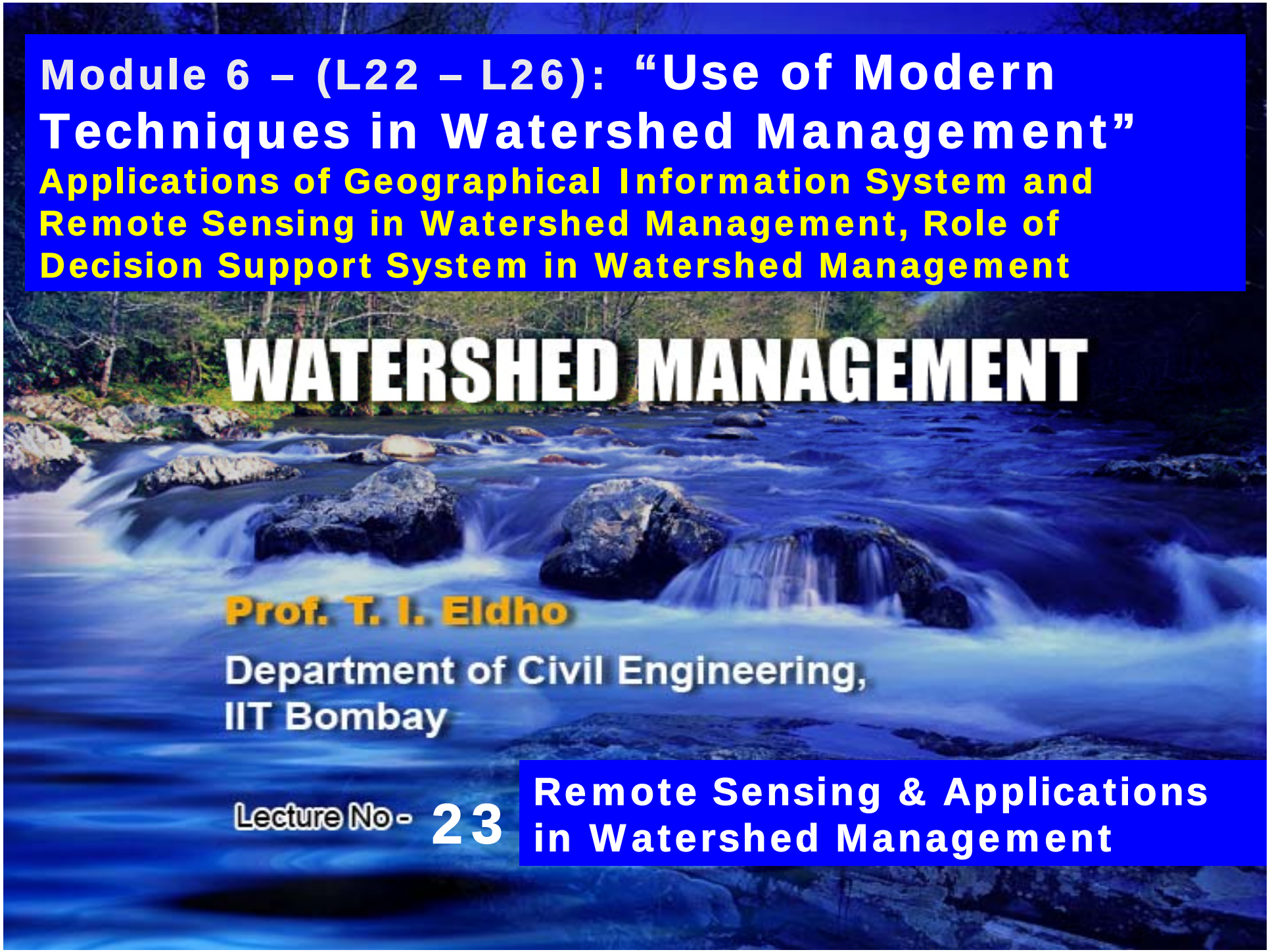
Module 6 – (L22 – L26): "Use of Modern Techniques in Watershed Management"

Applications of Geographical Information System and Remote Sensing in Watershed Management, Role of Decision Support System in Watershed Management



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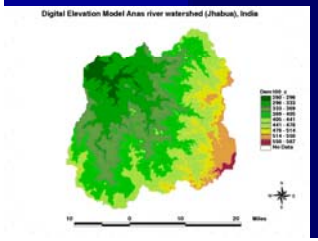
Lecture No - 23

Remote Sensing & Applications in Watershed Management

WATERSHED MANAGEMENT

L23– Remote Sensing & Applications in Watershed Management

- **Topics Covered**
- Remote sensing (RS), Basics, Features of remote sensing, Remote sensing process & advantages, Important satellites, Image processing, Applications of RS in surface water & groundwater, Applications of remote sensing in Watershed Management.
- Keywords: Remote sensing, Features, Image processing, Electromagnetic spectrum, Satellites.



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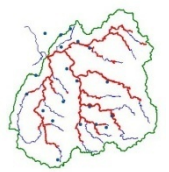
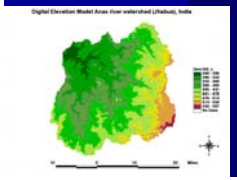


Remote Sensing (RS) - Basics

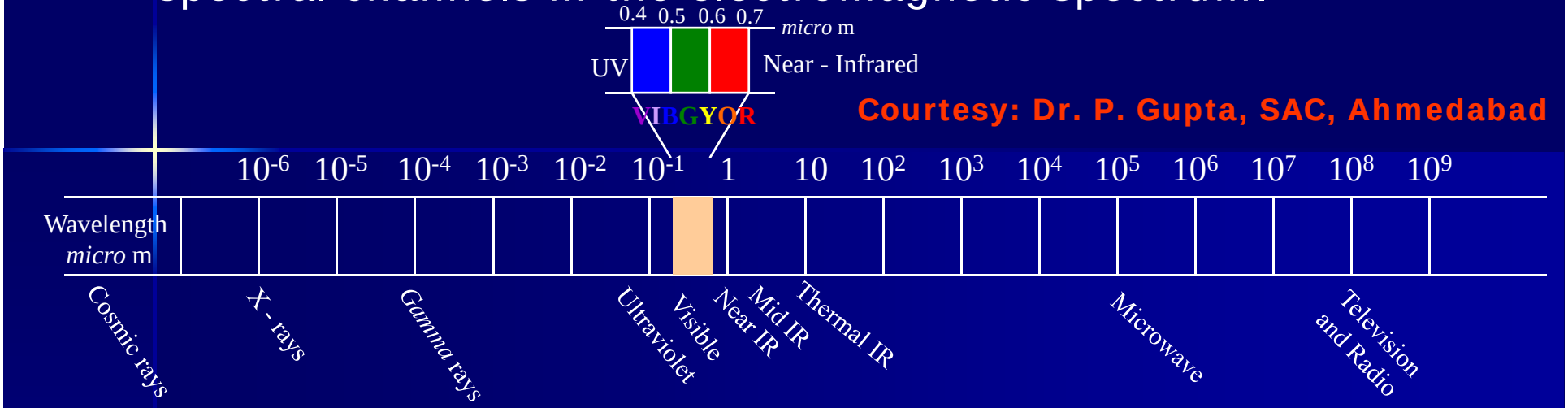
- **What is Remote Sensing? (RS):** Art and science of obtaining information about Earth features from measurements made at a distance.

- RS: Science of making inferences about objects from measurements, made at a distance, without coming into physical contact with the objects under study.'

- Generally 'Remote sensing means sensing of the Earth's surface from space by making use of the properties of electromagnetic wave emitted, reflected or diffracted by the sensed objects, for the purpose of improving natural resource management, land use, & protection of the environment.'



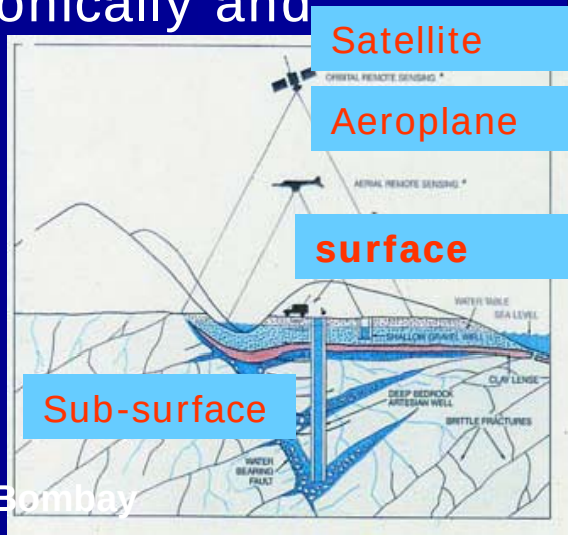
- **Electromagnetic Spectrum -** Bands refers to spectral channels in the electromagnetic spectrum.



Band	Wavelength (*micro* m)	Nominal Spectral Location	Principal Application
1	0.45 - 0.52	Blue	Coastal water mapping, soil / vegetation,
2	0.52 - 0.62	Green	Vegetation discrimination,
3	0.62- 0.69	Red	Chlorophyll absorption region,
4	0.76 - 0.90	Near IR	Vegetation, water body, soil moisture
5	1.55 - 2.35	Mid IR	Moisture content, Snow &Cloud, Mineral & rock discrimination, vegetation moisture content
6	10.4 - 12.5	Thermal IR	Vegetation, Soil moisture discrimination
7	1 cm – 1m	Microwave	Soil moisture

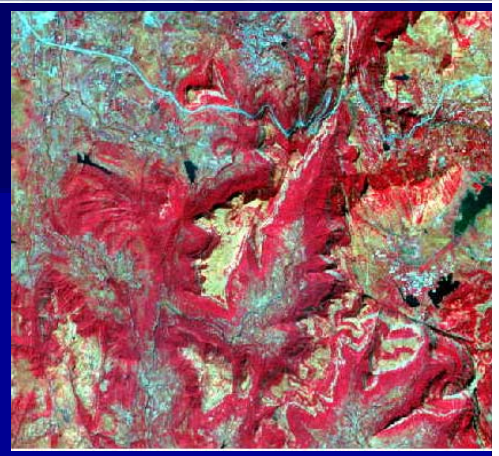
Features of Remote Sensing (RS)

- Remote sensing provides a regional view
- Remote sensing provides repetitive looks at the same area
- Remote sensors "see" over a broader portion of the spectrum than the human eye
- Sensors can focus in on specific bandwidth in an image
- They can also look at a number of bandwidths simultaneously
- Remote sensors often record signals electronically and provide geo-referenced, digital, data
- Some remote sensors operate in all seasons, at night, and in bad weather



Ref: Marwan Koudmani (2004)

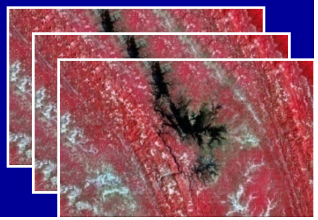
Remote Sensing -Process



- **RS Process:**
- Energy Source
- Energy Interaction with the atmosphere
- Interaction
- Recording of Energy by Sensor
- Data Transmission and Processing
- **Image Processing and Analysis:**
  - Image Restoration / Correction
  - Image Enhancement
  - Image transformation
  - Image Classification (supervised (ground truth)/ unsupervised)
- Applications

Advantages of Remote Sensing

- Advantages: Synoptic view, Temporal
- Multi-disciplinary applications – Land, ocean, atmosphere
- Spatial Resolution: A measure of the smallest angular or linear separation between two objects that can be resolved by the sensor.
- Spectral Resolution: Number & dimension of specific wavelength intervals in the electromagnetic spectrum to which a sensor is sensitive.
- Temporal Resolution: It refers to how often a sensor records imagery of a particular area.
- Radiometric Resolution: sensitivity of a detector to differences in signal strength



Courtesy: Dr. P. Gupta, SAC, Ahmedabad

RS - Some Important Satellites

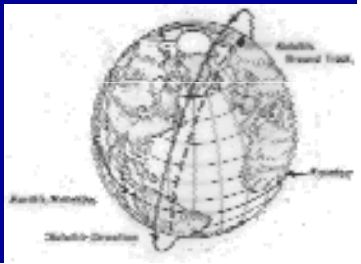
- LANDSAT - A series of satellites put into orbit around the earth to collect environmental data about the earth's surface.
- Various Landsats have had Multispectral Scanners (MSS), Return Beam Vidicon (RBV) scanners, and Thematic Mapper (TM) scanners.
- Each type has its own spectral range and spatial resolution.
- Three important methods of information extraction and interpretation

(i) Photo interpretation

(ii) Spectral analysis

(iii) Data integration

Courtesy: Dr. P. Gupta, SAC, Ahmedabad



RS - Some Important Satellites

- **Topography: Lidar (Airborne Laser Scanning)**

- Highly accurate 1 m DEMs; - High-costs
- Special software and expertise needed

- **Shuttle Radar Topography Mission (SRTM)**

-100 m DEM with almost global coverage; - Free data

- **ERS-1/2 tandem interferometry**

- 30-100 m DEM
- Data from years 1995-98 available for most parts of world
- Accuracy- vary depending on land cover & topography
- Reasonable accuracy (< 10m) for non-vegetated, flat terrain
- Data costs moderate- special software & expertise needed

RS - Some Important Satellites

Vegetation:

- **Lidar:** Airborne laser scanning
  - ✓ Research is still in the beginning
  - ✓ Full-waveform satellite lidars for vegetation mapping have been proposed
  - ✓ High-quality 1m vegetation height models, but expensive for large areas

Synthetic Aperture Radars (SAR) & SAR Interferometry

- Broad vegetation categories can be distinguished
- Not suited at local scale (< 100 m)
- Data costs moderate, need of specialised software and high level of expertise

Remote Sensing – Indian Satellites

- IRS-1A & 1B (1988 & 91) LISS-1&2 (72/36M, 4 BANDS; VIS & NIR)
- IRS-P2 (1994), LISS-2
- IRS-1C (1995) LISS-3 (23/70M, STEERABLE PAN (5.8 M); WiFS (188M)
- IRS-P3 (1996) WiFS MOS X-Ray,
- IRS-1D (1997) LISS-3 (23/70M, STEERABLE PAN (5.8 M); WiFS (188M)
- IRS-P4 (1999) OCEANSAT OCM, MSMR
- RESOURCESAT-1(2004) LISS3 - 23 M; 4 XS LISS4 - 5.8 M; 3-XS, AWIFS - 56 M; 4-XS
- CARTOSAT – 1 PAN - 2.5M, 30 KM, F/A
- CARTOSAT-2, 2A PAN - 1M

RS Applications - Surface Water

- Pure water reflects radiation in the visible bands of the electromagnetic spectrum & absorbs almost all of it in the near- & middle-infrared bands. In the infrared, water appears dark & is easily distinguishable from other land features
- Spectral response of water may vary with the presence suspended sediments, which increase the amount of radiation reflected

(i) Surface runoff modeling of a watershed with land use from remote sensing

- Type of LU/LC significantly affects the runoff characteristics of a watershed.
- The acquisition of land cover information is of significant value to water resources planners.

RS Applications - Surface Water..

(ii) In surface water resource development & management

- RS- data provide catchment characterization -better modeling surface water resource - rainfall runoff ratio
- RS - collects multi-spectral, multi resolution, & multi-temporal data, & turns them into information – LU/LC data sets

(iii) Snow melt runoff

(iv) Mapping and monitoring of surface water bodies

(v) Assessment of Water logging

(vi) Water temperature and other qualities of water

(vii) Detection of depth of shallow water and bed load

(Viii) Physical water quality

RS Applications - Groundwater

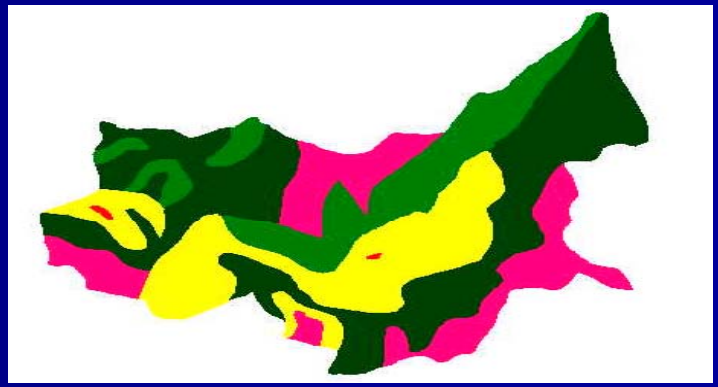
- Groundwater models need spatial and temporal distributions of input and calibration data.
- Patterns from remote sensing can be translated into a deterministic distribution of input data on a cell-by-cell basis or in the form of zones.
- Raw remote-sensing data present spatial patterns
  - ✓ features or processes above the surface (clouds)
  - ✓ on the surface (evapotranspiration)
  - ✓ shallow subsurface (hydraulic conductivity)
- Combination of the pattern information with point information at ground observation stations allows spatial distributions of parameter to be obtained
- RS – identifies lineament, faults, dikes etc.

RS Further Applications

- Climate parameters: Precipitation (using ground based Radars; Satellites images), Snow (fall & melting), Glaciers conditions; Cyclone prediction; Temperature variation; Cloud movement; Drought prediction
- Flood variations
- Vegetation cover type
- Forest management – variation, fire etc.
- Soil moisture (direct & indirect measurement)
- Evapotranspiration assessment
- Agricultural management – cropping pattern
- Desertification – sand, dunes, dust storm
- Ocean applications
- Environmental impact assessment

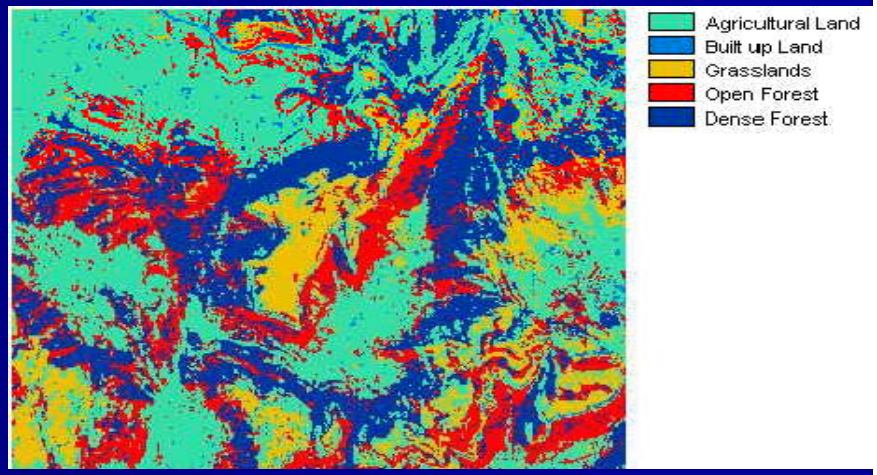
Applications of RS in WM

- Watershed delineation
- Resource mapping
- Identification of erosion-prone areas
- Modeling sediment yield
- Conservation prioritization
- Conservation planning
- Monitoring watershed for environmental impact assessment



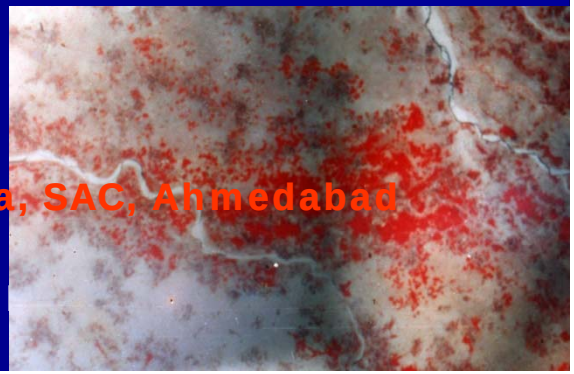
Resource Mapping Using RS

- Enables easy, accurate, time and cost effective mapping
- Updates several resources information such as:
  1. Stream Network Map
  2. Surface Water Map
  3. Land use Map
  4. Vegetation Map
  5. Physiographic Soil Map
  6. Erosion-prone Area Map
  7. Snow Cover Map
  8. Soil Moisture Map
  9. Landform Map
  10. Ground Water Prospect Map



Identification of Erosion-prone Areas

- Facilitates identification of existing or potential erosion prone areas
- Help in planning reclamation or preventive measures
- Based on satellite image, various erosion intensity classes can be assigned: nil to slight, slight, slight to moderate, moderate, moderate to severe and severe can be delineated and mapped
- Wastelands information are also possible using high resolution, multi-spectral and multi-temporal satellite images



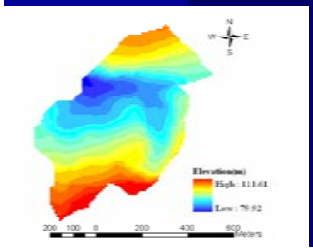
Courtesy: Dr. P. Gupta, SAC, Ahmedabad

Modeling Sediment Yield

- Empirical models are used to estimate sediment yield
- Average annual soil loss and conservation planning for erosion control in agricultural lands, construction sites, reclaimed mines & forest management, since it requires small areas, low cost, short project span and there is little risk of failure.
- These models require input parameters in terms of spatial information on land use, vegetation cover, soil, drainage density, runoff and rainfall intensity which are time consuming and costly by conventional surveys
- Satellite data provide convenient tool to derive these information

Conservation Prioritization in Watershed

- Identification of erosion-prone areas - To evolve appropriate conservation management strategies
- Hence, maximum benefit can be derived out of any such money-time-effort making scheme
- Priority classification – Arrangement of different units of a watershed in decreasing order of their sediment yield potentials
- Arrived through sediment yield modeling and then, provide threshold values through frequency distribution of such data into the priority classes
- Application of remote sensing

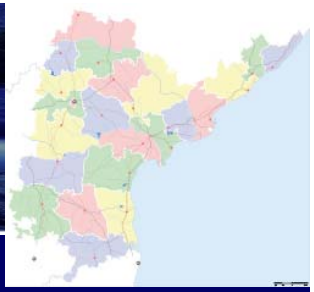


Conservation Planning in Watershed

- One of the key sectors for conservation planning in watershed is rain-water harvesting
- Rain-water harvesting - optimum site selection for constructing check dam & storage of water
- Site investigation needs following resources information:
  - Drainage area & stream network
  - Physiography and relief land use, vegetation and soil
  - Rainfall intensity-duration recurrence interval
  - Water utilization potential (socioeconomic)
  - Watershed management practice
- These resources information can be extracted using remote sensing technique

Monitoring Watershed for EIA

- Water resources development projects are essential for agricultural, industrialization & economic growth of a region
- Large-scale water resources projects may induce adverse impact on environment
- A sound approach for Environmental Impact Assessment (EIA) is required to assist engineers and decision makers
- To choose proper alternative so as to decrease environmental impact due to water resources development
- Monitoring is essential to know adverse impact of water resources development projects & beneficial impact of subsequent watershed management programs.
- This is possible by 'time series analysis' of satellite data of watershed over a period



Case Study: Remote Sensing Application For Management of Water & Land in Prakasam District, AP

- Ref: Padmaja Vuppala et al., (2004) Environmental Informatics Archives, Volume 2 (2004), 885-892
- Racherla mandal of Prakasam district falls under semi–arid zone in peninsular India
- Total area - 670.80Sq.k.m (165759acres)
- Identified as chronically drought affected area in the state with the agro–ecological situation
- Characterized by single crop systems due to predominantly rainfed cultivation with low and erratic rainfall
- Climate is dry, tropical semi-arid type with hot summer during March to May followed by southwest monsoon from June to September

Case Study: Application of RS

- Begins with acquiring the satellite image and topo sheet of the required study area
- The following steps are adopted for the watershed management of Racherla Watershed using Remote Sensing &GIS techniques:

  Step1: Preparation of Drainage map using SOI toposheets and satellite imagery to determine the Drainage pattern and for calculating various drainage characteristics like density, basin slope etc.

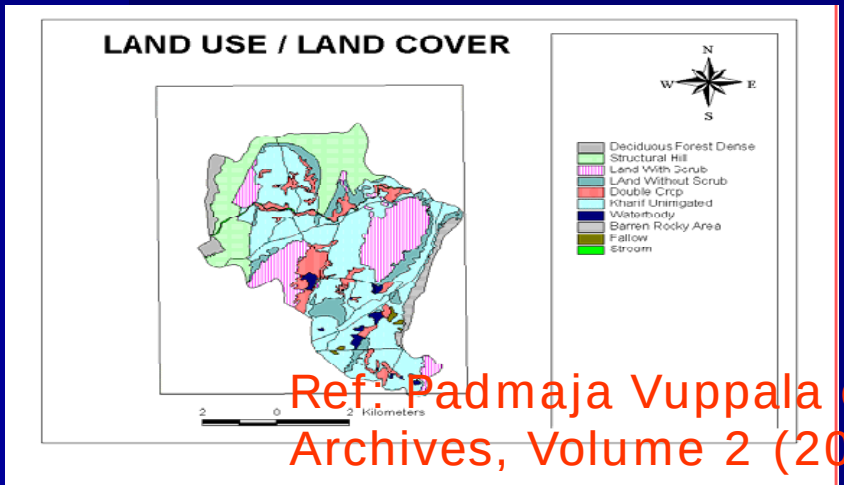
  Step2: Preparation of land use/land cover map using SOI toposheets and satellite imagery to know the various uses of the land. This may also used to find the area of cropland, Watershed etc.

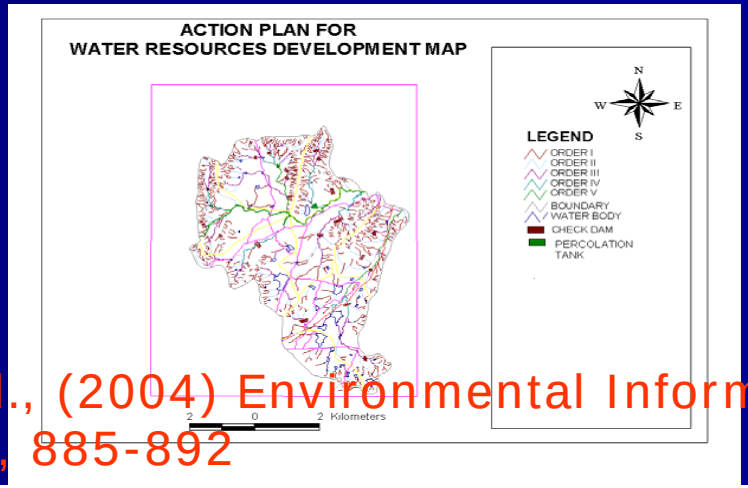
Case Study: Application of RS

Step3: Preparation of hydro geomorphology map using SOI toposheets and satellite imagery which is used for finding the groundwater prospects and suggest water-harvesting structures.

Step 4: Preparation of slope map using SOI toposheets to know the terrain properties.

Step 5: A GIS digital system, ARC/INFO is used for input and manipulation, and creation of error free digital database for all the natural resources.





Ref: Padmaja Vuppala et al., (2004) Environmental Informatics Archives, Volume 2 (2004), 885-892

Case Study: Application of RS

Step 6: Depending on the combination of above mentioned resources themes, action plans for land and water resources and treatment plans for catchments area are generated for the development of the watershed.

Step 7: Depending on the soils, climate, local practices & also keeping in view the long term market prospects, cropping patterns are determined based on crop water requirement in view of water availability.

- All the above steps aim for optimum development of land & water resources to meet the basic minimum needs of people thereby improving their socio-economic conditions.
- The information generated from such studies can be used by decision makers for sustainable development.

RS Applications – Concluding Remarks

- Remote Sensing data could be assessed without restrictions in many cases.
- The advantage of RS data is that it is not biased and is available shortly after satellite overpass.
- Special purpose RS products that can directly support various watershed management projects are:

  (i) hydrology,

  (ii) water accounting,

  (iii) disaster management,

  (iv) irrigation management,

  (v) wetland management,

  (vi) watershed management and

  (vii) land degradation

References

- J.V.S Murthy (1991), Watershed Management, New Age Int. Pub. http://www.esa.int/esaLP/ESAMBA2VMOC_LPsmos_1.html
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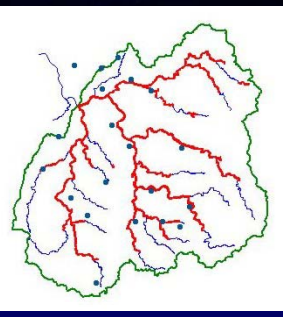
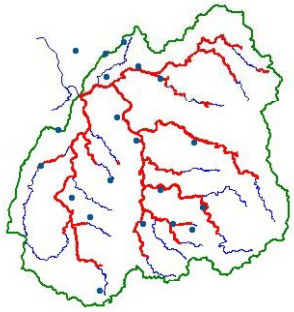


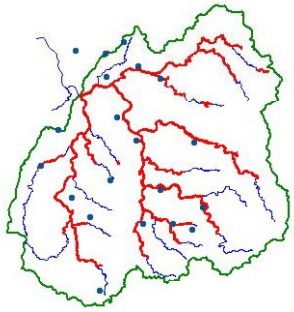
Tutorials - Question!.?.

- Critically study various Remote sensing satellites available (eg. Landsat, IRS etc.) and its capabilities, resolution of images etc (details can be obtained from Internet).
- Evaluate the capabilities of each Satellite for watershed management plans.
- Explore how effectively the Remote sensing data can be used for the development of watershed management plans.



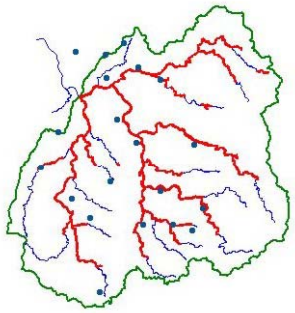
Self Evaluation - Questions!.

- Discuss the basics of remote sensing?. How the remote sensing data is obtained?.
- What are the important features of remote sensing?.
- What are the advantages of remote sensing for various problems?.
- Describe about the Indian Satellites available for remote sensing.
- What are the important applications of remote sensing for groundwater related problems?.
- Describe the various applications of remote sensing for watershed management/ development problems.



Assignment- Questions?.

- Discuss the evolution in remote sensing for the last 10 decades?.
- Explain the range of electromagnetic spectrum used for remote sensing.
- Discuss the various steps in remote sensing & image processing.
- Discuss the details about important satellites available for remote sensing in various countries.
- What are the important applications of remote sensing for surface water related problems?.
- What are the important applications of remote sensing related to atmospheric/ climate related studies?.



Unsolved Problem!.

- From ASTER (http://asterweb.jpl.nasa.gov/)/ SRTM (http://srtm.usgs.gov/index.php) / BHUVAN/ IRS (http://bhuvan.nrsc.gov.in/bhuvan_links.html), obtain the remote sensing image of your watershed. Delineate the watershed area.
- Based on Topo sheet and images & other available data, generate DEM, LU/LC map, slope map, soil map etc.
- Explore how effectively the remote sensing data can be used for watershed management plans.

WATERSHED MANAGEMENT

THANK YOU

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