wells, ensuring smooth drinking water management in rural areas.

Various layers of information generated and ground water data are integrated

Various decision support alternatives created for community level involvement in Drinking water and sanitation programmes

Swajaldhara

Swajaladhara latest community initiatives for developing drinking water and sanitation facilities at local level

Local bodies, NGOs and local people take part

Space science generate of various information base for appropriate treatment and development infrastructure in rural drinking water and sanitation sector

Interlinking of Rivers

*Country mapped river basins and in studying flood and drought,

*Estimated water draining to sea,

*Selective interlinking of rivers in country to control regular floods and reduce droughts.

*Recently States of Madhya Pradesh and Uttar Pradesh signed a MOU for linking two major rivers.

Central Water Commission, New Delhi

Preparation of National Perspective Plan and Basin wise Master Plans.
Surveys, investigations and designs of schemes for development of river valleys.
Techno-economic appraisal of Water Resources Projects.
Matters relating to inter-state water sharing/disputes.
Environmental aspects including Rehabilitation and Resettlement of Project Affected People.
Application of Remote Sensing techniques in Water Resources Sector.
Project Monitoring to ensure speedy implementation and timely completion.
Detailed Hydrological Studies of projects.
Collection, collation and publishing of Hydrological, Hydrometeorological, Sediment and Water Quality data.
Flood Management and Development and Operation of Flood Forecasting System.
Morphological studies, schemes for bank/coastal protection and preparation of relevant Status Reports and Manuals.
Studies for safety aspects of existing dams, issuing related procedures/guidelines and standardisation of instruments.

Central Ground Water Board, Faridabad

Systematic hydrogeological surveys.
Reappraisal hydrogeological surveys.
Ground Water exploration aided by drilling.
Monitoring of national hydrograph network stations.
Water Supply investigations.
Periodic assessment of ground water resources.
Publication of maps and reports.
Scientific source findings for drought affected states under the National Drinking Water Mission.
Chemical and geophysical studies.
Hydrogeological and hydromateorological studies.
Remote sensing studies.
Pollution studies.
Mathematical modelling studies.
Data storage and retrieval.
Water balance studies.
Artificial recharge studies.
Studies on conjunctive use of ground water and surface water.
Training in activities related to ground water.
Reviewing regulation of ground water development
Rain water Harvesting Schemes

Central Water And Power Research Station, Pune

Planning, organising and undertaking specific research studies on water resources development including water-borne transport, environmental aspects

Department of Science and Technology Initiatives

»hydrometeorology;
»snow and lake hydrology;
»surface and ground water hydrology;
»river morphology and hydraulics;
»assessment of water resources;
»water harvesting and ground water recharge;
»water quality;
»water conservation;
»evaporation and seepage losses;
»recycling and re-use;
»better water management practices and improvements in operational technology;
»crops and cropping systems;
»soils management
»the safety and longevity of water-related structures;
»economical designs for water resource projects;
»risk analysis and disaster management;
»use of remote sensing techniques in development and management;
»use of static ground water resource as a crisis management measure;
»sedimentation of reservoirs;
»use of sea water resources;
»prevention of salinity ingress;
»prevention of water logging and soil salinity;
»reclamation of water logged and saline lands;
»environmental impact;
»regional equity.

Department of Space Initiatives

Wastelands, Drought, Flood Monitoring, Disaster Management, Water Resources Management……..

NGO, CBO and Corporate Sector initiatives

Myrada
Development Alternatives
Ramakrishna Mission
Aghakhan Foundation
Tata Foundation
Birla Foundation

Expectations in near future

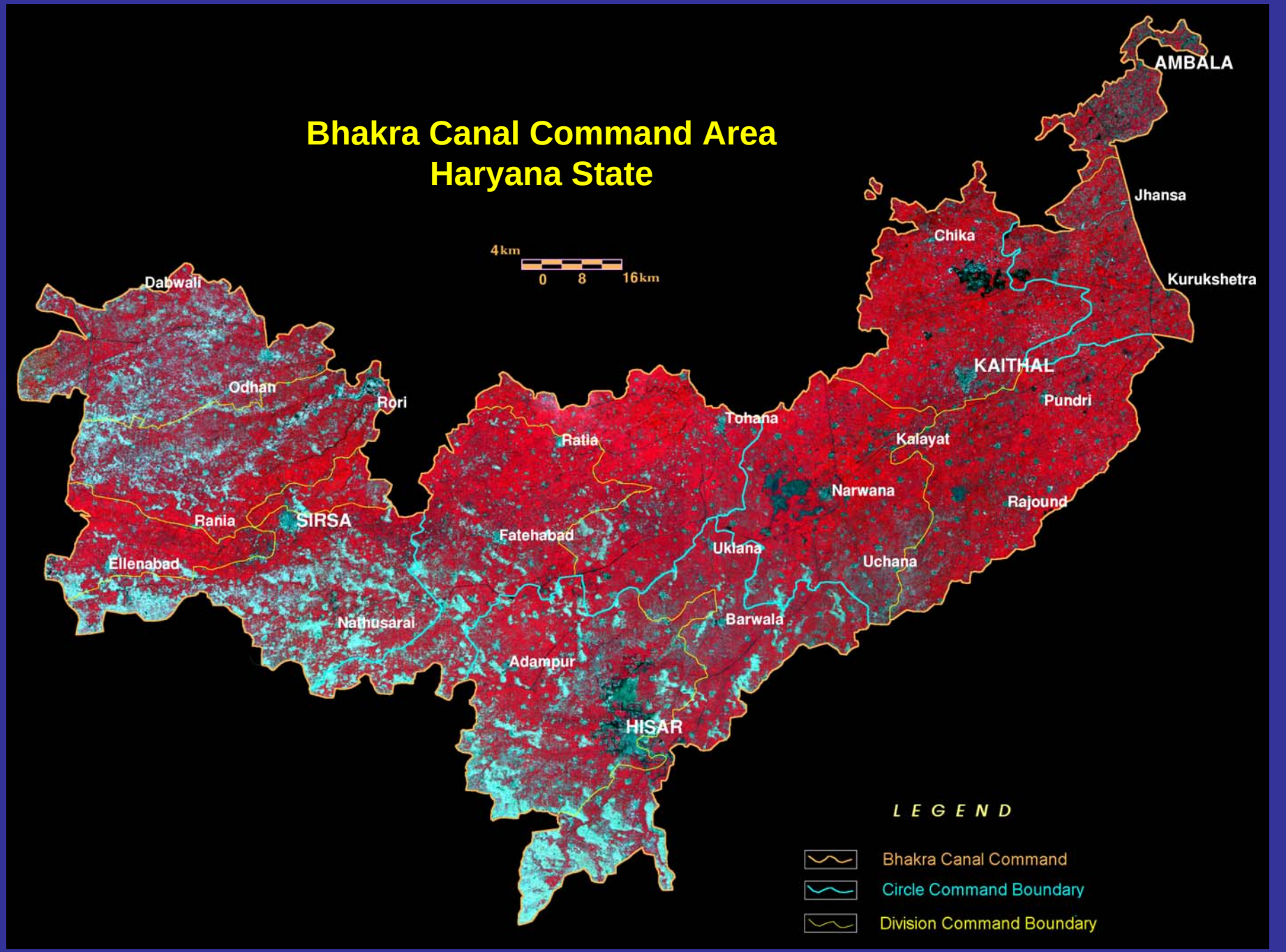
Time tested proven process methodology in space science application for local level use

Knowledge Mission 2007

Rajiv Internet Villages

IT Hub in rural India

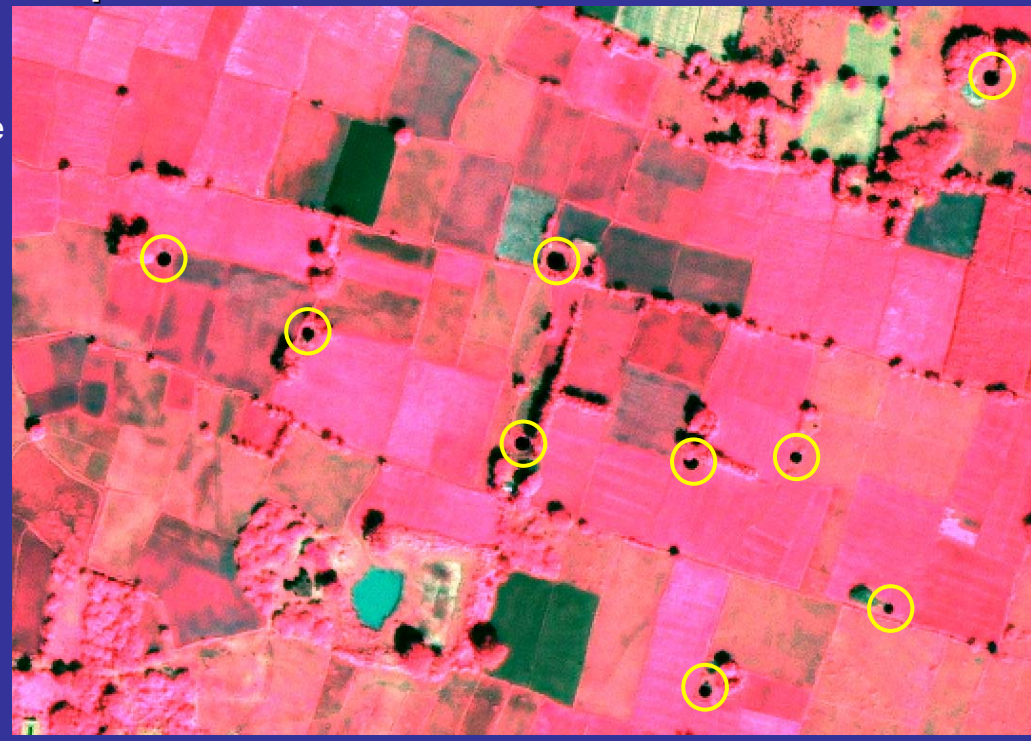
PURA


Bhakra Canal Command Area
Haryana State
4km
0 8 16km
AMBALA
Jhansa
Chika
Kurukshetra
KAITHAL
Pundri
Kalayat
Tohana
Ratia
Narwana
Rajound
Uchana
Uklana
Fatehabad
SIRSA
Rania
Ellenabad
Dabwali
Odhan
Rori
Nathusarai
Adampur
Barwala
HISAR
LEGEND
Bhakra Canal Command
Circle Command Boundary
Division Command Boundary

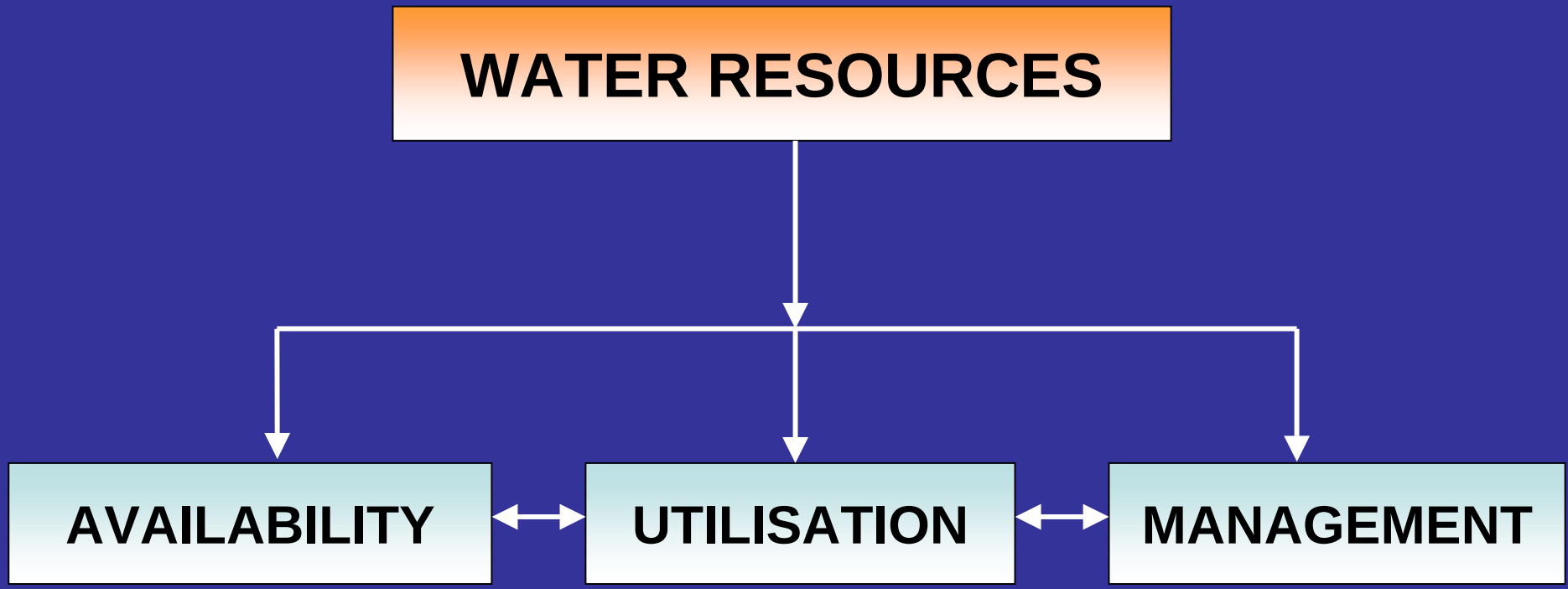
Nanjur tank cascade as on 08-Dec-2003

Different crops at field level

Open wells



IKONOS P + Xs FCC of 09 August 2003

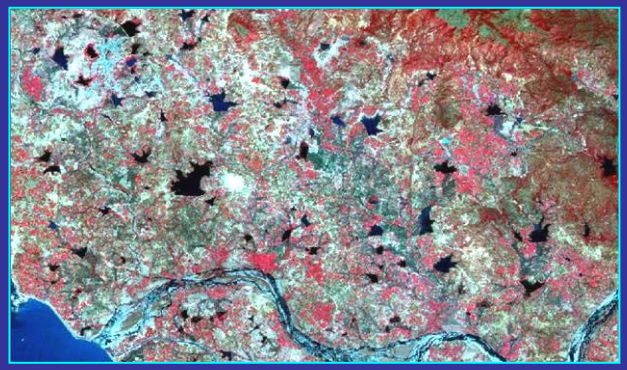


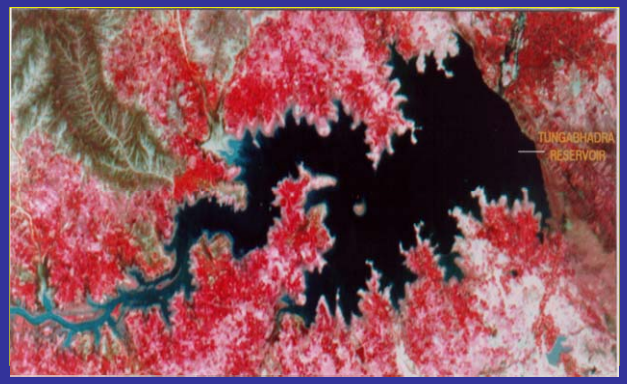
- Geographic Distribution
- Temporal Dimension
- Quality
- Quantity

- Sectoral water demand
- Optimum Utilisation

- Land Management
- Water Management
- Monitoring

RS & GIS for in Water Resources ...





Assessment, Development & Management
River Basin/ Watershed, Irrigation Command, Flood Inundation, Groundwater, Snow/Glacier

Problem Diagnostics
Irrigation commands, Reservoir Sedimentation, Water-logging, Water Pollution, EIA of Water Resource Projects

Infrastructure Planning
Site investigation for Hydropower, Reservoir, Rainwater Harvesting Structure, irrigation Command etc.

- Snowmelt Runoff
- Surface Runoff Estimation
- Flood Inundation & Damage Assessment
- Reservoir Sedimentation
- Hydro-Power
- Irrigation Water Management
- Long Distance Water Transport

- Near Real Time Flood Mapping and Damage Assessment
- River Engineering Studies
- Flood Hazard Zone Mapping
- Flood Forecasting
- Flood Inundation Simulation

- Snowmelt Runoff Forecasting
- Inventory of Glacial Lakes

- Assessment of Sedimentation
- Updating of Elevation-Area-Capacity Curve
- Estimation of Reservoir Capacity
- Assessment of Rate of Siltation
- Estimation of Life of Reservoir
- Reservoir Catchment Analysis
- Impact of Foreshore Cultivation

- Physical & Environmental Setting of Hydro-power Site
- Submergence Area Analysis
- Infrastructural Planning
- Rehabilitation & Relocation Studies
- Inputs for Ranking

- River Surveys
- Link Alignment
- Canal Network Planning
- Land irrigability assessment
- Land Use/Land Cover analysis
- Cropping System Analysis
- Command Area Survey
- Irrigation system performance assessment and diagnosis

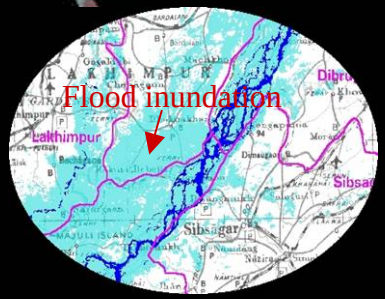
Indian Remote Sensing Satellites (IRS) : in Water Management

Satellite	Sensor	Launch Year	Resolution			Swath (km)
			Spectral (μm)	Spatial (m)	Temporal (days)	
IRS 1A/1B		1988/1991				
	LISS I		0.45-0.52, 0.52-0.59	72.5	22	148
	LISS II		0.62-0.68, 0.77-0.86	36.25		74
IRS P2		1994				
	LISS II		Same as in IRS 1A/1B	36.25	22	130
IRS P3		1996				
	WiFS		0.62-0.68, 0.77-0.86 1.55-1.70	188	5	774
IRS 1C/1D		1995/1997				
	PAN		0.50-0.75	5.8	24	148
	LISS III		0.52-0.59, 0.62-0.68, 0.77-0.86 1.55-1.70	23.5 70.5	24	74
	WiFS		0.62-0.68, 0.77-0.86	188	5	810
IRS P4		1999				
	OCM		8 bands : 0.402 to 0.885	360	2	1420
	MSMR		6.6, 10.65, 18, 21 GHz	120, 80, 40, 40 km		1360
IRS P5		2000/2001				
	PAN		0.50-0.75; 2 PAN Cameras	2.5	135	27.5 x 2
IRS P6		2001/2002				
	LISS III		Same as in IRS 1C/1D	23.5	24	140
	LISS IV	MSS	0.62-0.68, 0.77-0.86, 1.55-1.70	6.0	24	70
		PAN	0.62-0.68			
	AWiFS		Same as in IRS 1C/1D	80	5	1400

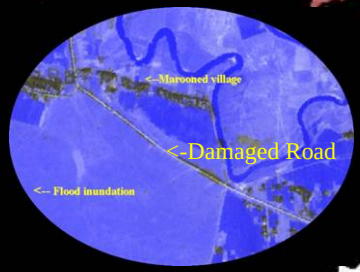
Space Technology for Flood Disaster Management

IRS-WiFS Image
08 Sept, 1998

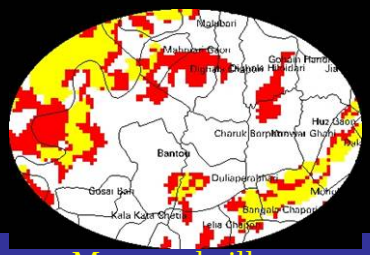
Historic flood of river
Brahmaputra during Sept, 1998



Flood map

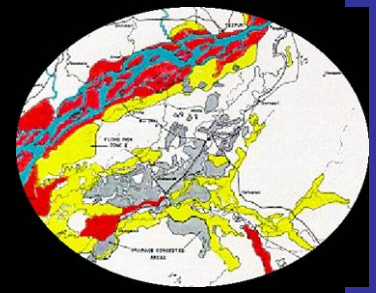


Assessment of damages

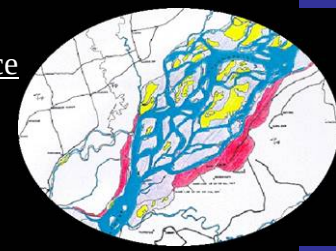


Marooned villages

Villages under inundation during 29 Jun-02 Aug, 199
Receded inundation in Villages by 02 Aug 1999



• Flood hazard zones



River Configuration
Bank Erosion & eroded bund

Information derived from Space

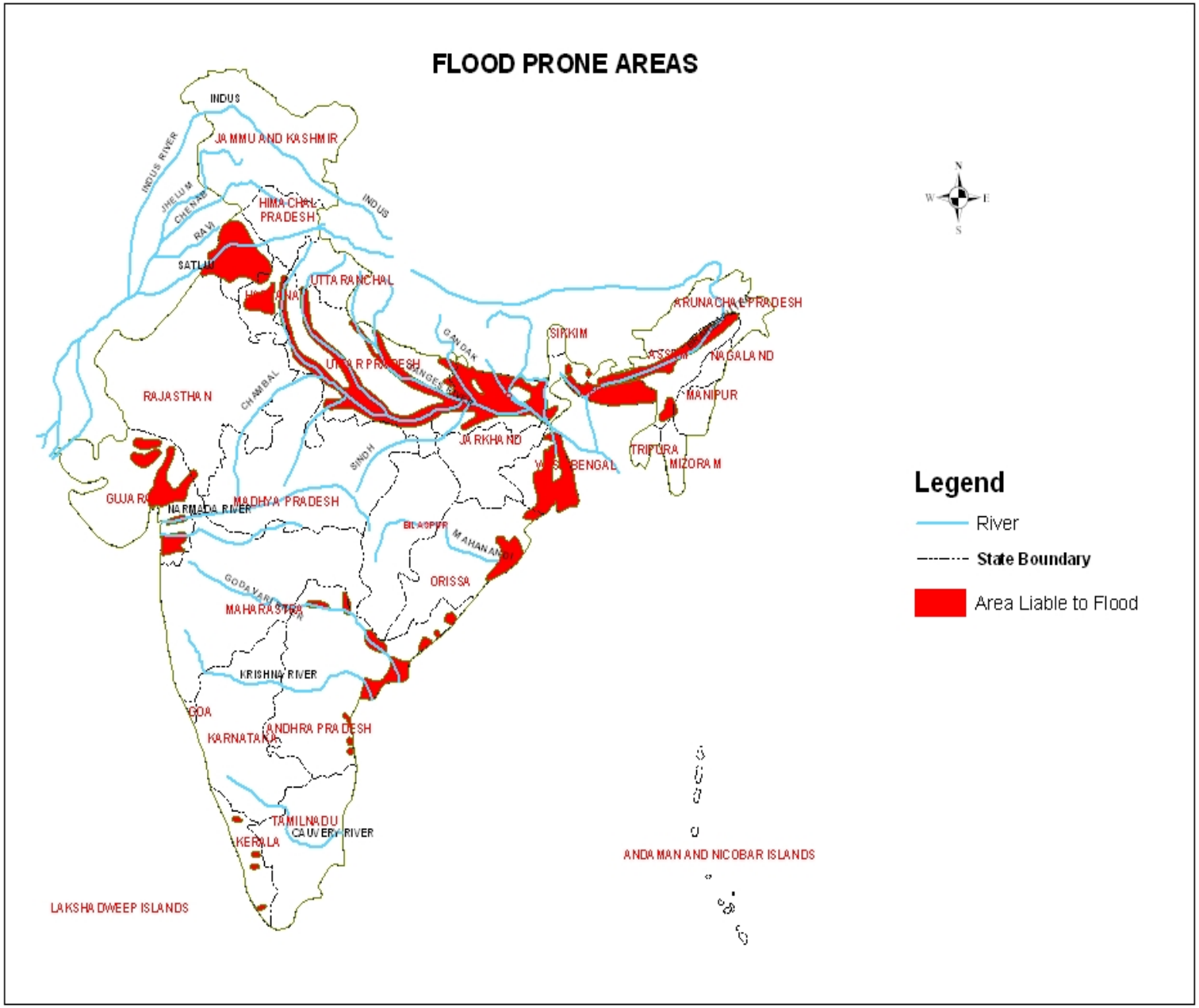
- Flood inundation map
- Flood damage assessment
- River Configuration & Flood control works
- Bank Erosion
- Flood Hazard Zones

Utilisation of information

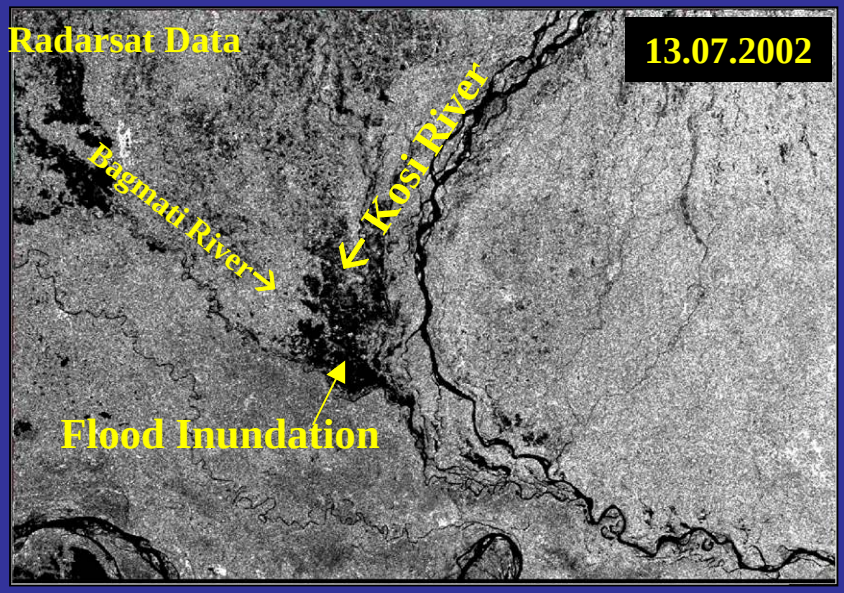
- Organising Relief operations
- Planning Flood Control Works
- Identification of chronic Flood prone areas
- Strengthening of existing Flood Control Works
- Flood plain zoning

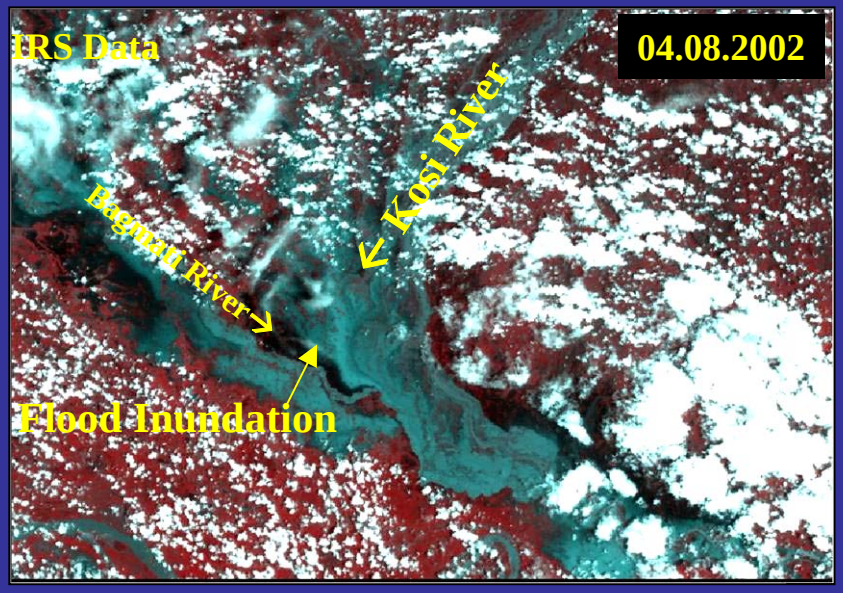
NATIONAL LEVEL

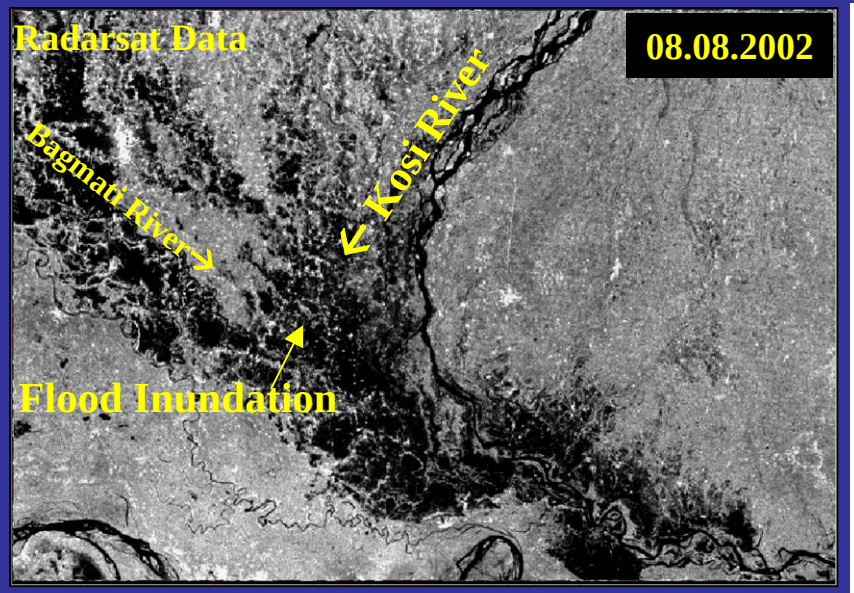
GEOGRAPHICAL INFORMATION SYSTEM

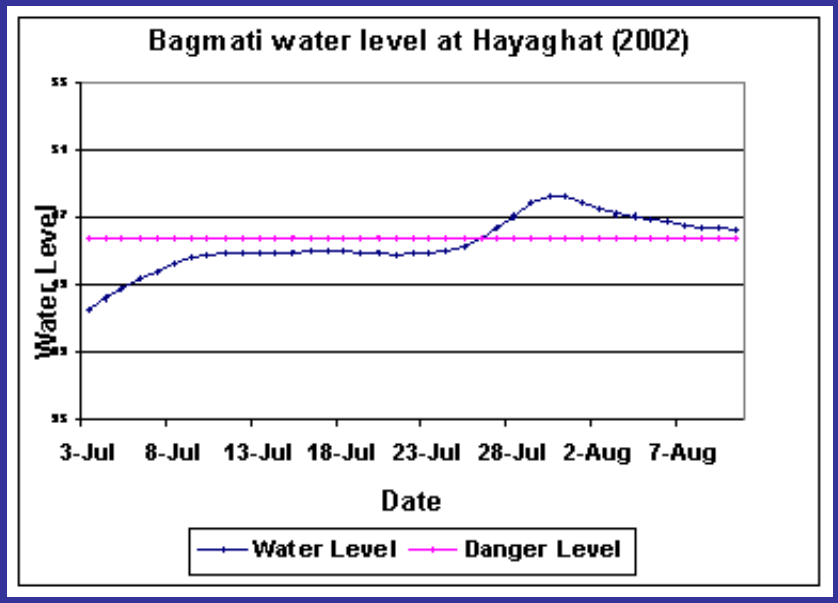


Bihar Floods -2002



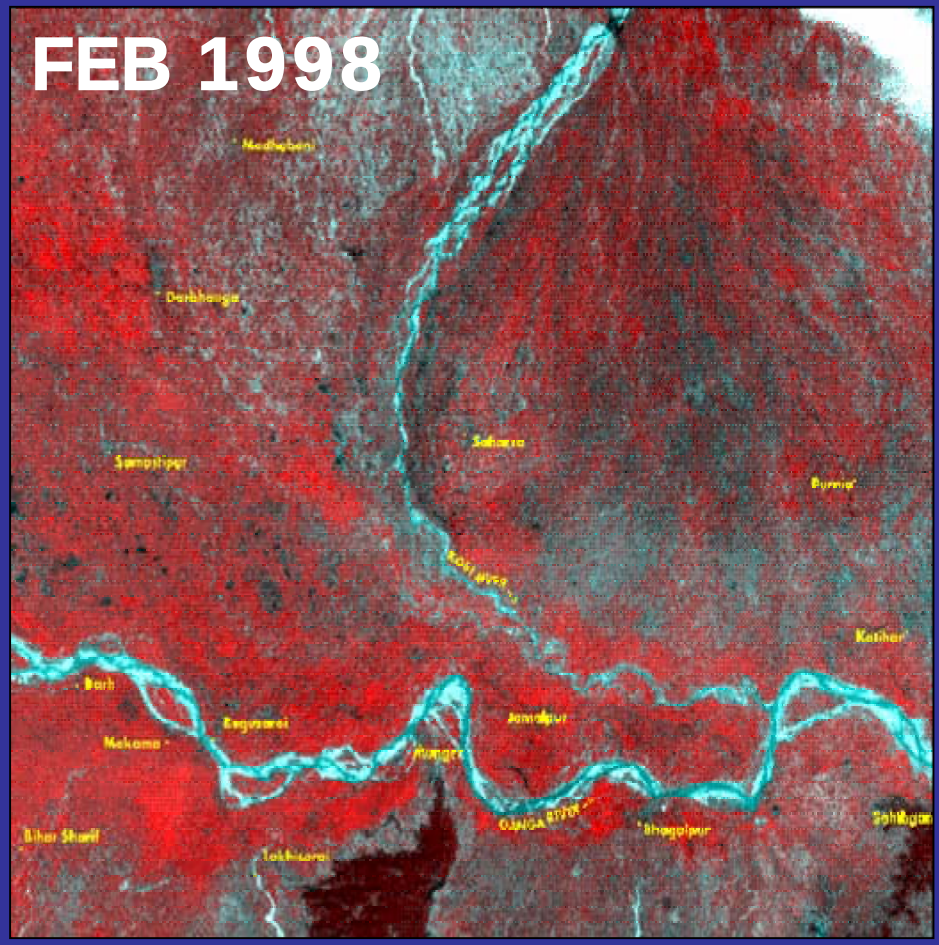


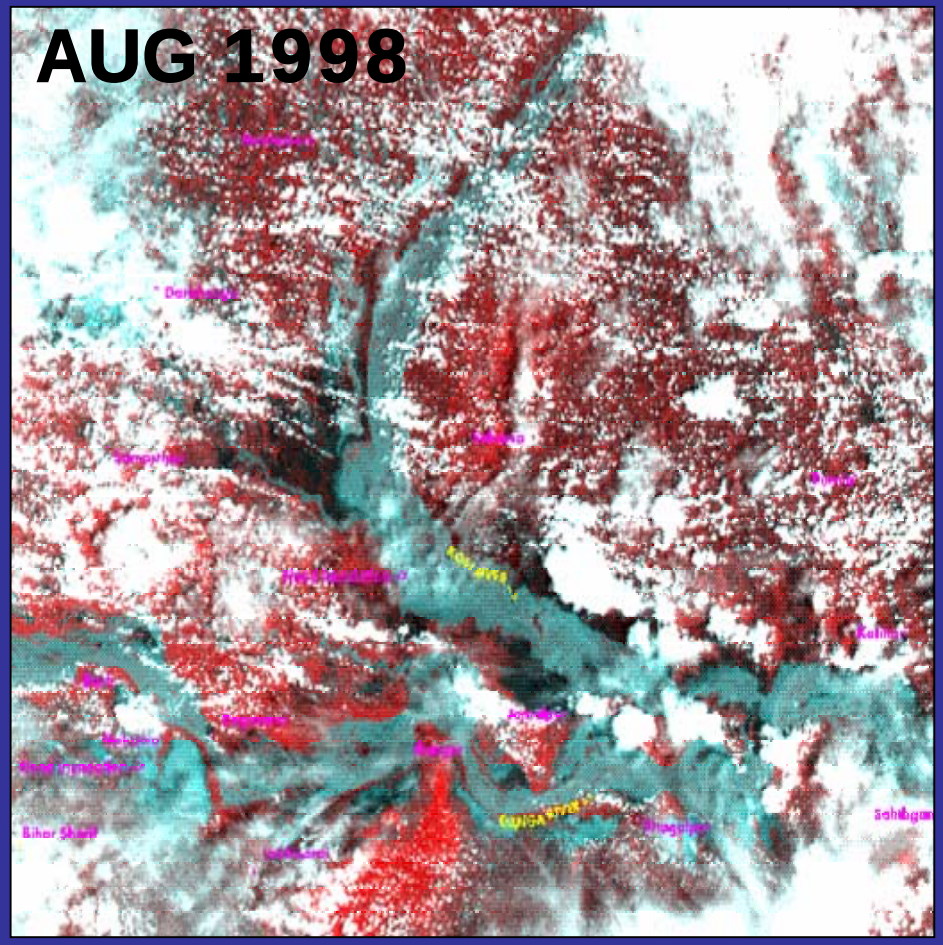




Flood Mapping And Damage Assessment

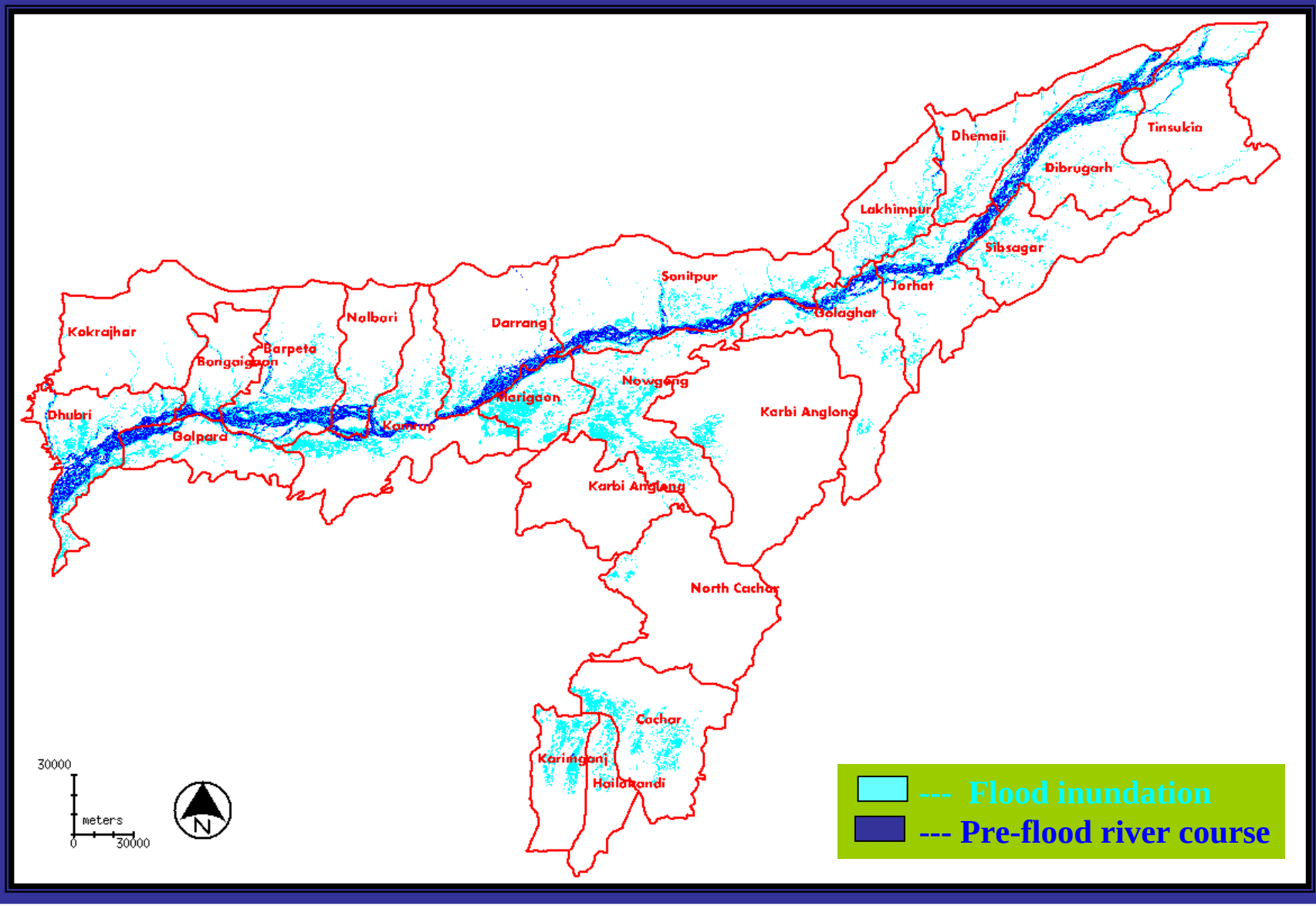
PRE AND POST-FLOOD SITUATION SEEN THROUGH IRS-1C WIFS SENSOR PART OF KOSI AREA, BIHAR





Brahmaputra River Floods - 2000

Flood Inundation derived from 27th & 30th Jun, 2000 RADARSAT data



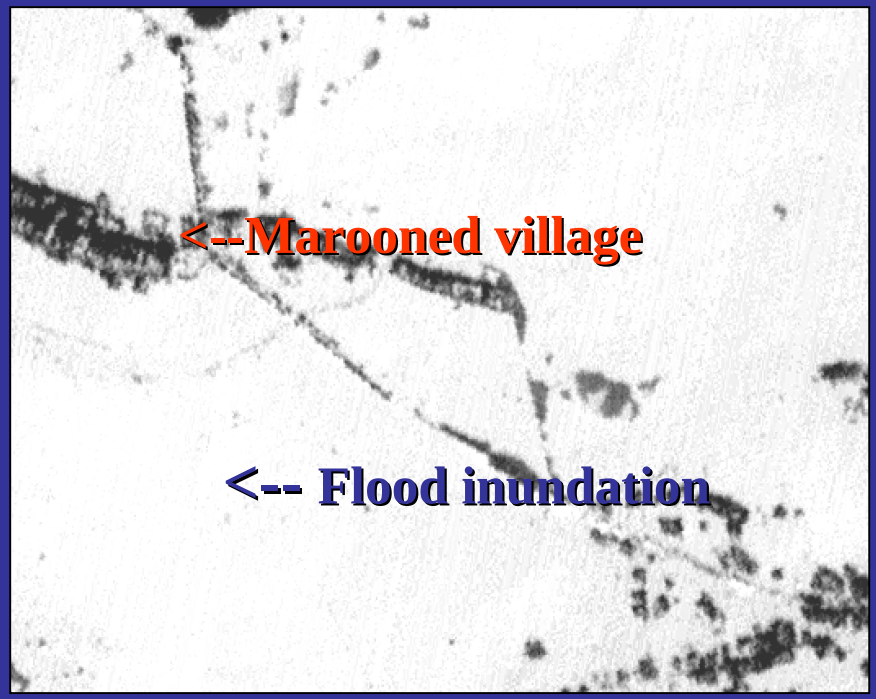
1998 Brahmaputra Floods - Damage to road network

Part of Marigaon district

Pre-Flood

IRS-1D PAN 03 March, 98

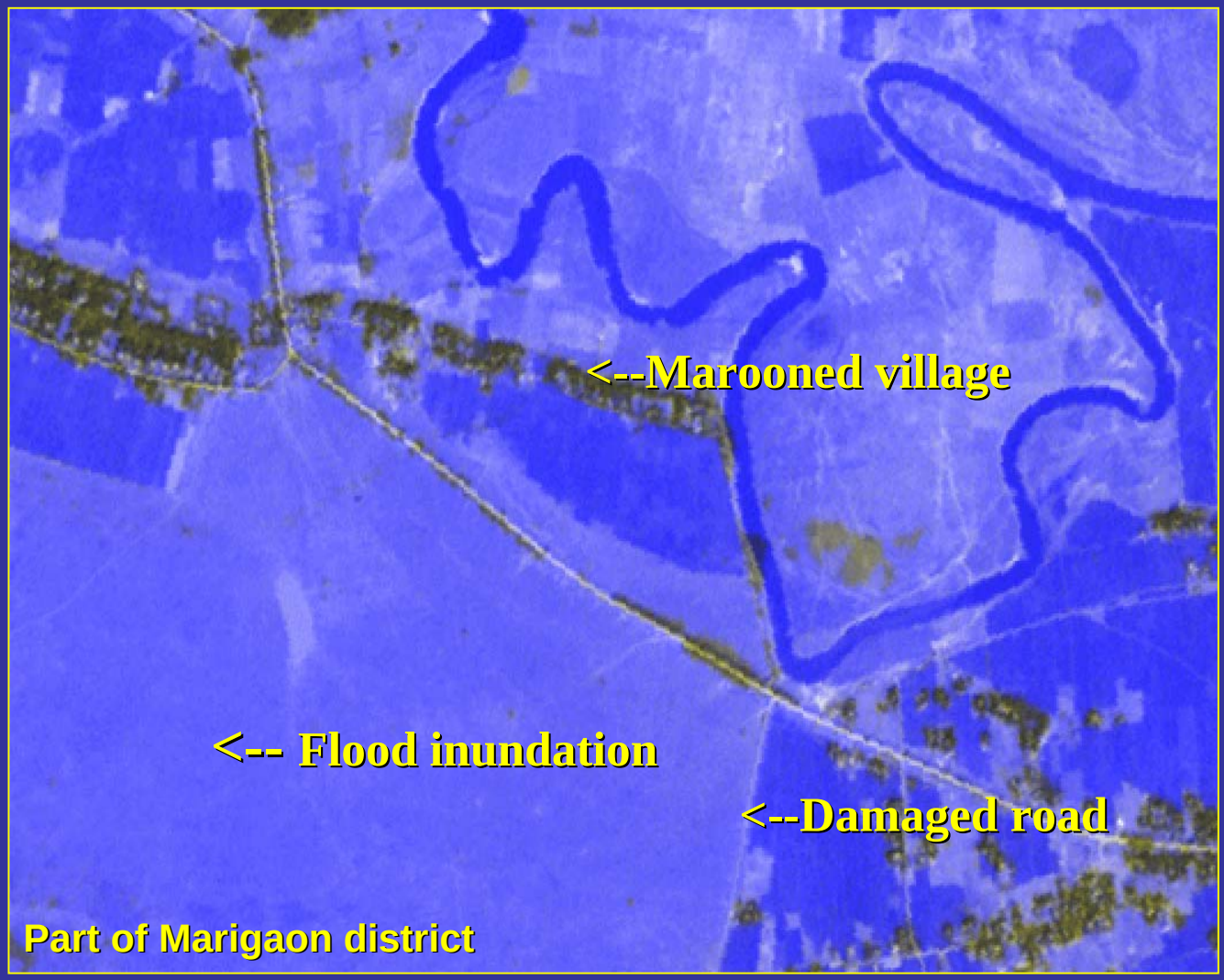
During Flood



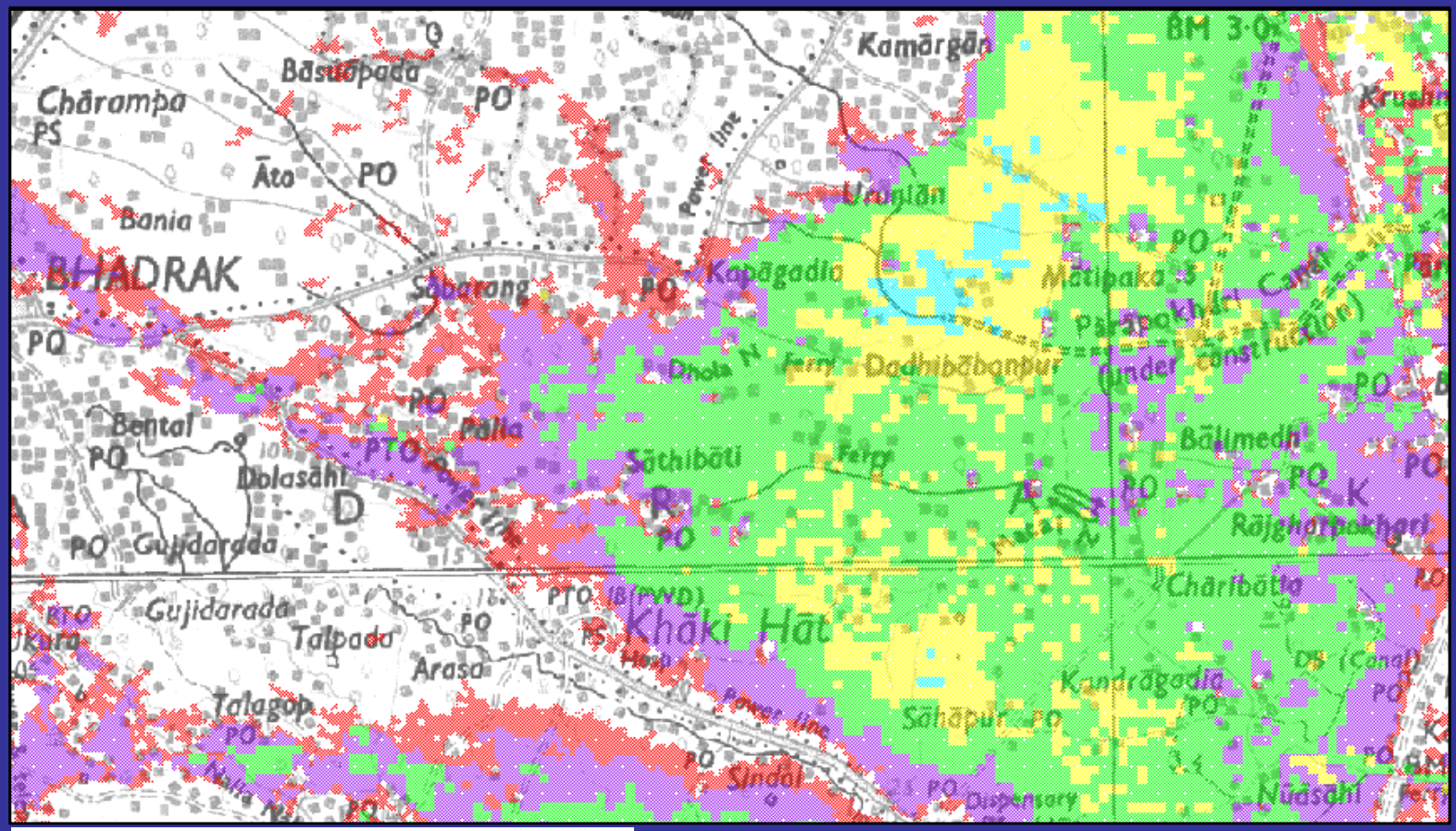
IRS-1C PAN 08 Sept, 98

1998 Brahmaputra Floods - Damage to road network

Pre & post flood PAN data merge



Inundation recession during 2nd through13th Nov, 1999



Inundation as on 13 Nov, 1999

Inundation recession during 2-4

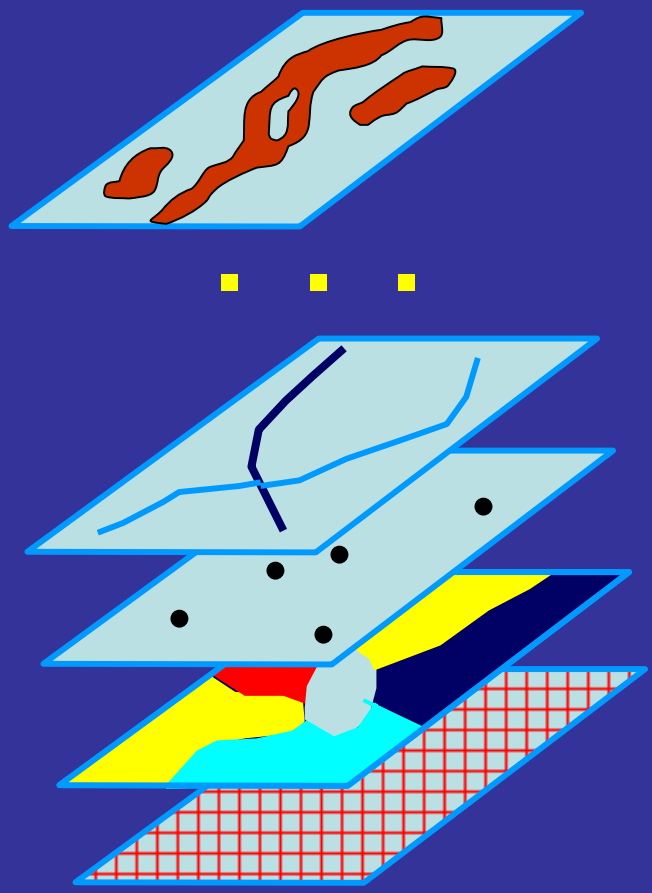
Inundation recession during 4-8

Inundation recession during 8-11 Nov,1999

Inundation recession during 11-13 Nov,1999

Flood

Damage information system



Flood inundation map

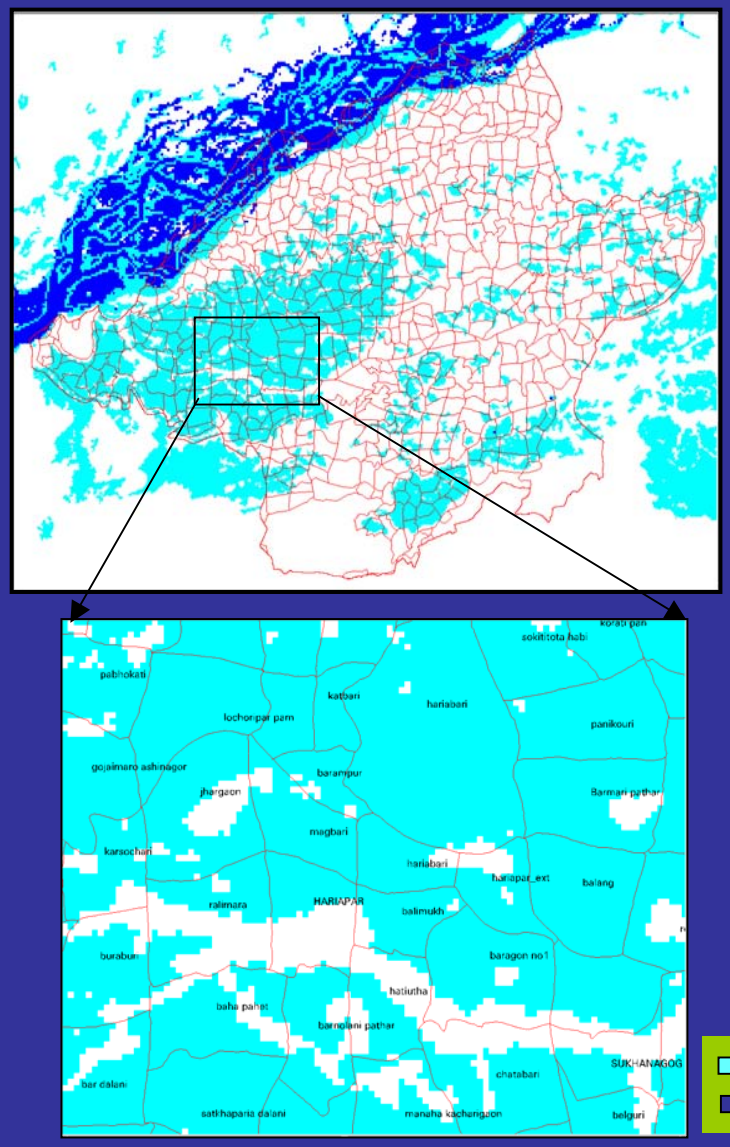
Road & Rail network

Settlements

Land use map

Base map

Brahmaputra River Floods - 2000
Villages affected in Marigaon district

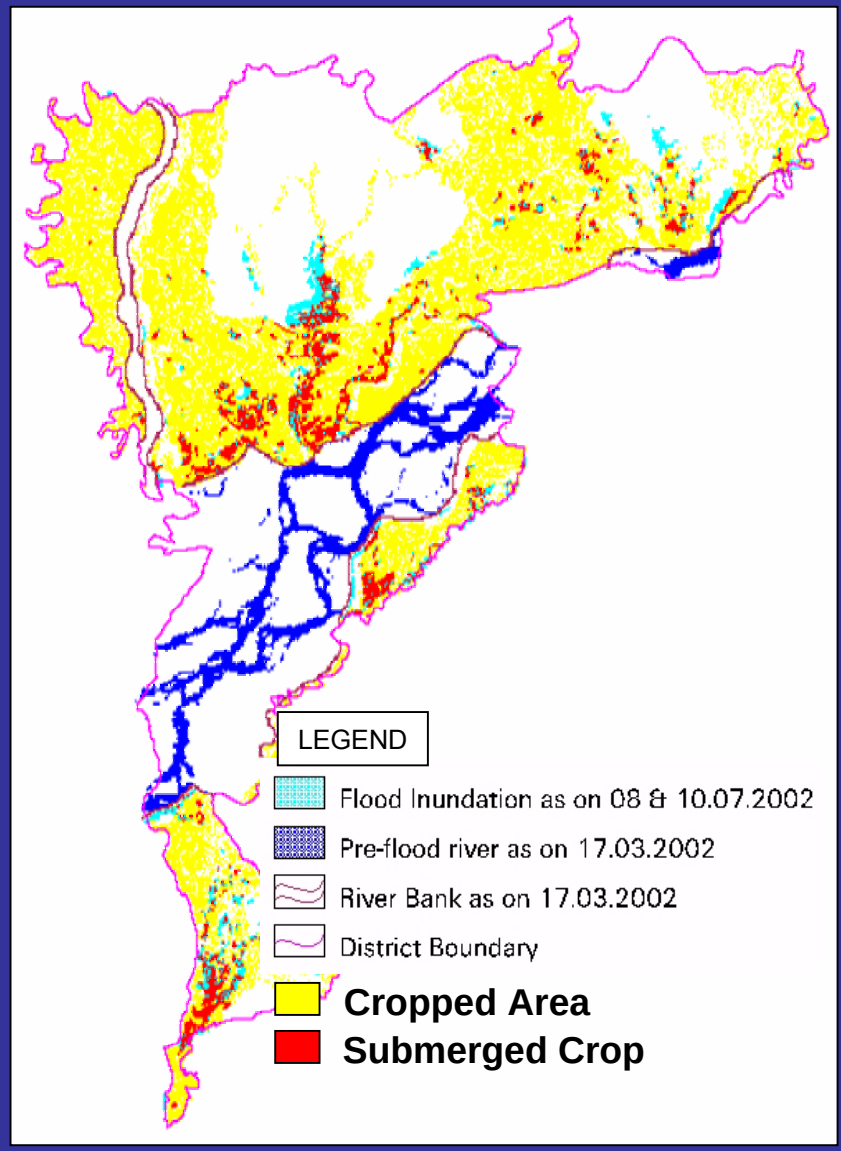


Flood damage statistics derived from RADARSAT SAR data of Jun, 2000

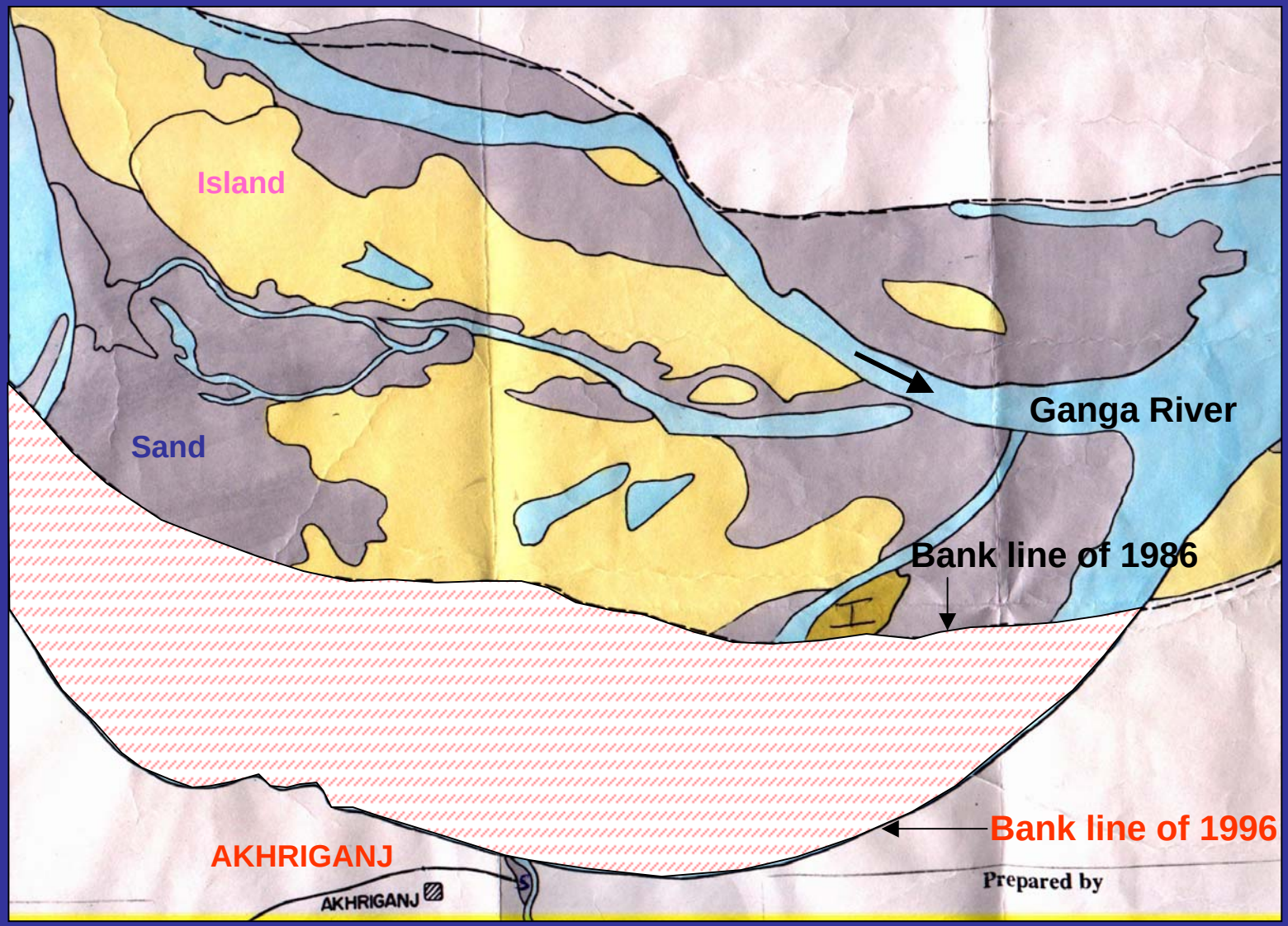
District	No. of villages affected	Area affected (Ha)	Crop area affected (Ha)
Dhemaji	73	5,658	3,611
Sibsagar	271	10,000	7,436
Jorhat	262	14,843	8,346
Lakhimpur	244	22,857	16,636
Marigaon	459	37,253	10,874
Darrang	278	11,708	5,254
Nalbari	211	6,528	3,457
Goalpara	297	16,668	10,510
Dhubri	647	41,511	16,425

Crop Area Submerged - Dhubri District, Assm

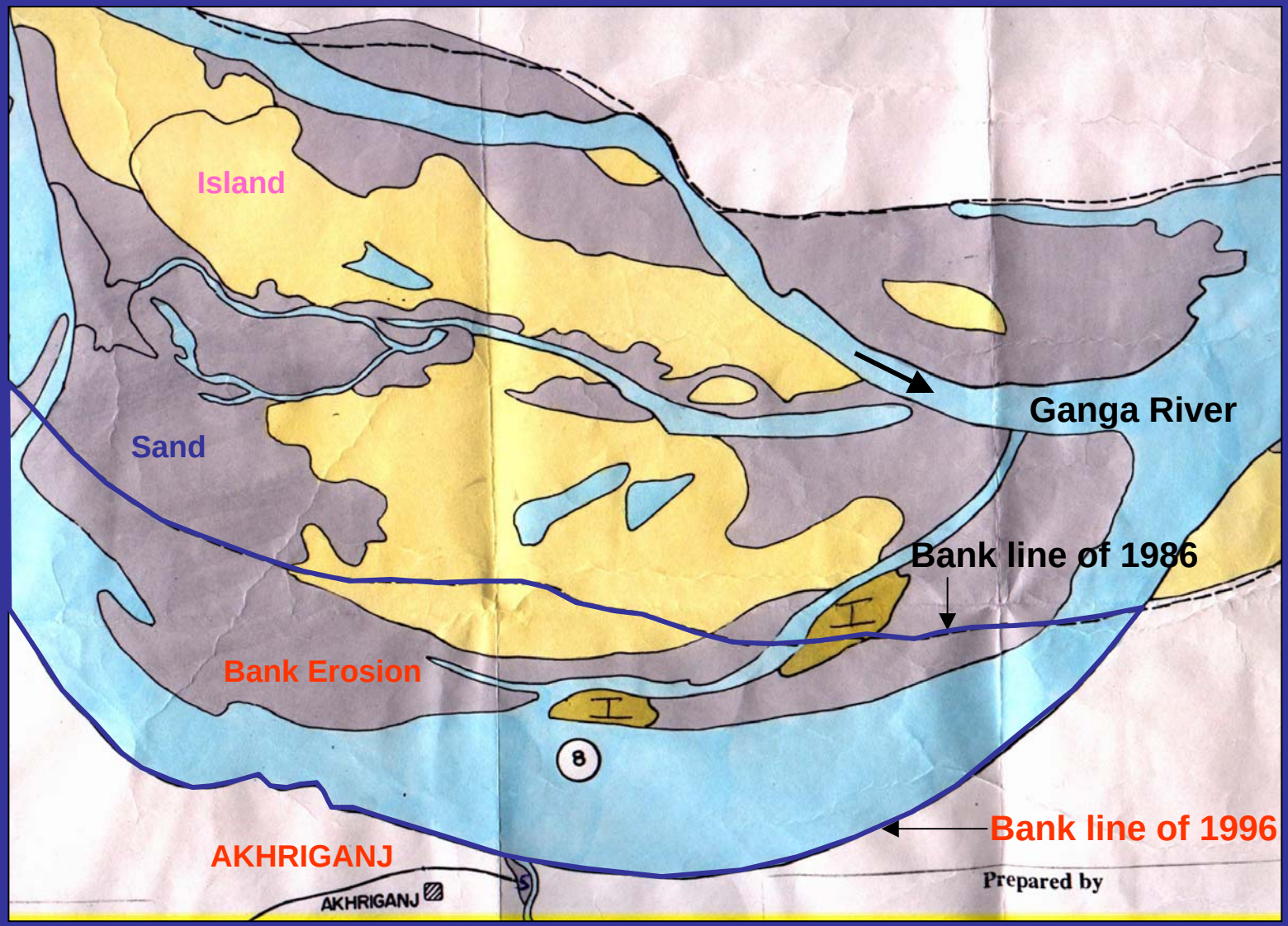
Based on the analysis of RADARSAT SAR data of 10th July 2002



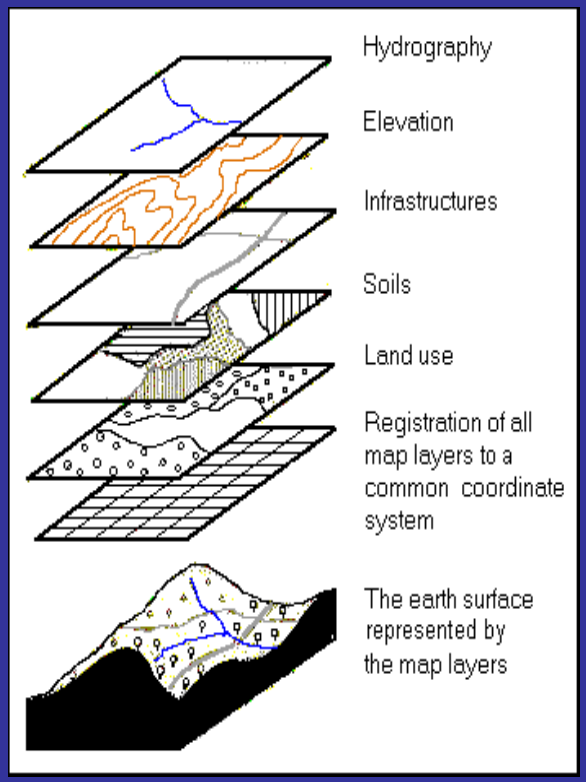
Change of Ganga river course D/S of Farakka during 1986 through 1996



Change of Ganga river course D/S of Farakka during 1986 through 1996



Watershed
Runoff estimation

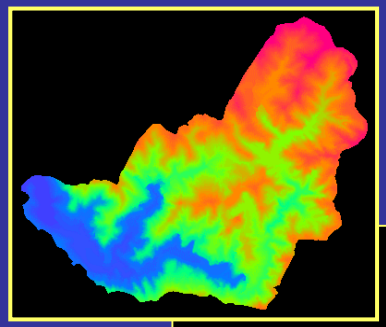


Land use / Land cover Map
Soil Information Map

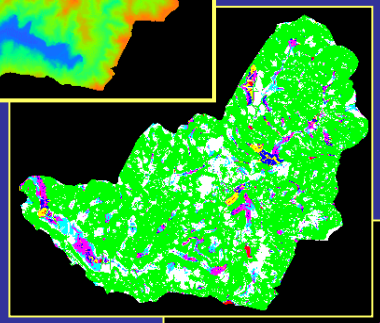
Runoff Coefficient Map
Isohyetal Map

Unit-wise Runoff Estimation

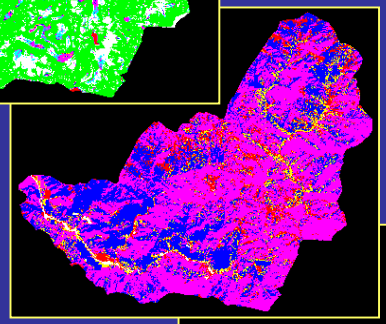
Simulation of Effect of change in Land Cover on Runoff can also be studied



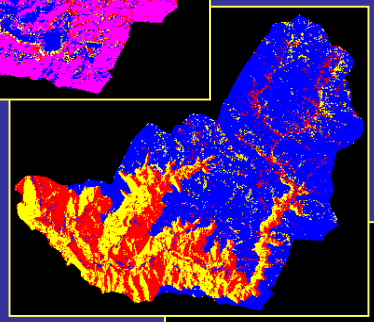
Elevation



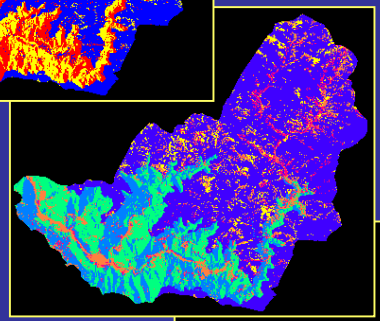
Slope



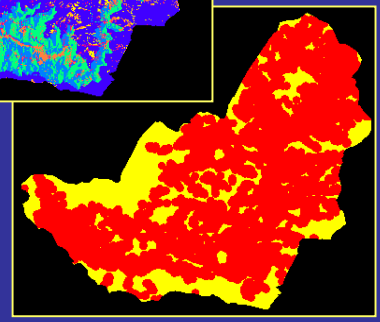
Land use/cover



Soil texture



Runoff
Potential Map



Buffer zone

Hydro-geomorphology

Sites Water
Harvesting
Structures

Farm Ponds

Flat topography and low soil permeability is required

Check Dams

Medium slope, low permeability is required. The available area should be more than 25 ha. Preferably check dams should be constructed at a lower order streams(upto third order)

Ground Water Recharges

Flat to moderate slope and soil should be permeable

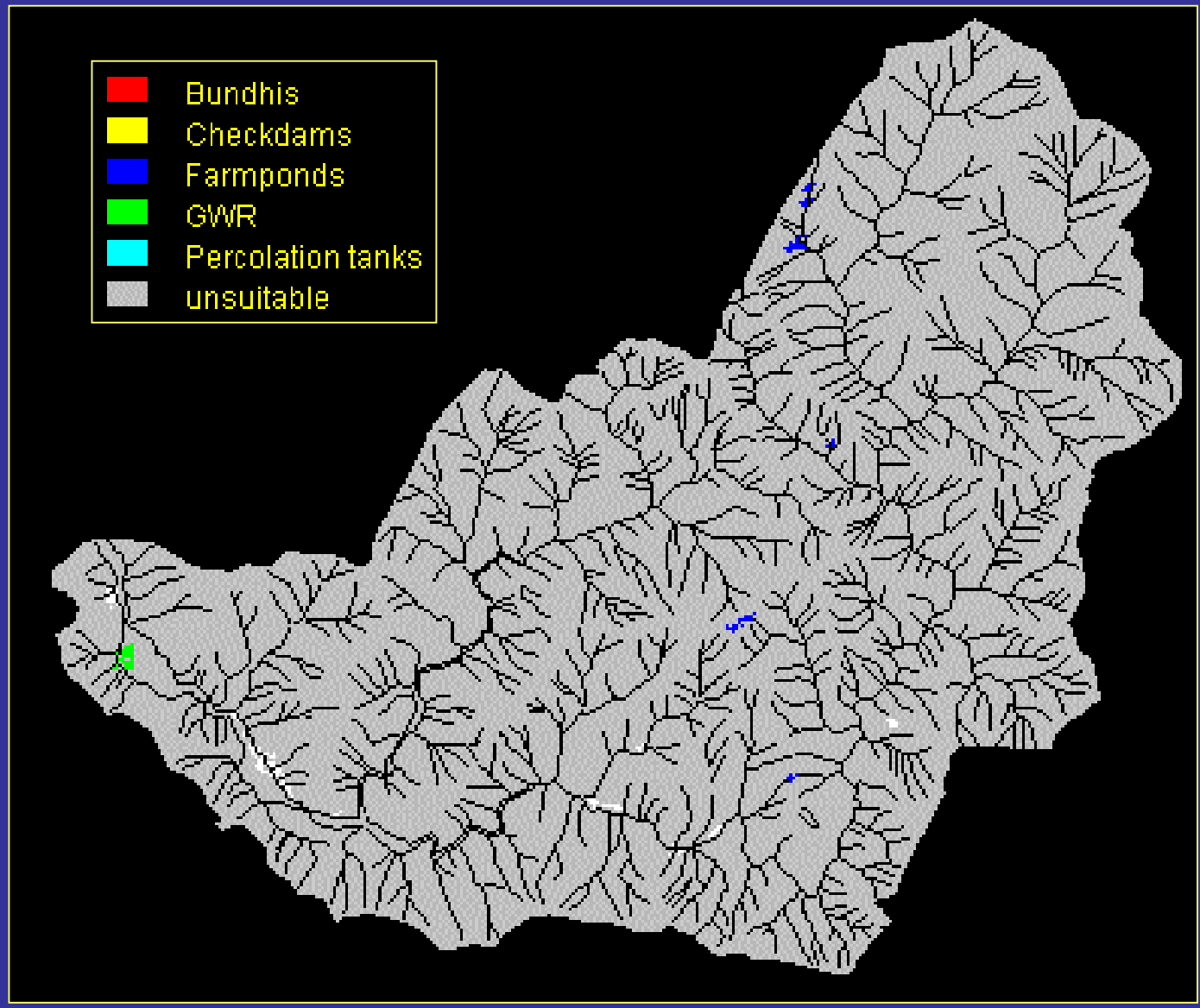
Percolation Tanks

Flat topography and pervious strata is required. The available area should be more than 40 ha.

Bundhis

Medium permeable soils, adequate area are the requisites for bundhis and preferably it should be nearer to cultivated land

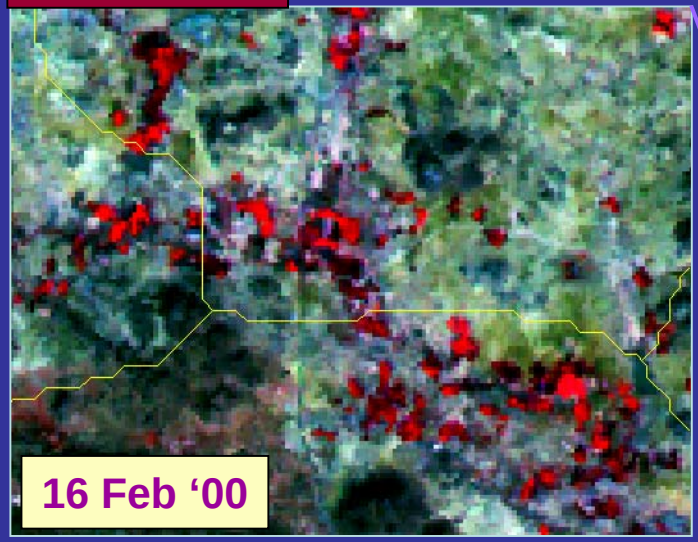
Sites Suitable For Water Harvesting Structures



Water harvesting

Impact Assessment on crops

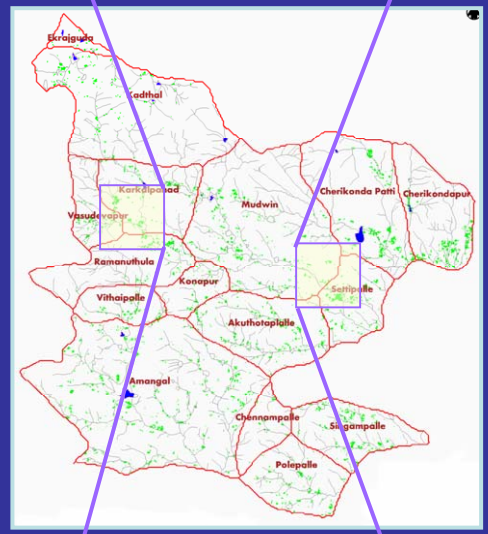
Up Stream



16 Feb ‘00

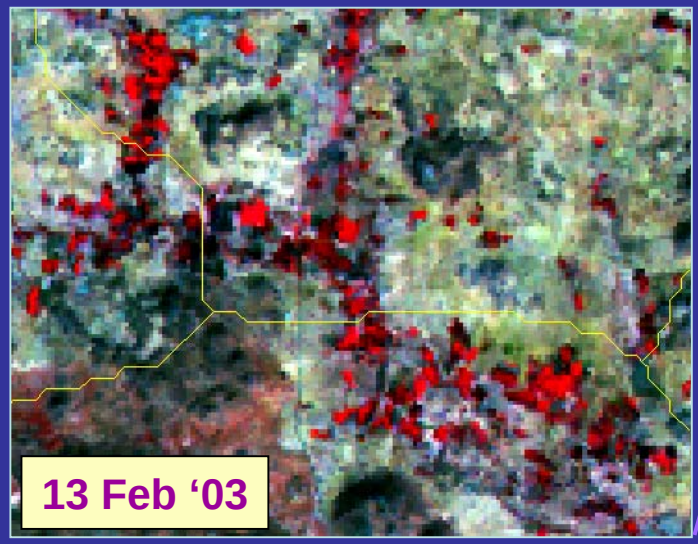
PRE

Amangal Mandal
Mahaboob Nagar Dist.
Andhra Pradesh



Down Stream

16 Feb ‘00



13 Feb ‘03

POST

13 Feb ‘03

GIS and Remote Sensing Application
by the Rajiv Gandhi National Drinking Water Mission

Groundwater prospect maps for problematic villages

Project carried out on a 1:50000 scale.

IRS1D LISSIII used to prepare maps by using visual interpretation technique.

Themes generated Surface water bodies viz. streams and tanks, Structures, geomorphology, lineaments and litho logy.

Point level source identification

Socio economic and insetu data integrated

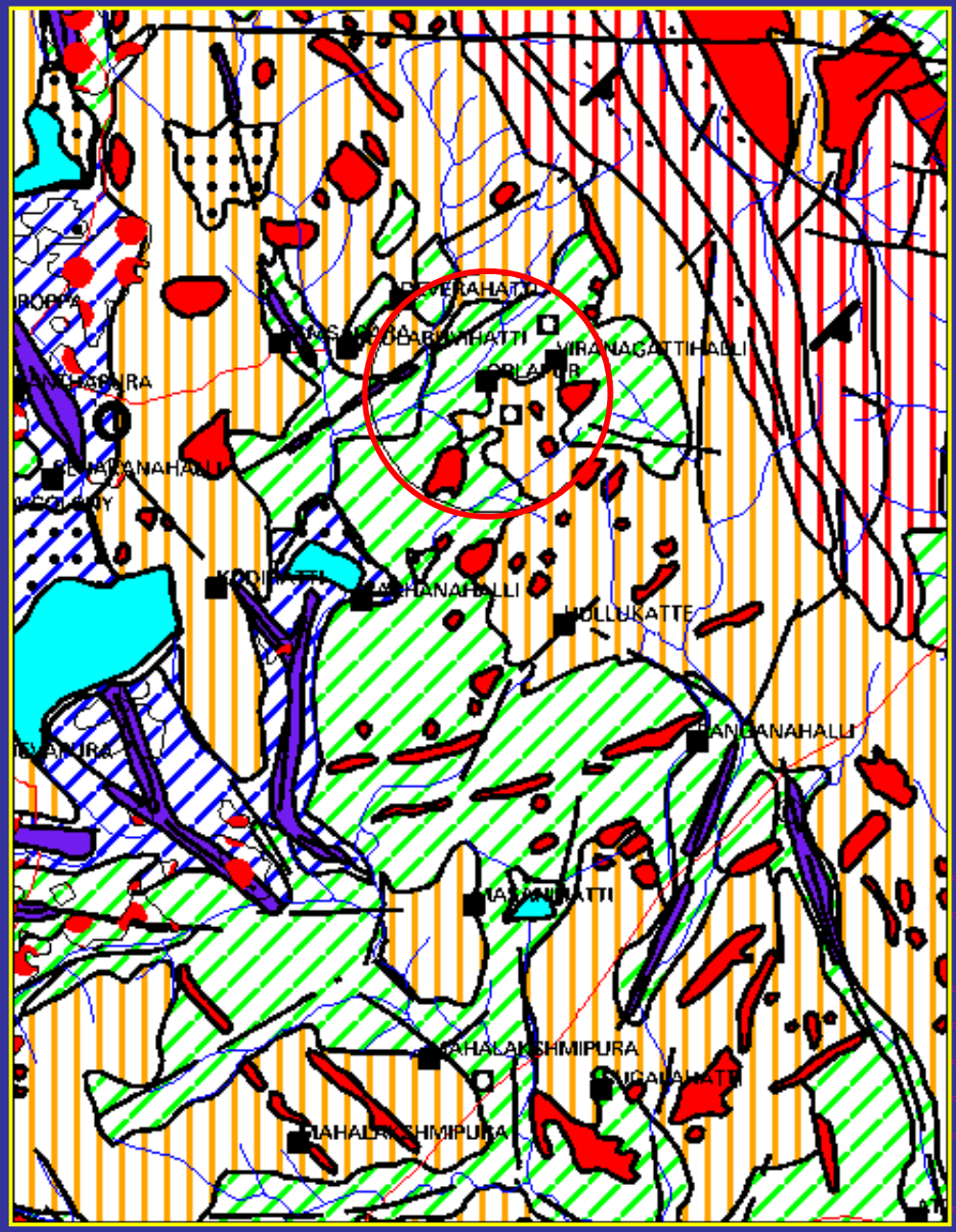
Field survey to confirm interpretation

Output in digital form.

Plan of action to combat water supply related problems

RAJIV GANDHI NATIONAL DRINKING WATER MISSION

GROUND WATER PROSPECTS MAP - PARTS OF CHITRADURGA DISTRICT, KARNATAKA



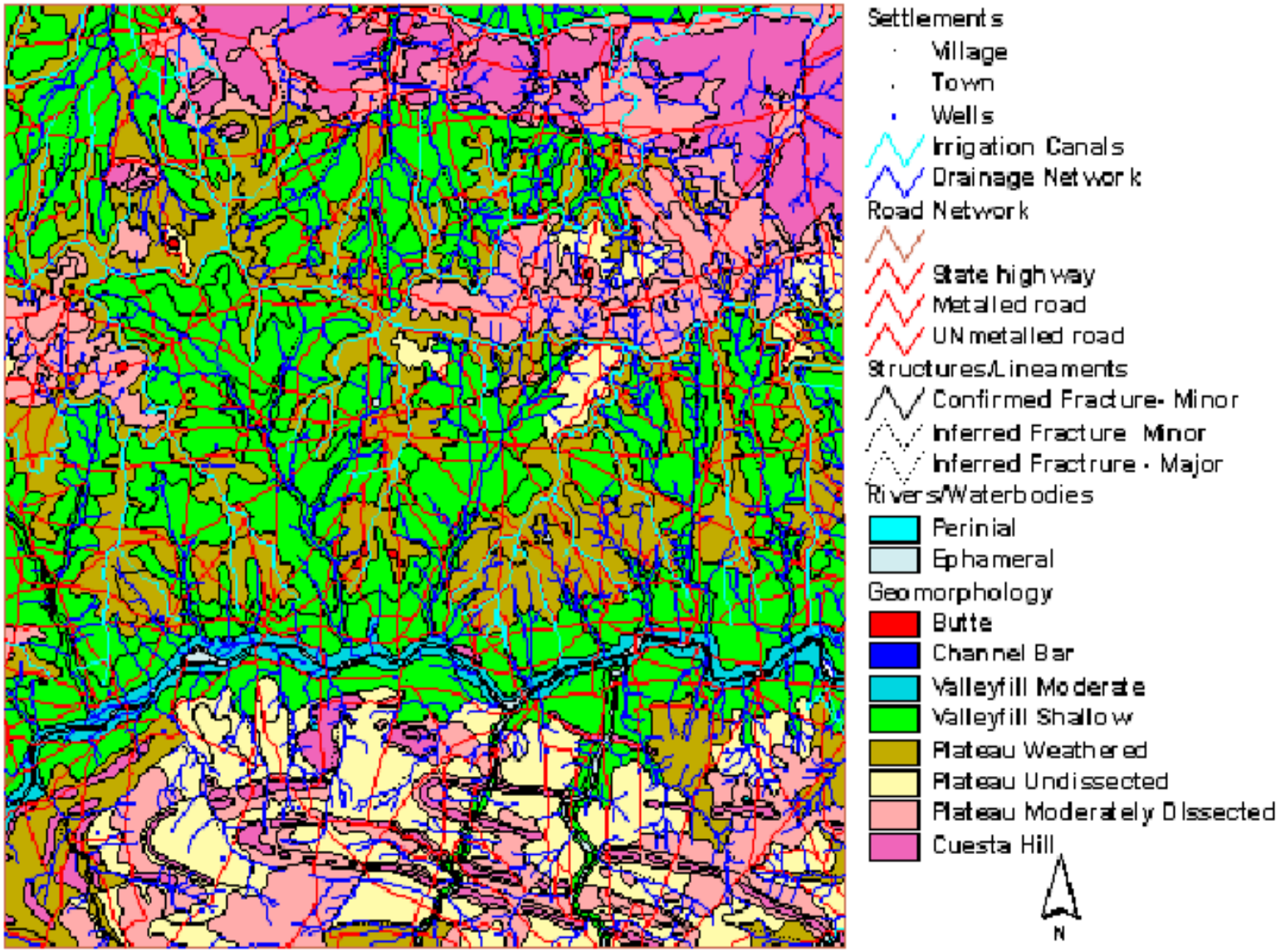
YIELD RANGE	DEPTH RANGE		
	SHALLOW <20 m	MODERATE 20-80 m	DEEP >80 m
EXCELLENT >200 lpm			
GOOD 100-200 lpm			
MODERATE 50-100 lpm			
LIMITED 20-50 lpm			
POOR <20 lpm			
NIL			

PROBLEM AREA

- FRACTURE ZONES
- RUNOFF ZONES
- GROUND WATER IRRIGATED AREA
- FRACTURE/LINEAMENT
- NC VILLAGE
- GEOLOGICAL/GEOMORPHOLOGICAL BOUNDARIES

INFORMATION CONTENT IN THE MAP

- MAP UNIT
- ROCK TYPE & GEOLOGICAL SEQUENCE
- GEOMORPHIC UNIT/LANDFORM
- RECHARGE CONDITIONS
- NATURE OF THE UNIT
- TYPE OF WELLS SUITABLE
- PROBABLE DEPTH RANGE OF WELLS
- EXPECTED YIELD RANGE OF WELLS
- PROBABLE SUCCESS RATE OF WELLS
- REFERENCE NO. OF OBSERVATION WELLS
- GROUND WATER IRRIGATED AREA
- RECHARGE STRUCTURE SUITABLE
- PROBLEMS/LIMITATIONS /REMARKS



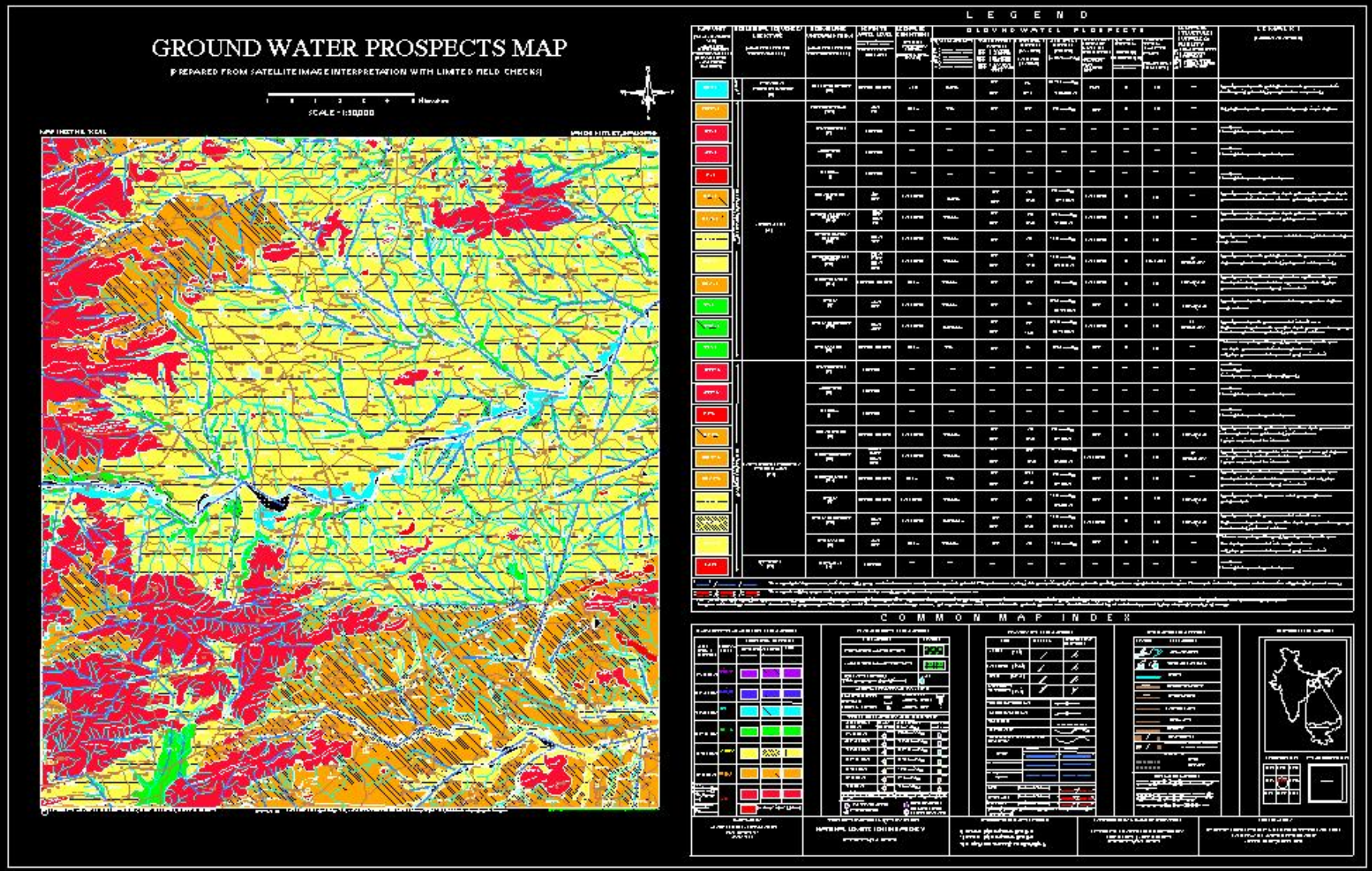
47P/3 SOI Sheet Area covering Bijapur & Bagalkot Dts., Karnataka.

Prepared through LISS III imagery Interpretation coupled with Field Surveys

Hydro-geomorphological mapping under Rajiv Gandhi National Drinking Water Mission

ARCPLOT

Pan/Zoom



X:28.77421 Y:28.08811 dx:-28.54644 dy:18.57127 Dist 34.05571

LAND RESOURCE ACTION PLAN

CADASTRAL LEVEL INFORMATION SYSTEM

Applet Viewer: gecm.project.class

Applet

survno | = | 38

PROCEED | AND | COLOUR

QUERY | OR

SHOW | HELP

HOME | BACK

UPDATE | COMMIT

Applet started.

CADASTRAL LEVEL INFORMATION

અમીયાપુર

Query Demonstration - Microsoft Internet Explorer

Edit View Favorites Tools Help

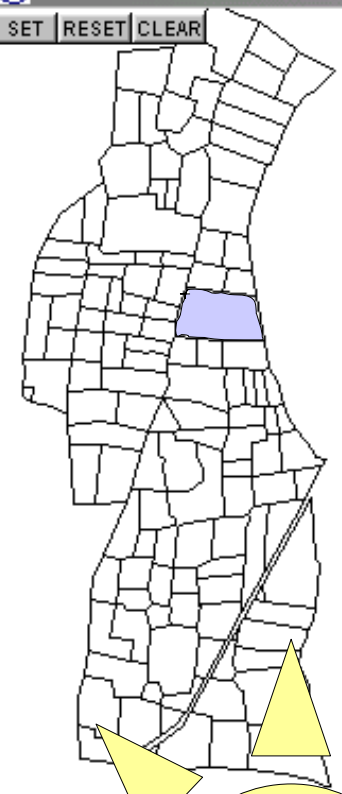
Back Links

http://128.1.1.12/novelty/ExAir/query2.asp

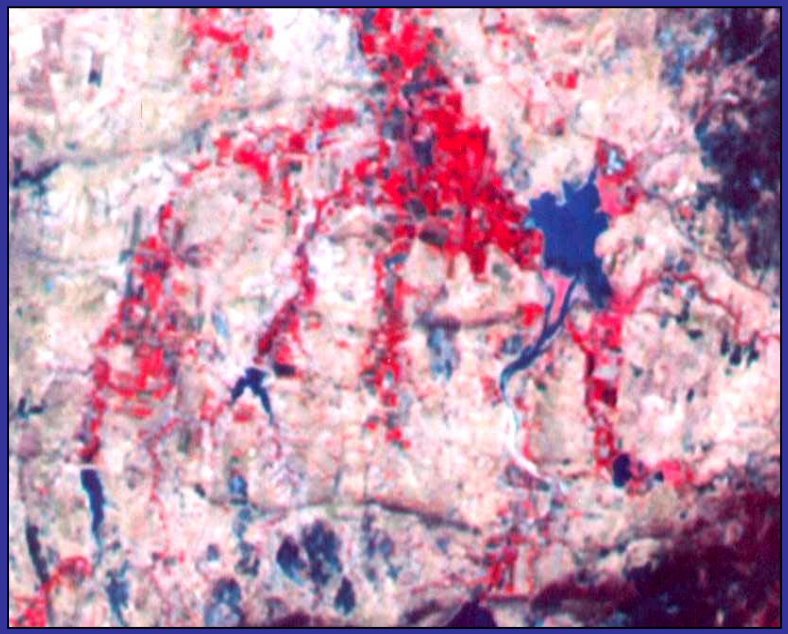
ગામડા નો નંબર VILLCD	સરવે નંબર SURVEY NO	ખેડૂત નું નામ FARMER NAME	ખેતી વિસ્તાર CROPAREA	મહેસૂલ વરસ REVENUE YEAR	જરાયત વિસ્તાર AREA૧	બાગાયત વિસ્તાર	ક વિ
૦૫૮	૩૮/૧-xC	ઠાકોર ગાભાજી ચુથાજી	૦.૩૭૪૩	૧૯૯૮-૧૯૯૯	૦.૦૯૧૧	૦	૦
૦૫૮	૩૮/૧-xX	ઠાકોર ગાભાજી ચુથાજી	૦.૧૦૧૨	૧૯૯૮-૧૯૯૯	૦.૨૧૨૫	૦	૦
૦૫૮	૩૮/૧-xD	ઠાકોર ગાભાજી ચુથાજી	૦.૦૯૧૧	૧૯૯૮-૧૯૯૯	૧.૪૩૬૬	૦	૦
૦૫૮	૩૮/૨	ગાભાજી	૧.૪૮૭૨	૧૯૯૮-	૦.૧૩૯૪	૦	૦

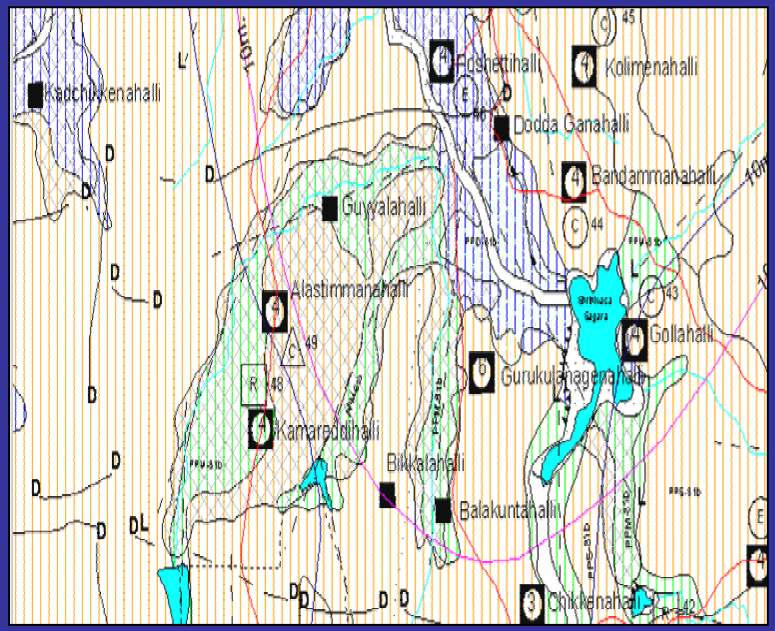
MAP

SET | RESET | CLEAR



JAVA / ASP SYSTEM OUTPUT





GROUND WATER PROSPECTS MAP NANDI HILLS, KARNATAKA

GROUND WATER PROSPECTS

YIELD RANGE	DEPTH RANGE		
	SHALLOW	MODERATE	DEEP
Very Good			
Good			
Moderate			
Poor to Limited			

Ground Water Irrigated

Depth to water Table

D – Dyke L - Lineament

SPACE TECHNOLOGY – Long Distance Water Transport

RS/GIS based Studies (1:50k – 1k), DEM

- Basin Characterization
- Command Area Survey
- Geology/Geomorphology/Tectonic
- Landslide/Seismic
- Tunnel Alignment
- Cropping System Analysis
- Reservoir Capacity Assessment
- Biome & Forest Habitat

RS based Monitoring (1:50k – 10k), DEM

- Land Use/Land Cover Change
- Reservoir Sedimentation
- Irrigation Efficiency
- Land Degradation
- Equitable Distribution of Water
- Submergence Assessment
- Rehabilitation & Reconstruction
- Terminal Reservoirs Siltation

Feasibility Report
Footprint Analysis …

Detailed Project Report
Implementation Strategy…

Aerial RS (1:0.5k – 1k), DEM

- River Surveys
- Link Alignment
- Submergence Assessment
- Full Reservoir Level (FRL) Survey
- Canal Network Planning
- Sites for Online New Storages

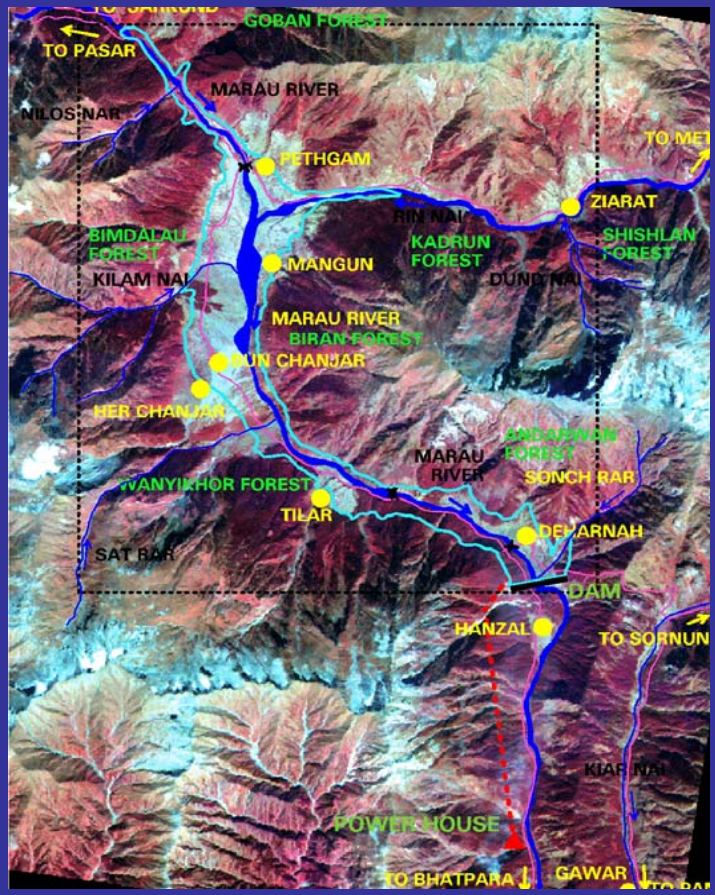
Benefit to Stakeholders

- Socioeconomic
- Natural resources
- Ecological
- Vulnerability reduction….

PRE-ILR

POST-ILR

ENVIRONMENTAL IMPACT ASSESSMENT

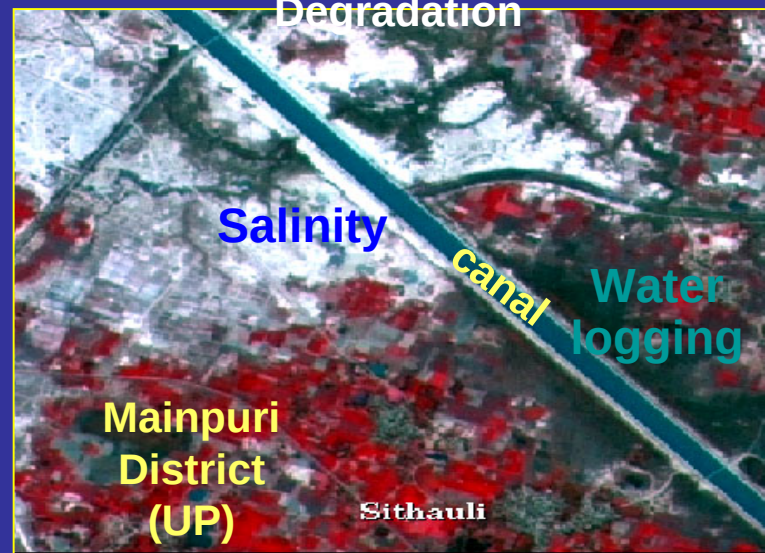


Submergence Boundary Line

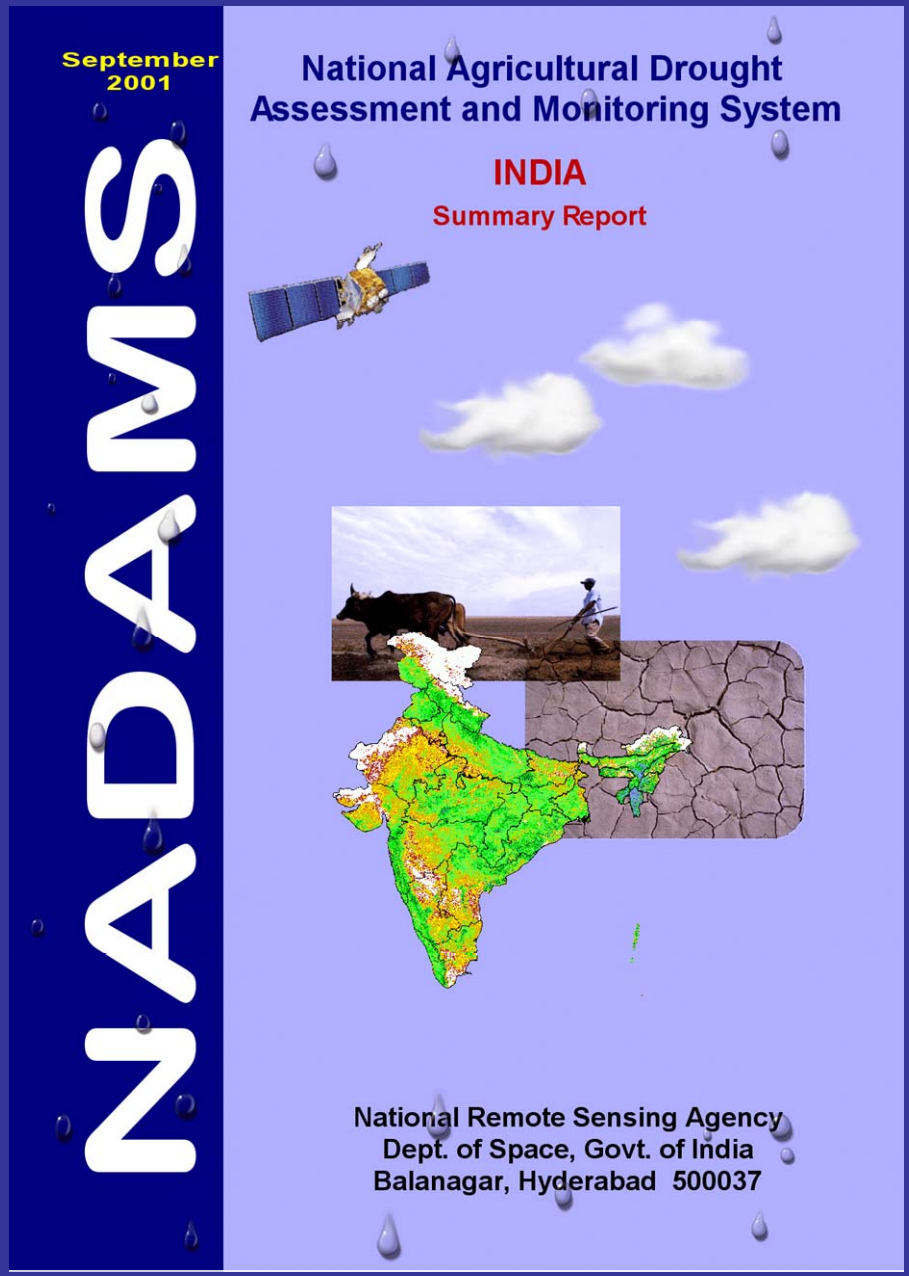
- Baseline information for proposed projects
- Evaluating the impact of existing project
  - Water logging & salinity
  - Siltation of reservoirs
  - Inventory of submergence area

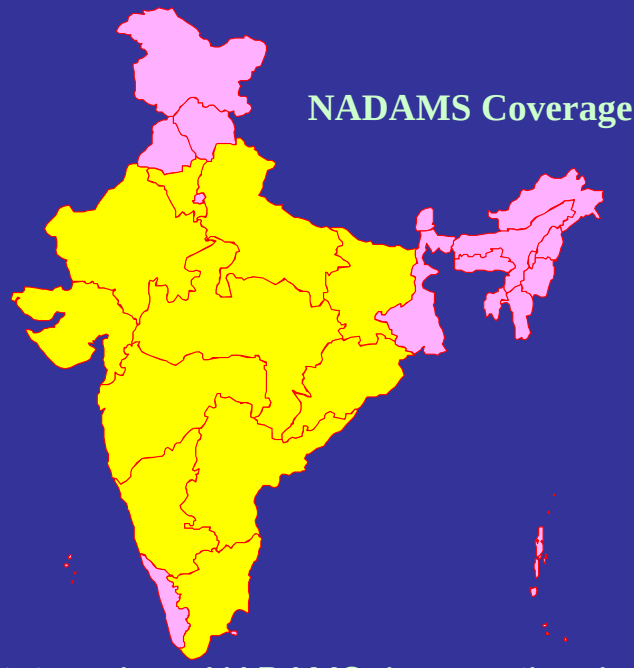
- Alignment of canal-environmentally fragile areas
- Health hazards- surface / standing water areas- mosquito breeding grounds

Severity of Land Degradation



NADAMS – Drought Reports

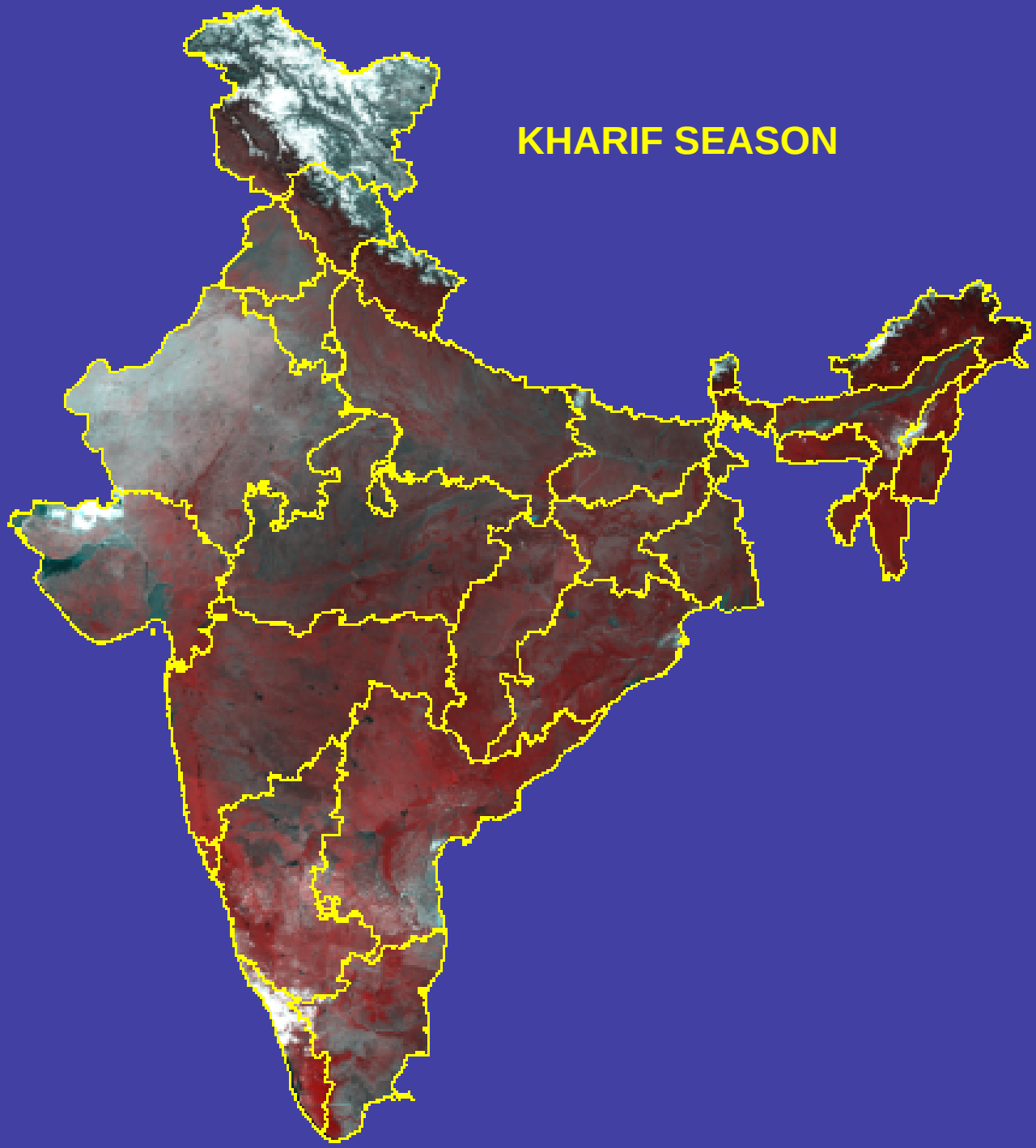




- Monthly reports for 14 states.
- Each state report contains satellite based assessment on current vegetation development, crop condition along with ground data
- Sent to Central and State Govt. Departments related with agriculture and relief.

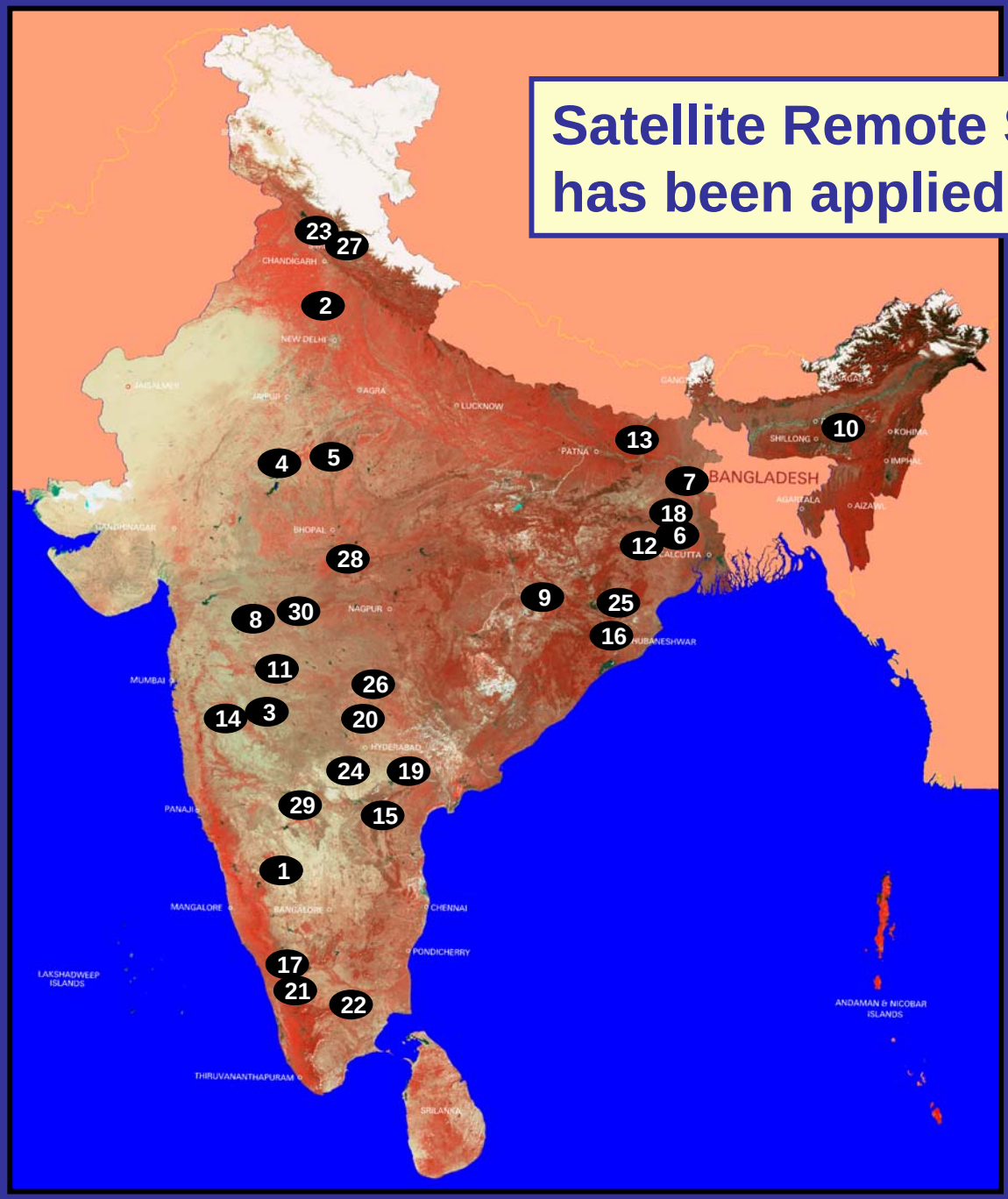
NATIONAL LEVEL

KHARIF SEASON



REMOTE SENSING

Satellite Remote Sensing Technology has been applied to ...



- **Diverse cropping systems**
- **Macro level to Micro level**
  (Command to Water Course)

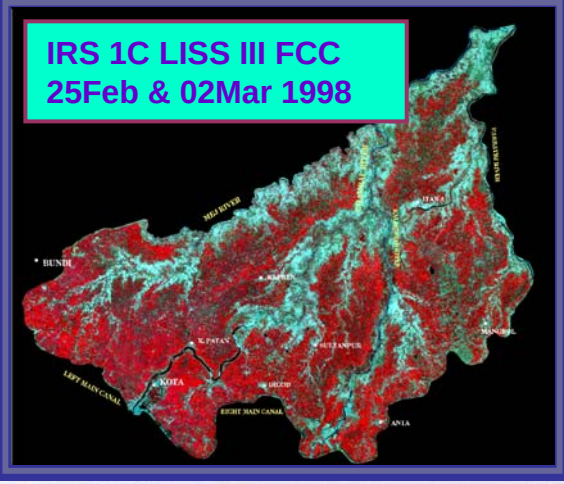
Sensor-wise Retrievable Information and its Application to Irrigation Water Management

Sensor System	Deliverables from Remote Sensing Application	Application to Irrigation Water Management
Medium Resolution (IRS LISS-I,II,III, AWiFS) (Landsat TM	Distributary level information on Different crops, crop condition, Productivity variations, crop Calendar variation	Performance assessment – equity and efficiency indicators, crop Yield variations, water Distribution performance, at major distributary canal level
High Resolution (IRS-PAN, LISS-IV IKONOS, QUICKBIRD)	Inventory & Mapping of irrigation infrastructure Water course level information on irrigation utilisation	Impact (structural & non-structural)studies Assessment of existing physical infrastructure Monitoring of irrigation works

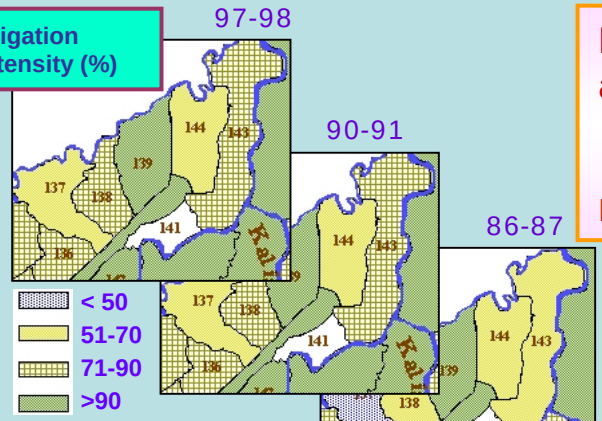
- **Inventory of Irrigated Agriculture**
  - Cropping Pattern
  - Crop Condition
- **Performance Evaluation/Monitoring**
  - Irrigation Intensity
  - Principle Crop Intensity
  - Crop Productivity
  - Water Use Efficiency
  - Water Delivery vs Demand
- **Monitoring Intervention Schemes**
  - Equity in improvement
  - Sustenance of improvement
- **Near Real-Time Monitoring**
  - Irrigation Progress
  - Spatial & Temporal Variability in Irrigation Water Demand
  - Optimization of Water Allocation
- **Environmental Impact Assessment**
  - Surface Water Logging
  - Soil Salinity/Alkalinity
- **Irrigation Infrastructure Mapping**
  - Assessment Potential Created/Utilized

PERFORMANCE EVALUATION OF CHAMBAL IRRIGATION COMMAND, RAJASTHAN, INDIA

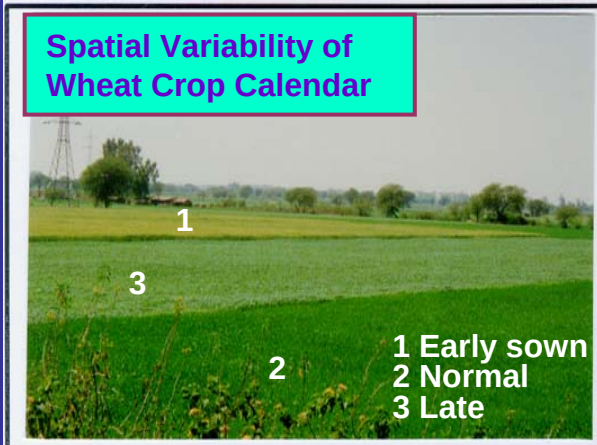
IRS 1C LISS III FCC 25Feb & 02Mar 1998



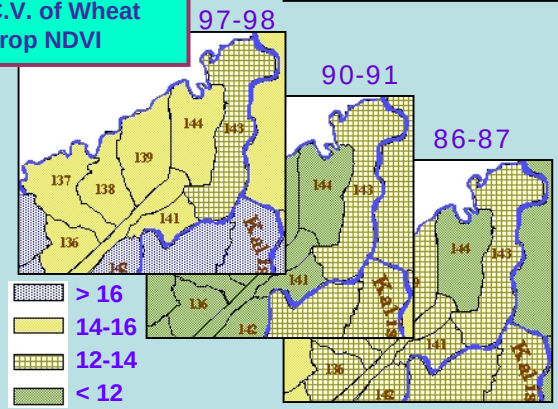
Irrigation Intensity (%)



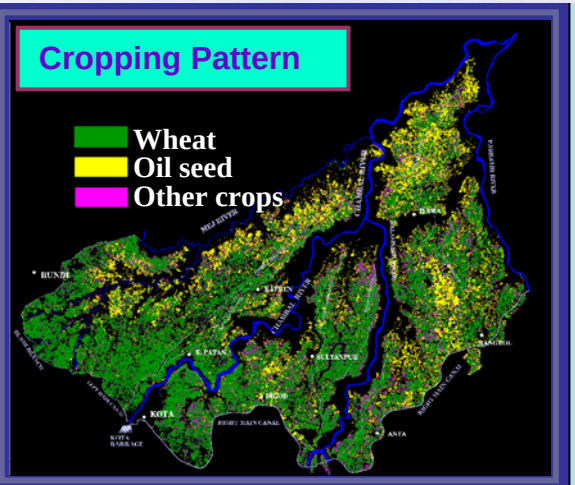
Spatial Variability of Wheat Crop Calendar

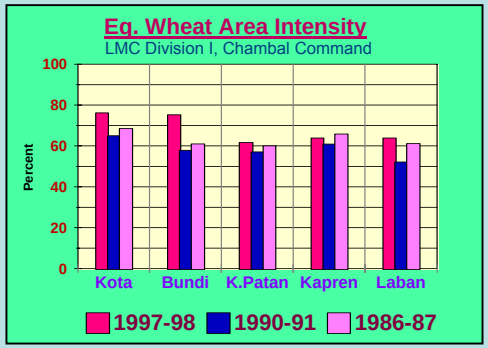


C.V. of Wheat crop NDVI



Cropping Pattern





Primary Irrigated Agriculture Data at Dis-aggregated level on

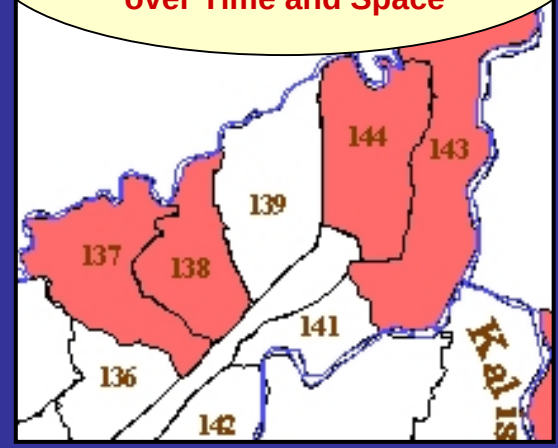
- Cropping Pattern and
- Crop Condition/Yield

Integrated with Field Data

Indicators of Irrigation System Performance

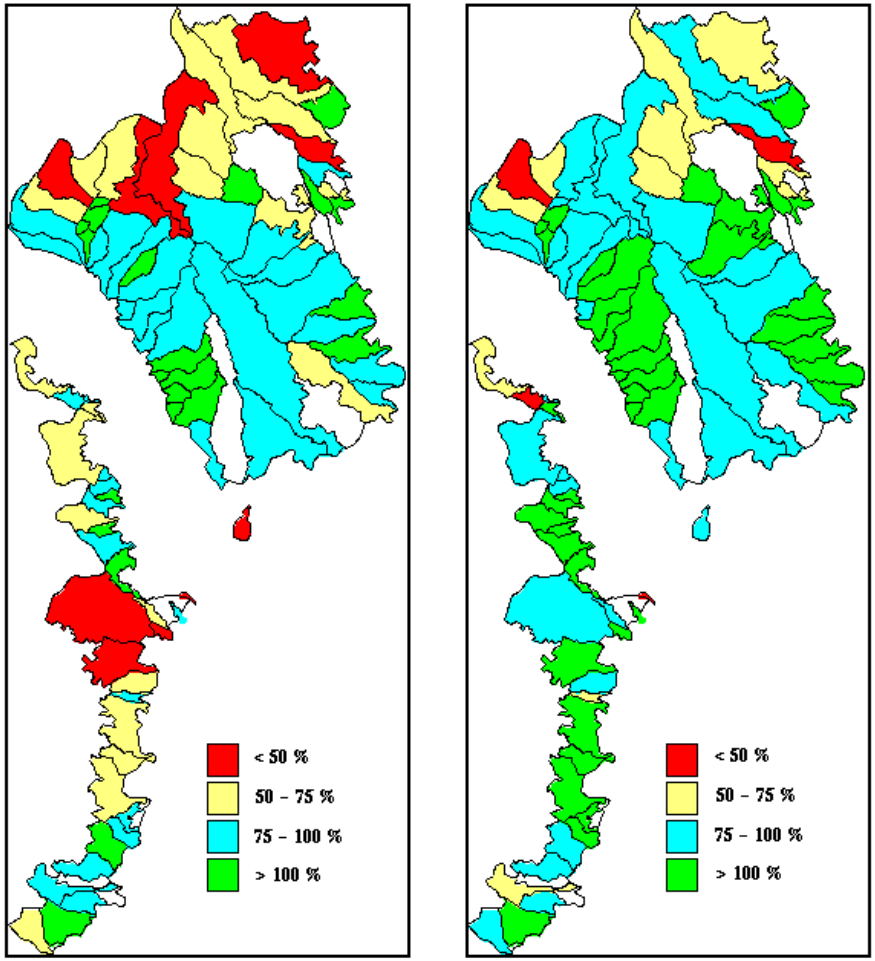
- Irrigation Intensity
- Principal Crop Intensity
- Water Distribution Equity
- Area irrigated Per Unit Water
- Production Per Unit Water
- Tail-Head Ratio of NDVI/Yield
- Coeff. Variation of NDVI/Yield

Identification of Canals with Differential / Poor Performance over Time and Space



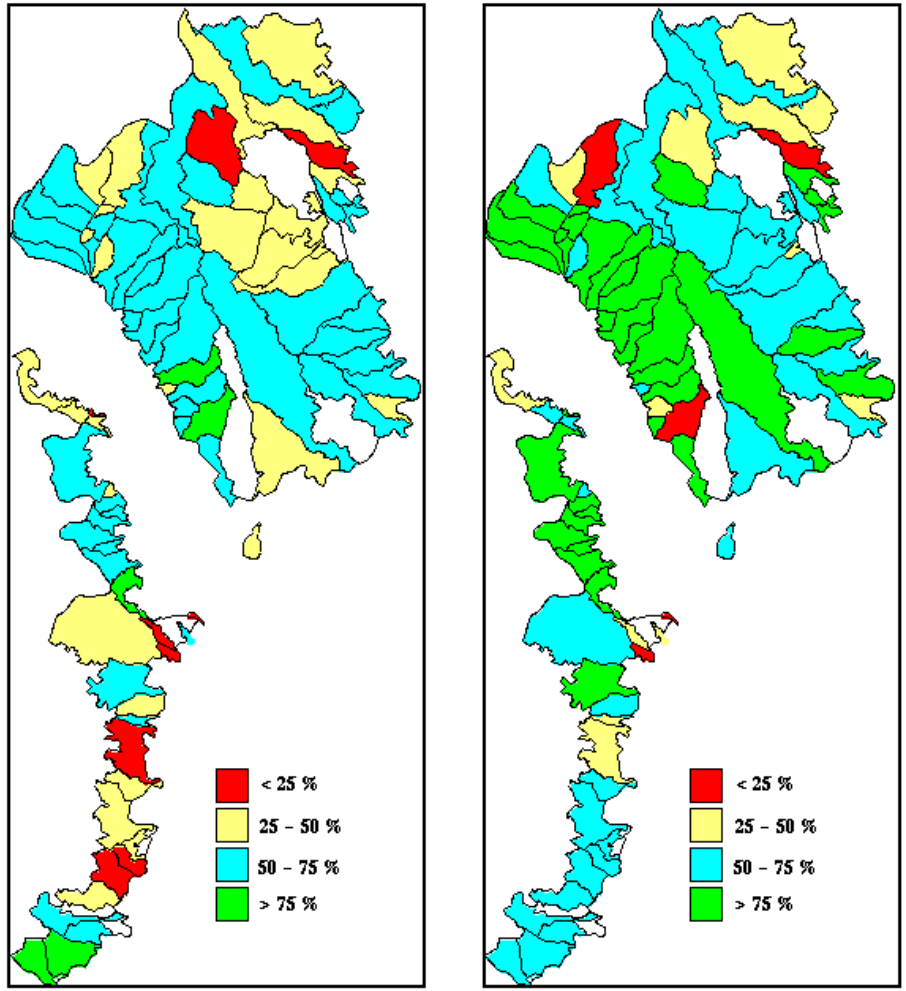
IRRIGATION INTENSITY

PRE NWMP (1986–87 RABI) POST NWMP (1992–93 RABI)



PERCENTAGE PADDY AREA

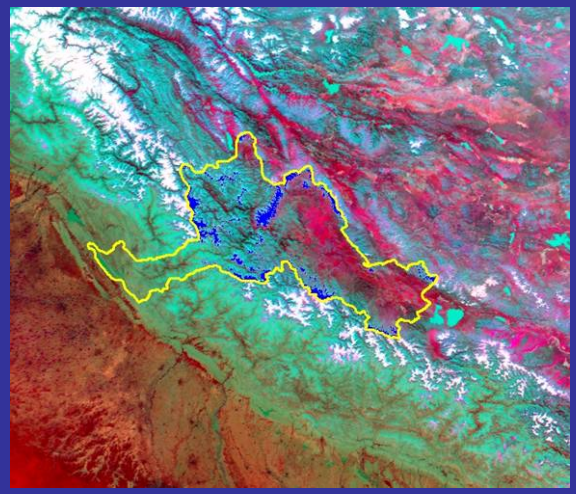
PRE NWMP (1986–87 RABI) POST NWMP (1992–93 RABI)



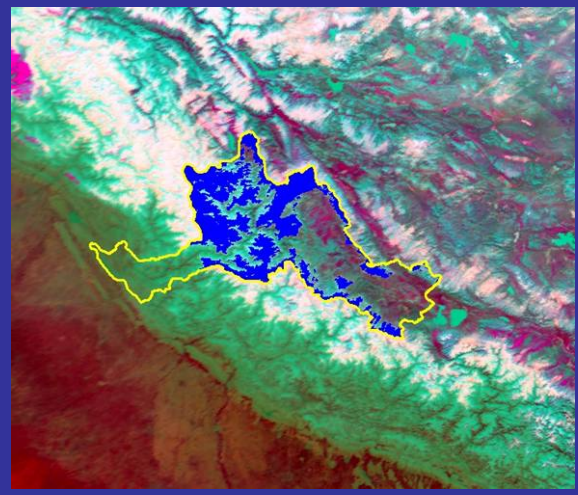
Snowmelt Runoff

- Water in Bhakra reservoir on Sutlej river is used for irrigation, power generation and drinking water purposes.
- This water is shared by 5 North Indian States HP, Punjab, Haryana, Rajasthan, Delhi

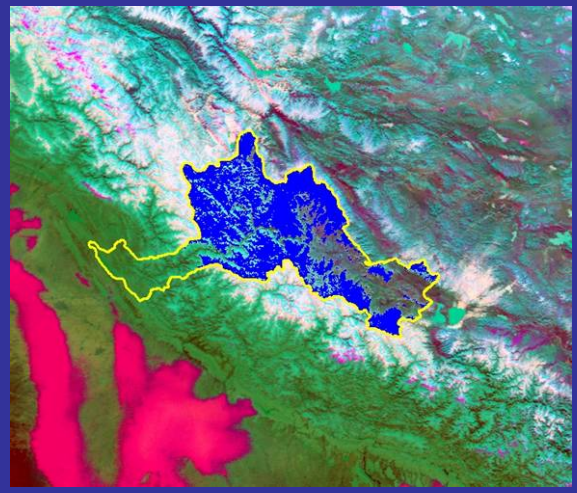
Snowcover Accumulation in Sutlej



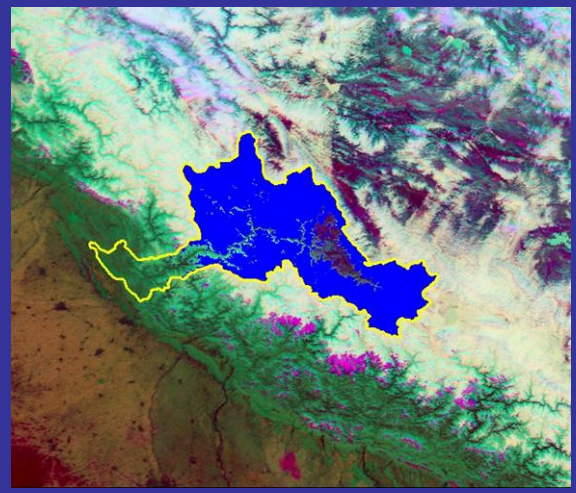
12 Oct 2003



19 Nov 2003



22 Dec 2003

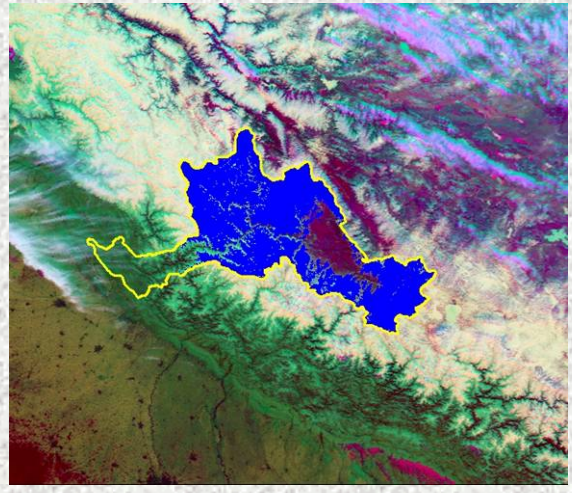


27 Jan 2004

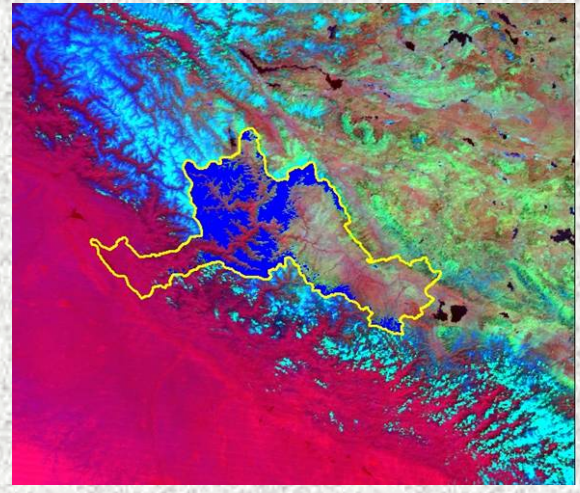
Basin Boundary

Snow

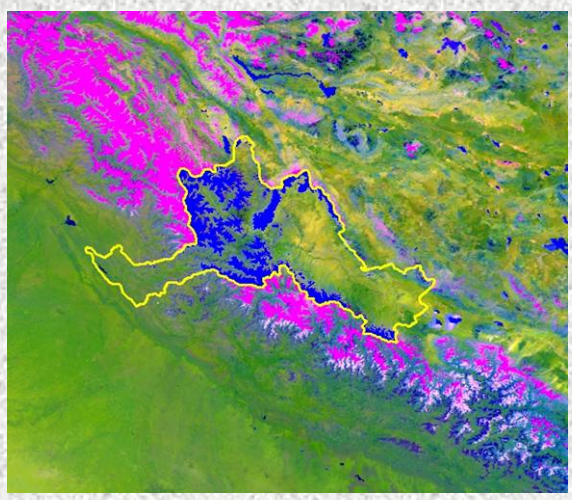
Snowcover Depletion in Sutlej



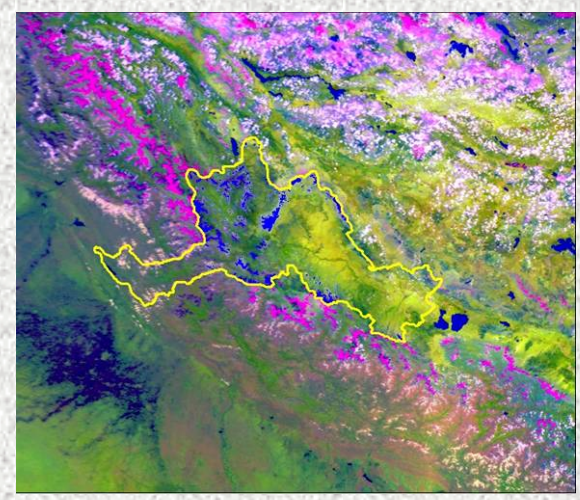
03 Feb 2004



27 Mar 2004



15 May 2004



29 Jun 2004

Basin Boundary
Snow

Thank You