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

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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
  - 1KM
- IRS
  - IRS LiSS IV: 5.8m
  - IRS LiSS III: 23m
  - IRS LiSS II: 36m
  - IRS LiSS I: 72m
  - IRS AWiFS: 56m
  - IRS WiFS: 188m
- QUICKBIRD
  - Sub metre: 2.4m

DTM
### Sensors or satellites that produce images suitable for Water Resources

<table>
<thead>
<tr>
<th>Purpose</th>
<th>SPOT</th>
<th>IRS</th>
<th>TM</th>
<th>MSS</th>
<th>AVHRR</th>
<th>ERS-SAR</th>
<th>Radarsat</th>
<th>ERS-ALT</th>
<th>ATSR</th>
<th>Meteosat</th>
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<td>Crop yield</td>
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<td>Potential evapotranspiration</td>
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<td>Root-zone moisture</td>
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<td>Soil salinity</td>
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<td>River discharge</td>
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<td>Precipitation</td>
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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 rainwater 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

Swajaladhara

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.
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 hydrometeorological 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
Nanjur tank cascade as on 08-Dec-2003

Different crops at field level

Open wells

- Sugarcane
- Gram

as on 08-Dec-2003
WATER RESOURCES

- Geographic Distribution
- Temporal Dimension
- Quality
- Quantity

- Sectoral water demand
- Optimum Utilisation

- Land Management
- Water Management
- Monitoring

AVAILABILITY

UTILISATION

MANAGEMENT
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

<table>
<thead>
<tr>
<th>Satellite</th>
<th>Sensor</th>
<th>Launch Year</th>
<th>Resolution</th>
<th>Swath (km)</th>
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<td>IRS 1A/1B</td>
<td>LISS I</td>
<td>1988/1991</td>
<td>0.45-0.52, 0.52-0.59</td>
<td>148</td>
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<td>LISS II</td>
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<td>0.62-0.68, 0.77-0.86</td>
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<td>WIFS</td>
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<td>PAN</td>
<td>1995/1997</td>
<td>0.50-0.75</td>
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<td>LISS III</td>
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<td>0.52-0.59, 0.62-0.68, 0.77-0.86</td>
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<td>WIFS</td>
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<td>1.55-1.70</td>
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<td>8 bands : 0.402 to 0.885</td>
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<td>MSMR</td>
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<td>6.6, 10.65, 18, 21 GHz</td>
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<td>IRS P5</td>
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<td>2000/2001</td>
<td>0.50-0.75; 2 PAN Cameras</td>
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<td>LISS III</td>
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<td>LISS IV</td>
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Space Technology for Flood Disaster Management

Historic flood of river Brahmaputra during Sept, 1998

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

Villages under inundation during 29 Jan-02 Aug, 1999
Receded inundation in Villages by 02 Aug 1999
Flood Mapping And Damage Assessment

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

FEB 1998

AUG 1998
Brahmaputra River Floods - 2000
Flood Inundation derived from 27th & 30th Jun, 2000 RADARSAT data

--- Flood inundation
--- Pre-flood river course
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

<-- Flood inundation

<-- Marooned village
1998 Brahmaputra Floods - Damage to road network

Pre & post flood PAN data merge

Part of Marigaon district

-- Marooned village

-- Flood inundation

-- Damaged road
Inundation recession during 2nd through 13th Nov, 1999

Inundation as on 02nd Nov, 1999
Inundation as on 04 Nov, 1999
Inundation as on 08 Nov, 1999
Inundation as on 11 Nov, 1999
Inundation as on 13 Nov, 1999

Inundation recession during 2-4 Nov, 1999
Inundation recession during 4-8 Nov, 1999
Inundation recession during 8-11 Nov, 1999
Inundation recession during 11-13 Nov, 1999
Flood

Damage information system

- Base map
- Land use map
- Settlements
- Road & Rail network
- Flood inundation map
### Brahmaputra River Floods - 2000
Villages affected in Marigaon district

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

<table>
<thead>
<tr>
<th>District</th>
<th>No. of villages affected</th>
<th>Area affected (Ha)</th>
<th>Crop area affected (Ha)</th>
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<td>Dhemaji</td>
<td>73</td>
<td>5,658</td>
<td>3,611</td>
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<td>Sibsagar</td>
<td>271</td>
<td>10,000</td>
<td>7,436</td>
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<td>Jorhat</td>
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<td>14,843</td>
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<td>Lakhimpur</td>
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<td>22,857</td>
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<td>Marigaon</td>
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<td>Darrang</td>
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<td>Nalbari</td>
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<td>16,668</td>
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<tr>
<td>Dhubri</td>
<td>647</td>
<td>41,511</td>
<td>16,425</td>
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</table>

--- Flood inundation
--- Pre-flood river course
Crop Area Submerged - Dhubri District, Assam

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

Legend:
- Flood inundation as on 08 & 10.07.2002
- Pre-flood river as on 17.03.2002
- River Bank as on 17.03.2002
- District Boundary
- Cropped Area
- Submerged Crop
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

Bank line of 1986

Bank line of 1996

Island

Sand

Ganga River

Bank Erosion

AKHRIGANJ

Prepared by
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
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

- Bundhis
- Checkdams
- Farmponds
- GWR
- Percolation tanks
- Unsuitable
Water harvesting
Impact Assessment on crops

Amangal Mandal
Mahaboob Nagar Dist.
Andhra Pradesh

Down Stream

16 Feb '00
13 Feb '03

Up Stream

16 Feb '00
13 Feb '03

PRE

POST
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 lithology.

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

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 / REMARKS
- PROBABLE SUCCESS RATE OF WELLS
- REFERENCE NO. OF OBSERVATION WELLS
- GROUND WATER IRRIGATED AREA
- RECHARGE STRUCTURE SUITABLE
- PROBLEMS/ LIMITATIONS

YIELD RANGE

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<tr>
<th>YIELD RANGE</th>
<th>DEPTH RANGE</th>
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<tr>
<td>EXCELLENT &gt;200 lpm</td>
<td>&lt;20 m</td>
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<tr>
<td>GOOD 100-200 lpm</td>
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<td>MODERATE 50-100 lpm</td>
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<tr>
<td>LIMITED 20-50 lpm</td>
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<td>POOR &lt;20 lpm</td>
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<td>NIL</td>
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DEPTH RANGE

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<th>DEPTH RANGE</th>
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<tr>
<td>SHALLOW &lt;20 m</td>
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<tr>
<td>MODERATE 20-80 m</td>
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<td>DEEP &gt;80 m</td>
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PROBLEM AREA

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

NC VILLAGE
Hydro-geomorphological mapping under Rajiv Gandhi National Drinking Water Mission

Prepared through LISS III imagery Interpretation coupled with Field Surveys

Area covering Bijapur & Bagalkot Dts., Karnataka.
LAND RESOURCE ACTION PLAN

- Improved agricultural practices
- Agro-horticulture / Crop rotation
- Gypsum application
- Fodder & Fuel plantation / Development of pasture & grazing
- Plantation / Social forestry
- Silvi-pasture / Afforestation
- No action
CADAstral LEVEL INFORMATION SYSTEM
## GROUND WATER PROSPECTS MAP NANDI HILLS, KARNATAKA

### Ground Water Prospects

<table>
<thead>
<tr>
<th>Yield Range</th>
<th>Depth Range</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Shallow</td>
</tr>
<tr>
<td>Very Good</td>
<td></td>
</tr>
<tr>
<td>Good</td>
<td></td>
</tr>
<tr>
<td>Moderate</td>
<td></td>
</tr>
<tr>
<td>Poor to Limited</td>
<td></td>
</tr>
</tbody>
</table>

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

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

Feasibility Report
Footprint Analysis ...

Detailed Project Report
Implementation Strategy...

Benefit to
Stakeholders
- Socioeconomic
- Natural resources
- Ecological
- Vulnerability reduction....

PRE-ILR

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

POST-ILR

SPACE TECHNOLOGY – Long Distance Water Transport
ENVIRONMENTAL IMPACT ASSESSMENT

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

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

Severity of Land Degradation

Salinity

Mainpuri District (UP)

Sithauli
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.

NADAMS Coverage

States where NADAMS is operational

National Agricultural Drought Assessment and Monitoring System

INDIA
Summary Report

National Remote Sensing Agency
Dept. of Space, Govt. of India
Balanagar, Hyderabad 500037
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

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

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

Spatial Variability of Wheat Crop Calendar

Cropping Pattern

- Wheat
- Oil seed
- Other crops

IRS 1C LISS III FCC
25Feb & 02Mar 1998
• 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 Depletion in Sutlej

03 Feb 2004

27 Mar 2004

15 May 2004

29 Jun 2004
Thank You