Lecture On

Introduction to Remote Sensing and GIS

Training Course on
‘Coastal Vulnerability Mapping and Analysis’

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REMOTE SENSING

• SCIENCE OF MAKING INFERENCES ABOUT OBJECTS FROM MEASUREMENTS MADE WITHOUT ACTUAL PHYSICAL CONTACT WITH THE OBJECTS

• ANY FORCE FIELD - GRAVITY, MAGNETIC OR ELECTROMAGNETIC - COULD BE USED FOR REMOTE SENSING IN VARIOUS DISCIPLINES, FROM ASTRONOMY TO MATERIAL TESTING

• MORE COMMONLY, REMOTE SENSING IS ASSOCIATED WITH EARTH FEATURES IDENTIFICATION BY DETECTING AND RECORDING ELECTROMAGNETIC RADIATION REFLECTED OR EMMETTED FROM EARTH’S SURFACE AND ATMOSPHERE
Introduction

Remote Sensing is the science of

- Acquiring
- Processing and
- Interpreting

images and related data obtained from aircrafts and satellites that record the interaction between matter and electromagnetic radiation
Energy Interactions

- Scattered by Atmosphere
- Absorbed by Atmosphere
- Reflected Solar Radiation
- Emitted Surface Radiation
- Absorbed by Ground Surface
Data Collection Platforms

Satellite

High Altitude

Low Altitude

Ground Observation
**Principle**

» Detection and discrimination of objects means detecting and recording of radiant energy reflected or emitted by objects.

» Different objects return different amount and kind of energy in different bands of EMR.

» This unique property depends on the property of the material (Structural, Chemical and Physical), Surface roughness, Angle of incidence, Intensity and Wavelength radiant energy.

*Fig. 4 Spectral responses of a few common features*
The diagram illustrates the spectrum of electromagnetic radiation, from radio waves to gamma rays, with specific labels for different regions such as near infrared, visible light, and ultraviolet. The diagram also indicates the wavelength range for each region, with 1 micron equal to 10^-6 meter. The ERS1 and LANDSAT TM Bands are highlighted, showing the bands used in these satellite systems.
Atmospheric Windows

Transmission

Absorption
Types of satellite orbits

Geostationary
- Constant view of hemisphere
- 35,800 km

Polar
- Sun-synchronous
- Covers entire Earth
- 700-900 km
Polar Orbit – Earth Observation Satellites
Remote Sensing - Why?

- Synoptic coverage
- Repetitivity
- Inaccessible Area Coverage
- Information in Spatial Domain
- Data Quantifiable
- Large Archives of Historical data

Himalayas as seen by IRS
SENSOR:

IT IS DEVICEC THAT GATHER ENERGY (EMR), CONVERT IT INTO A SIGNAL AND PRESENT IT IN A FORM SUITABLE FOR ODTAING INFORMATION ABOUT THE TARGET UNDER INVESTIGATION

THESE MAY BE ACTIVE OR PASSIVE DEPENDING ON THE SOURCE OF ENERGY
Sensor Types

PASSIVE SENSOR

ACTIVE SENSOR

Image Provided Courtesy of the Canada Centre for Remote Sensing
IRS 1C/1D LISS III

SPECIFICATIONS:
• SPATIAL RESOLUTION (m) : 23.5 70.5
• SWATH (Km) : 141 148
• SPECTRAL BANDS (mm) : 0.52-0.59 0.62-0.68 0.77-0.86 1.55-1.70
• REPETIVITY (days) : 24

APPLICATIONS:
► SIGNIFICANT IMPROVEMENT IN THE SEPERABIL-ITY AMONGST VARIOUS CROPS & VEGETATION LEADING TO IDENTIFICATION OF SMALL FIELDS AND BETTER CLASSIFICATION ACCURACY
► SWIR BAND TO STUDY CROP CANOPY WATER STATUS AND ESTIMATION OF LAI
► PREPARATION OF MAPS ON 1:50000 SCALE
IRS 1C/1D PAN

SPECIFICATIONS
SPATIAL RESOLUTION (m) : 5.8
SWATH (Km) : 70
SPECTRAL BAND (mm) : 0.5-0.75
REPETIVITY (days) : 5

APPLICATIONS:

- ENHANCED TOPOGRAPHIC FEATURE IDENTIFICATION
- STEREO CAPABILITY
- GENERATION OF ELEVATION CONTOURS OF SMALLER INTERVALS AND DIGITAL ELEVATION MODELS
- PREPARATION OF MAPS ON 1:12,500 SCALE
- CADAstral LEVEL MAPPING
**WiFS (Wide Field Sensor)**

**SPECIFICATIONS**
- Spatial Resolution (m): 188.3
- Swath (Km): 810
- Spectral Band (mm): 0.62-0.68 and 0.77-0.86
- Repetivity: 5 days

**APPLICATIONS:**
- Early crop acreage estimation for monocropped regions
- Monitoring crop vigour and health, cropping pattern, crop rotation, progress of harvest etc.
- Generation of spectral growth profiles at almost every stage of crop
- Regional level mapping
IRS P4 (OCM)

SPECIFICATIONS

• SPATIAL RESOLUTION (m) : 188.3
• SWATH (Km) : 1500
• SPECTRAL BAND (mm) : 0.40 – 0.88
• REPETIVITY (days) : 2

APPLICATIONS:

- Retrieval of chlorophyll-a concentration
- Retrieval of Total Suspended Matter concentration
- Retrieval of Yellow substance
- Coastal environmental studies
- To delineate Potential Fishing Zone
- National Level Mapping
Resolution

Resolution is a broad term, four types of resolutions are considered in Remote Sensing

- **Spectral**
  Specific wavelength intervals that a sensor can record

- **Spatial**
  Area on the ground represented by each pixel

- **Radiometric**
  Number of possible data file values in each band (indicated by the number of bits into which the recorded energy is divided)

- **Temporal**
  How often a sensor obtains imagery of a particular area
Instantaneous Field of View (IFOV) determines the dimension, D, of the Ground Resolution Cell (GRC) imaged on the ground.

1m, 3m, 10m
Spatial Resolution

Spatial resolution is a measure of the smallest object that can be resolved by the sensor, or the area on the ground represented by each pixel. The finer the resolution, the lower the number. For instance, spatial resolution of 79 meters is coarser than spatial resolution of 10 meters.
### Spectral Resolution

Spectral Resolution refers to the specific wavelength intervals in the electromagnetic spectrum that a sensor can record.

<table>
<thead>
<tr>
<th>Band</th>
<th>Wavelength</th>
<th>Comments</th>
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</thead>
<tbody>
<tr>
<td>1. Blue</td>
<td>0.45 to 0.52 nm</td>
<td>mapping coastal water areas, differentiating soil and vegetation, forest type mapping.</td>
</tr>
<tr>
<td>2. Green</td>
<td>0.52 to 0.62 nm</td>
<td>This band corresponds to the green reflectance of healthy vegetation.</td>
</tr>
<tr>
<td>3. Red</td>
<td>0.63 to 0.69 nm</td>
<td>for discriminating between many plant species and determining soil boundary and geological boundary delineations.</td>
</tr>
<tr>
<td>4. NIR</td>
<td>0.76 to 0.90 nm</td>
<td>This band is responsive to the amount of vegetation biomass present, useful for crop identification.</td>
</tr>
<tr>
<td>5. MIR</td>
<td>1.55 to 1.75 nm</td>
<td>Useful to study plant water content, crop drought studies, and to discriminate among cloud, ice and snow.</td>
</tr>
<tr>
<td>6. TIR</td>
<td>10.40 to 12.50 nm</td>
<td>for vegetation and crop stress detection, heat intensity, insecticide application, and for locating thermal pollution.</td>
</tr>
<tr>
<td>7. MIR</td>
<td>2.08 to 2.35 nm</td>
<td>This band is important for the differentiation of geologic rock types.</td>
</tr>
</tbody>
</table>
Spectral bands - 8 bit data

Spectral (where we look)

Radiometric (how finely can we measure the return)

0-63, 0-255, 0-1023
Radiometric Resolution

Radiometric resolution refers to the dynamic range of possible data file values in each band. This is referred to by the number of bits into which the recorded energy is divided. For instance in 8-bit data, the data file values ranges from 0-255 for each pixel, but in 7-bit data, the data file values for each pixel range 0 to 128.

6 bit = 0-63,
8 bit = 0-255,
10 bit = 0-1023
Temporal Resolution

Temporal resolution refers to how often a sensor obtains imagery of a particular area. For example, the Landsat satellite can view the same area of the globe once every 16 days. IRS, on the other hand revisits the same area every 24 days. Temporal resolution is an important factor to consider in change detection studies.

As spatial resolution increases, the revisit time is also increased, as are the applications that are appropriate and the cost.
Steerable Camera – Stereovision
NATIONAL SPACE SYSTEMS

LAUNCH VEHICLES

INSAT

IRS
<table>
<thead>
<tr>
<th>Serial No.</th>
<th>Satellite</th>
<th>Date of Launch</th>
<th>Launch Vehicle</th>
</tr>
</thead>
<tbody>
<tr>
<td>IRS P6 (Resourcesat-1)</td>
<td>17 October 2003</td>
<td>PSLV-C5</td>
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<tr>
<td>IRS P5 (Cartosat1)</td>
<td>5 May 2005</td>
<td>PSLV-C6</td>
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<tr>
<td>IRS P7 (Cartosat2)</td>
<td>10 January 2007</td>
<td>PSLV-C7</td>
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<tr>
<td>Cartosat2A</td>
<td>28 April 2008</td>
<td>PSLV-C9</td>
<td></td>
</tr>
<tr>
<td>IMS 1</td>
<td>28 April 2008</td>
<td>PSLV-C9</td>
<td></td>
</tr>
<tr>
<td>Oceansat-2</td>
<td>23 September 2009</td>
<td>PSLV-C14</td>
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<tr>
<td>Cartosat-2B</td>
<td>12 July 2010</td>
<td>PSLV-C15</td>
<td></td>
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<tr>
<td>Resourcesat-2</td>
<td>20 April 2011</td>
<td>PSLV-C16</td>
<td></td>
</tr>
<tr>
<td>Megha Tropiques</td>
<td>12 October 2011</td>
<td>PSLV-C18</td>
<td></td>
</tr>
<tr>
<td>RISAT-1</td>
<td>26 April 2012</td>
<td>PSLV-C19</td>
<td></td>
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<tr>
<td>SARAL</td>
<td>25 Feb 2013</td>
<td>PSLV-C20</td>
<td></td>
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<tr>
<td>RESOURCESAT-2A</td>
<td>07 Dec 2016</td>
<td>PSLV-C36</td>
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<tr>
<td>Cartosat-2D</td>
<td>15 Feb 2017</td>
<td>PSLV-C37</td>
<td></td>
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<tr>
<td>Cartosat-2E</td>
<td>23 June 2017</td>
<td>PSLV-C38</td>
<td></td>
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<tr>
<td>Cartosat-2F</td>
<td>12 Jan 2018</td>
<td>PSLV-C40</td>
<td></td>
</tr>
</tbody>
</table>
Natural colour image

Screen: Satellite bands:

- Red
- Green
- Blue
MUMBAI AS SEEN BY IRS 1C PAN

IRS IMAGE
OVER MUMBAI
Landsat TM

Landsat 4 Launched 1983
Upgraded instrument

- Landsat Thematic Mapper (TM)
- Seven bands - Blue, Green, Red, NIR, SWIR x 2, TIR
- 30m ground resolution
- 185Km swath
- Landsat 7 launched 1999
- Additional 5m panchromatic
SPOT

- Multi-spectral
- MS - 3 bands
- Green, Red, NIR
- Twenty meters resolution
- PAN - 1 band
- 10m resolution
Shola vegetation

‘ISLANDS OF EVERGREEN’ VEGETATION FOUND IN REGIONS ABOVE 1400 M ALTITUDE SURROUNDED BY GRASSLANDS

Brahmmagiri
Evergreen Forest

FOREST WITH TALL TREES AND DENSE CROWNS COMPOSED OF EVERGREEN SPECIES.
Semi Evergreen

ASSOCIATION OF EVERGREEN AND DECIDUOUS SPECIES DOMINATED BY EVERGREEN SPECIES

Tadiandamol
Moist Deciduous

Devamachi

Patches dominated by Deciduous species with few evergreen species
Coffee Plantation

Virajpet
Rubber

Portland Estate, Makut
Scrub Forest

FOUND IN LOW RAINFALL AREA DOMINATED BY THORNY AND XEROPHYTIC SPECIES
Lincoln Memorial, Washington

First IKONOS image
Introduction to GIS
What is GIS?

“GIS System, Science and Studies”

Geographical information system

GIS is an organized collection of computer hardware, software & geographic data designed to efficiently capture, store, manipulate, analyze and display all forms of geographically referenced information.

A working GIS integrates five key components involved in managing and processing geographic information.

- Hardware
- Software
- Data
- People
- Workflow
Historical Setting and GIS Evolution

Traditional Mapping
manually drafted map

Computer Mapping
automates the cartographic process (70s)

Spatial Database Management
links computer mapping techniques with
traditional database capabilities (80s)

GIS Modeling
representation of relationships within and among mapped data (90s)

Virtual GIS (city models)
GIS – A New Language for Geography

Introducing New Concepts and Methods

... Building on the Theories of Geography

Complex Data Modeling
Interactive Mapping
Integrating Data
Geoprocessing
Visualization
Modeling
Input Geographical Data

**Spatial Information:** Representing geographical feature (Location and shape) associated with the real world locations and their relationship to other features.

**Representations of the spatial Information:** Geographical features are depicted on map by Point, Line & Polygon.

<table>
<thead>
<tr>
<th>Name</th>
<th>Distance (km) From-To</th>
<th>Bearing (deg)</th>
<th>Depth (mtr) From-To</th>
<th>Latitude (dnm)</th>
<th>Longitude (dms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sarjekot</td>
<td>18-23</td>
<td>250</td>
<td>36-41</td>
<td>16 1 0 N</td>
<td>73 17 12 E</td>
</tr>
<tr>
<td>Vasai</td>
<td>72-77</td>
<td>260</td>
<td>36-41</td>
<td>19 14 1 N</td>
<td>72 8 9 E</td>
</tr>
<tr>
<td>Dongi Point</td>
<td>55-60</td>
<td>262</td>
<td>39-44</td>
<td>17 47 8 N</td>
<td>72 22 14 E</td>
</tr>
<tr>
<td>Anjarik</td>
<td>76-81</td>
<td>265</td>
<td>34-45</td>
<td>72 24 55 E</td>
<td></td>
</tr>
<tr>
<td>Kolibare</td>
<td>58-63</td>
<td>267</td>
<td>40-45</td>
<td>72 34 55 E</td>
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<tr>
<td>Veasna</td>
<td>42-47</td>
<td>274</td>
<td>23-28</td>
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<td>Amalapada</td>
<td>78-83</td>
<td>260</td>
<td>36-41</td>
<td>72 1 9 E</td>
<td></td>
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<tr>
<td>Hume</td>
<td>61-66</td>
<td>264</td>
<td>42-47</td>
<td>72 30 50 E</td>
<td></td>
</tr>
<tr>
<td>Sindhutung (Mahara)</td>
<td>16-21</td>
<td>223</td>
<td>30-35</td>
<td>73 20 25 E</td>
<td></td>
</tr>
<tr>
<td>Kolad</td>
<td>90-95</td>
<td>259</td>
<td>67-72</td>
<td>72 13 20 E</td>
<td></td>
</tr>
<tr>
<td>Mange</td>
<td>41-46</td>
<td>243</td>
<td>62-67</td>
<td>73 4 44 E</td>
<td></td>
</tr>
<tr>
<td>Aish Pt</td>
<td>26-31</td>
<td>244</td>
<td>45-59</td>
<td>73 12 6 E</td>
<td></td>
</tr>
<tr>
<td>Kadgaon</td>
<td>110-115</td>
<td>237</td>
<td>94-99</td>
<td>72 5 25 E</td>
<td></td>
</tr>
</tbody>
</table>

**Non-spatial information:** Descriptive information about the characteristics of the Feature.

**Representation of non-spatial (Attribute) information:** consists of description on the properties associated with geographical entities. Attributes are stored as a set of numbers and characters in the form of a table. Many attribute data files can be linked together through the use of common identifier code.
Capabilities Of GIS

Major capabilities of GIS are:

Cartographic capability allows accurate maps and engineering drawing to be produced efficiently. This capability includes digitizing (converting analog products to digital form), graphic display generation, interactive graphic manipulation (e.g. add, modify, delete, create window) and plotting.

Data management capability enables the efficient storage and manipulation of geographic data, both graphic and non-graphic. Storage and retrieval of non-geographic data is linked to graphic images. It is sometimes called Attribute Processing. Attribute processing can select data and produce graphic and reports on the basis of attribute value.

Analytical capability permits sophisticated processing and interpretation of spatial data. Collectively, these capabilities give managers an enhanced ability to manipulate and use data more effectively. Graphic representations are especially powerful for conveying information.

Decision Support system for application based analysis and serves at the management, operations, and planning levels.
Data storage type in GIS

Raster Data:
Raster data type consists of rows and columns of cells, with each cell storing a single value. Raster data can be images (raster images) with each pixel (or cell) containing a color value.

Vector Data:
Points: A point is defined by a single pair of coordinate values.

Polylines: A line is defined by a sequence of coordinate pairs defining the points through which the line is drawn.

Polygon: An area is defined in a similar way, only with the first and last points joined to make a complete enclosure.
## Raster v/s Vector

<table>
<thead>
<tr>
<th>Advantages of Raster Data</th>
<th>Disadvantages of Raster Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simple data structure, Sampling is done uniformly (Uniform resolution).</td>
<td>Huge volume of data (Though may be reduced by coding).</td>
</tr>
<tr>
<td>Spatial analysis is easier and faster.</td>
<td>Fitness of data is limited by cell size.</td>
</tr>
<tr>
<td>Data are acquired in that form -Remote</td>
<td>Less appreciable output.</td>
</tr>
<tr>
<td>Most common format (for data interchange).</td>
<td>Projection transformations are time-consuming.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Advantages of Vector Data</th>
<th>Disadvantages of Vector Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less storage.</td>
<td>Overlay based on criteria difficult.</td>
</tr>
<tr>
<td>Editing is faster and convenient.</td>
<td>Spatial analysis is cumbersome.</td>
</tr>
<tr>
<td>Estimation of area / perimeter is accurate.</td>
<td></td>
</tr>
<tr>
<td>Network analysis is faster.</td>
<td></td>
</tr>
<tr>
<td>Projection transformations are easier.</td>
<td></td>
</tr>
</tbody>
</table>
Coordinates & Projections

Coordinate system
A coordinate system is a reference system used to represent the locations of geographic features, imagery, and observations.

Geographic coordinate systems
• A geographic coordinate system (GCS) uses a 3-D spherical surface to define locations on the earth.
• A point is referenced by its longitude and latitude values.

Projected coordinate systems
A projected coordinate system (PCS) is defined on a flat, two-dimensional surface. A PCS includes a map projection, a set of projection parameters that customize the map projection for a particular location, and a linear unit of measure.
Map Projections

Projections are a mathematical transformation that take spherical coordinates (latitude and longitude) and transform them to an XY (planar) coordinate system.

This enables you to create a map that accurately shows distances, areas, or directions. With this information, you can accurately work with the data to calculate areas and distances and measure directions.
Benefits of Using GIS

- Automation (Cost Savings)
- Better Data Management (More Efficient Storage and Updating)
- Faster Information Access (Better Decisions)
- Operational Efficiencies
- New Applications

**Why is GIS so important?**

- GIS offers a consistent framework for analysing geographical data
- GIS allows us to manipulate, analyse, display geographical knowledge in new ways
- It can add additional value to existing information
- Integrates spatial and other types of information
## GIS Software – Free and Open Source Products

<table>
<thead>
<tr>
<th>Software</th>
<th>Links</th>
</tr>
</thead>
<tbody>
<tr>
<td>GRASS</td>
<td><a href="http://grass.itc.it/">http://grass.itc.it/</a></td>
</tr>
<tr>
<td>Quantum GIS</td>
<td><a href="http://qgis.org">http://qgis.org</a></td>
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<tr>
<td>GvSIG</td>
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<td>OpenEV</td>
<td><a href="http://openev.sourceforge.net/">http://openev.sourceforge.net/</a></td>
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<tr>
<td>Mapserver</td>
<td><a href="http://mapserver.gis.umn.edu/">http://mapserver.gis.umn.edu/</a></td>
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<tr>
<td>GeoDA</td>
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<tr>
<td>SurfIT</td>
<td><a href="http://surfit.sourceforge.net/">http://surfit.sourceforge.net/</a></td>
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<tr>
<td>GDAL/OGR</td>
<td><a href="http://www.gdal.org/">http://www.gdal.org/</a></td>
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<td>OpenMAP</td>
<td><a href="http://openmap.bbn.com/">http://openmap.bbn.com/</a></td>
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<tr>
<td>PostGIS</td>
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Thank you