5. OBSERVATION

- General
- Images & Its Characteristics
- Applications Of Remote Sensing
- Remote Sensing: Indian Program
CHAPTER 5: REMOTE SENSING

5.1 General

Definition
“Remote Sensing is the science and art of acquiring information (spectral, spatial, temporal) about material objects, area, or phenomenon, without coming into physical contact with the objects, or area, or phenomenon under investigation”.

The sensing device mounted on an aircraft or on satellite platforms observes physical emanations, such as electromagnetic radiation, from the target. Nowadays satellite is used as the sensing device mostly.

Elements Involved In Remote Sensing
In remote sensing process, it involves an interaction between incident radiation and the targets of interest. This is explained by the following seven elements are involved. However that remote sensing also involves the sensing of emitted energy and the use of non-imaging sensors.
1. Energy Source or Illumination (A) - The first requirement for remote sensing is to have an energy source which illuminates or provides electromagnetic energy to the target of interest.

2. Radiation and the Atmosphere (B) - As the energy travels from its source to the target, it will come in contact with and interact with the atmosphere it passes through. This interaction may take place a second time as the energy travels from the target to the sensor.

3. Interaction with the Target (C) - Once the energy makes its way to the target through the atmosphere, it interacts with the target depending on the properties of both the target and the radiation.

4. Recording of Energy by the Sensor (D) - After the energy has been scattered by, or emitted from the target, one require a sensor
(remote - not in contact with the target) to collect and record the electromagnetic radiation.

5. **Transmission, Reception, and Processing (E)** - The energy recorded by the sensor has to be transmitted, often in electronic form, to a receiving and processing station where the data are processed into an image (hardcopy and/or digital).

6. **Interpretation and Analysis (F)** - The processed image is interpreted, visually and/or digitally or electronically, to extract information about the target, which was illuminated.

7. **Application (G)** - The final element of the remote sensing process is achieved when one apply the information, which one is able to extract from the imagery about the target in order to better understand it, reveal some new information, or assist in solving a particular problem.

**Bands Used in Remote Sensing**

Emission of EMR (Electro-Magnetic Radiation) from gases is due to atoms and molecules in the gas. Atoms consist of a positively charged nucleus surrounded by orbiting electrons, which have discrete energy states. Transition of electrons from one energy state to the other leads to emission of radiation at discrete wavelengths. The wavelengths, which are emitted by atoms/molecules, are also the ones, which are absorbed by them. Emission from solids and liquids occurs when they are heated and
results in a continuous spectrum. This is called thermal emission and it is an important source of EMR from the viewpoint of RS.

The Electro-Magnetic Radiation (EMR) is the usual source of RS data. However, any medium, such as gravity or magnetic fields, can be used in Remote Sensing. Remote Sensing Technology makes use of the wide range Electro-Magnetic Spectrum (EMS) from a very short wave "Gamma Ray" to a very long 'Radio Wave'. Wavelength regions of electro-magnetic radiation have different names ranging from Gamma ray, X-ray, Ultraviolet (UV), Visible light, Infrared (IR) to Radio Wave, in order from the shorter wavelengths. The optical wavelength region, an important region for Remote Sensing applications, is further subdivided as follows:

<table>
<thead>
<tr>
<th>Name</th>
<th>Wavelength (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optical wavelength</td>
<td>0.30-15.0</td>
</tr>
<tr>
<td>Reflective</td>
<td></td>
</tr>
<tr>
<td>1. Portion Visible</td>
<td>0.38-3.00</td>
</tr>
<tr>
<td>2. Near IR</td>
<td>0.38-0.72</td>
</tr>
<tr>
<td>3. Middle IR</td>
<td>0.72-1.30</td>
</tr>
<tr>
<td>Far IR (Thermal, Emissive)</td>
<td>1.30-3.00</td>
</tr>
<tr>
<td></td>
<td>7.00-15.0</td>
</tr>
</tbody>
</table>

*Table 5.1 wavelengths for Remote Sensing application*

Microwave region (1mm to 1m) is another portion of EM spectrum that is frequently used to gather valuable RS information.
**Satellite Orbits**

A satellite follows a generally elliptical orbit around the earth. The time taken to complete one revolution of the orbit is called the **orbital period**. The satellite traces out a path on the earth surface, called its **ground track**, as it moves across the sky. As the earth below is rotating, the satellite traces out a different path on the ground in each subsequent cycle. Remote sensing satellites are often launched into special orbits such that the satellite repeats its path after a fixed time interval. This time interval is called the **repeat cycle** of the satellite.

![The electromagnetic spectrum](image)
Geostationary Orbits

If a satellite follows an orbit parallel to the equator in the same direction as the earth's rotation and with the same period of 24 hours, the satellite will appear stationary with respect to the earth surface. This orbit is a geostationary orbit. Satellites in the geostationary orbits are located at a high altitude of 36,000 km. These orbits enable a satellite to always view the same area on the earth. A large area of the earth can also be covered by the satellite. The Geostationary orbits are commonly used by meteorological satellites e.g. INSAT series.

Near Polar Orbits

A near polar orbit is one with the orbital plane inclined at a small angle with respect to the earth's rotation axis. A satellite following a properly designed near polar orbit passes close to the poles and is able to cover nearly the whole earth surface in a repeat cycle.
**Sun Synchronous Orbits**

Earth observation satellites usually follow the sun synchronous orbits. A sun synchronous orbit is a near polar orbit whose altitude is such that the satellite will always pass over a location at a given latitude at the same local solar time. In this way, the same solar illumination condition (except for seasonal variation) can be achieved for the images of a given location taken by the satellite e.g. IRS – 1A, 1B, 1C, 1D etc.

As a satellite revolves around the Earth, the sensor "sees" a certain portion of the Earth's surface. The area imaged on the surface, is referred to as the swath. Imaging swaths for space borne sensors generally vary between tens and hundreds of kilometers wide. As the satellite orbits the Earth from pole to pole, its east-west position wouldn't change if the Earth didn't rotate. However, as seen from the Earth, it seems that the satellite is shifting westward because the Earth is rotating (from west to east) beneath it. This
apparent movement allows the satellite swath to cover a new area with each consecutive pass. The satellite's orbit and the rotation of the Earth work together to allow complete coverage of the Earth's surface, after it has completed one complete cycle of orbits.

If one starts with any randomly selected pass in a satellite's orbit, an orbit cycle will be completed when the satellite retraces its path, passing over the same point on the Earth's surface directly below the satellite (called the nadir point) for a second time. The exact length of time of the orbital cycle will vary with each satellite. The interval of time required for the satellite to complete its orbit cycle is not the same as the "revisit period". The revisit period is an important consideration for a number of monitoring applications, especially when frequent imaging is required (for example, to monitor the spread of an oil spill, or the extent of flooding). In near-polar orbits, areas at high latitudes will be imaged more frequently than the equatorial zone due to the increasing overlap in adjacent swaths as the orbit paths come closer together near the poles.

Figure 5.6 The swaths & Orbit paths around the world
Platforms

The vehicles or carriers for remote sensors are called the platforms. Typical platforms are satellites and aircraft, but they can also include radio-controlled aeroplanes, balloons kits for low altitude RS, as well as ladder trucks or 'cherry pickers' for ground investigations. The key factor for the selection of a platform is the altitude that determines the ground resolution and which is also dependent on the instantaneous field of view (IFOV) of the sensor on board the platform.

<table>
<thead>
<tr>
<th>Features</th>
<th>Landsat1,2,3</th>
<th>Landsat 4,5</th>
<th>SPOT</th>
<th>IRS-IA</th>
<th>IRS-IC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nature</td>
<td>Sun Sys</td>
<td>Sun Sys</td>
<td>Sun Sys</td>
<td>Sun Sys</td>
<td>Sun Sys</td>
</tr>
<tr>
<td>Altitude (km)</td>
<td>919</td>
<td>705</td>
<td>832</td>
<td>904</td>
<td>817</td>
</tr>
<tr>
<td>Orbital period (minutes)</td>
<td>103.3</td>
<td>99</td>
<td>101</td>
<td>103.2</td>
<td>101.35</td>
</tr>
<tr>
<td>Inclination (degrees)</td>
<td>99</td>
<td>98.2</td>
<td>98.7</td>
<td>99</td>
<td>98.69</td>
</tr>
<tr>
<td>Temporal resolution (days)</td>
<td>18</td>
<td>16</td>
<td>26</td>
<td>22</td>
<td>24</td>
</tr>
<tr>
<td>Revolutions</td>
<td>251</td>
<td>233</td>
<td>369</td>
<td>307</td>
<td>341</td>
</tr>
<tr>
<td>Equatorial crossing (AM)</td>
<td>09.30</td>
<td>09.30</td>
<td>10.30</td>
<td>10.00</td>
<td>10.30</td>
</tr>
<tr>
<td>-------------------------</td>
<td>-------</td>
<td>-------</td>
<td>-------</td>
<td>-------</td>
<td>-------</td>
</tr>
<tr>
<td>Sensors</td>
<td>RBV,MSS</td>
<td>MSS,TM</td>
<td>HRV</td>
<td>LISS-I,LISS-II</td>
<td>LISS-III,PAN,ViFS</td>
</tr>
</tbody>
</table>

*Table 5.2 Salient feature of some important satellite platforms.*

**Sensors**

<table>
<thead>
<tr>
<th><strong>ACTIVE SENSORS</strong></th>
<th><strong>PASSIVE SENSORS</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>(Detect the reflected or emitted electromagnetic radiation from natural sources.)</td>
<td>(Detect reflected responses from objects that are irradiated from artificially-generated energy sources such as radar.)</td>
</tr>
</tbody>
</table>

**Passive**
- Non-Scanning
  - Non-Imaging. (They are a type of profile recorder, ex. Microwave Radiometer. Microwave Altimeter. Laser Water Depth Meter. Laser Distance Meter. Scanning)
  - Imaging. (It is a radar ex. Object Plane)

**Active**
- Non-Scanning
  - Non-Imaging. (They are a type of profile recorder, ex. Microwave Radiometer. Microwave Altimeter. Laser Water Depth Meter. Laser Distance Meter. Scanning)
  - Imaging. (Examples of these are the cameras, which can be: Monochrome, Natural Object Plane)

  1. Real Aperture Radar.
  2. Synthetic Aperture
CHAPTER 2: REMOTE SENSING

Colour, Infrared etc.)

Scanning

- Imaging. Image Plane scanning. Ex. TV Camera
- Solid scanner. Object Plane scanning. Ex. Optical Mechanical Scanner,
- Microwave radiometer.

Radar.

Image Plane Scanning:


---

Table 5.3 Active sensors v/s passive sensors.

Microwave Remote Sensing

There are some remote sensing satellites, which carry passive or active microwave sensors. The active sensors emit pulses of microwave radiation to illuminate the areas to be imaged. Images of the earth surface are formed by measuring the microwave energy scattered by the ground or sea back to the sensors. These satellites carry their own "flashlight" emitting microwaves to illuminate their targets. The images can thus be acquired day and night. Microwaves have an additional advantage as they can penetrate clouds. Images can be acquired even when there are clouds covering the earth surface.
A microwave imaging system which can produce high resolution image of the Earth is the synthetic aperture radar (SAR). Since the physical mechanisms responsible for this backscatter is different for microwave, compared to visible/infrared radiation, the interpretation of SAR images requires the knowledge of how microwaves interact with the targets.

5.1.1 Images & Its Characteristics

Electromagnetic energy may be detected either photographically or electronically. The photographic process uses chemical reactions on the surface of light-sensitive film to detect and record energy variations. It is important to distinguish between the terms images and photographs in RS. An image refers to any pictorial representation, regardless of what wavelengths or RS device has been used to detect and record the electromagnetic energy. A photograph refers specifically to images that have been detected as well as recorded on photographic film.

A photograph could also be represented and displayed in a digital format by subdividing the image into small equal-sized and shaped areas, called picture elements or pixels, and representing the brightness of each area with a numeric value or digital number. The photograph was scanned and subdivided into pixels.
with each pixel assigned a digital number representing its relative brightness.

The computer displays each digital value as different brightness levels. Sensors that record electromagnetic energy, electronically record the energy as an array of numbers in digital format right from the start. These two different ways of representing and displaying RS data, either pictorially or digitally, are interchangeable as they convey the same information (although some detail may be lost when converting back and forth).

The information from a narrow wavelength range is gathered and stored in a channel, also sometimes referred to as a band. We can combine and display channels of information digitally using the three primary colours RGB (red, blue, & green). The data from each channel is represented as one of the primary colours and, depending on the relative brightness (i.e. the digital value) of each pixel in each channel, the primary colours combine in different proportions to represent different colours. Because the brightness level of each pixel is the same for each primary colour, they

![Pixels and Digital number](image)

*Figure 5.8 Pixels and Digital number.*
combine to form a **black and white image**, showing various shades of gray from black to white. When we display more than one channel each as a different primary colour, then the brightness levels may be different for each channel/primary colour combination and they will combine to form a **colour image**.

**Resolution**

In general resolution is defined as the ability of an entire remote-sensing system, including lens antennae, display, exposure, processing, and other factors, to render a sharply defined image. Resolution of a remote sensing is of different types.

1. Spectral Resolution: of a remote sensing instrument (sensor) is determined by the bandwidths of the Electro-magnetic radiation of the channels used. High spectral resolution, thus, is achieved by narrow bandwidths width, collectively, are likely to provide a more accurate spectral signature for discrete objects than broad bandwidth.

2. Radiometric Resolution: is determined by the number of discrete levels into which signals may be divided.

3. Spatial Resolution: in terms of the geometric properties of the imaging system, is usually described as the instantaneous field of view (IFOV). The IFOV is defined as the maximum angle of view in which a sensor can effectively detect electro-magnetic energy.
4. Temporal Resolution: is related to the repetitive coverage of the ground by the remote-sensing system. The temporal resolution of Landsat 4/5 is sixteen days.

**Data Analysis**

Visual interpretation and digital image processing techniques are two important techniques of data analysis to extract resource related information either independently or in combination with other data. Geographic information system techniques are facilitating integration of remotely sensed data with other spatial and aspatial data.

**Visual analysis**

Visual interpretation methods have been the traditional methods for extracting information, based on characteristics such as tone, texture, shadow, shape, size, association and etc., some limitations of visual interpretations are limited data volume handling problems of interpreting multi data/multi band data & inability to quantify training data sets and limited capability to deduct gray levels.

**Digital analysis**

Digital techniques facilitate quantitative analysis, use of face spectral information and avoid individual bias. Simultaneous analysis of multitemporal and multi sensor data is greatly facilitated in digital methods. In digital classification, computer analyses of spectral signatures are to associate each pixel with a particular class in imagery. Since signatures are not unique due to natural
variations, radiance value for a class will have a mean and a variance. The digital classification techniques essentially partition this feature space statistically so that each pixel in the feature space can be uniquely associated with one of the classes.

The classification techniques can be broadly categorized as either supervised or unsupervised approaches. A series of training sites or areas of state/district spectral homogeneity corresponding to the test site classifications in multidimensional statistical parameters (number of spectral bands in the imagery) are calculated. For the pixel clusters comprising each of the training sites are then identified or classified by matching its spectral properties to the multiversity mean of the class with the shortest distance from the point.

Unsupervised classification procedures are generally based on the multivariate statistical technique of cluster analysis, with dimensionality again corresponding to the number of spectral bands in the imagery. Unsupervised classification uses algorithms that examine a large number of unknown pixels and groups them into clusters based on different criteria. Each clusters is then associated with a physical category. Most routines permit the uses to vary the statistical parameters which guide programmed algorithms.
5.1.2 Applications of Remote Sensing

Remotely sensed data along with ground truth information and other collateral data have been extensively used to survey various natural resources. The applications are listed as,

<table>
<thead>
<tr>
<th></th>
<th>Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a)</td>
<td>Agriculture</td>
</tr>
<tr>
<td>(b)</td>
<td>Forestry</td>
</tr>
<tr>
<td>(c)</td>
<td>Environment</td>
</tr>
<tr>
<td>(d)</td>
<td>Coastal mapping</td>
</tr>
<tr>
<td>(e)</td>
<td>Marine applications</td>
</tr>
<tr>
<td>(f)</td>
<td>Urban environment</td>
</tr>
<tr>
<td>(g)</td>
<td>Land and Water resources development</td>
</tr>
<tr>
<td>(h)</td>
<td>Geology</td>
</tr>
<tr>
<td>(i)</td>
<td>Land use / land cover</td>
</tr>
<tr>
<td>(j)</td>
<td>Information systems</td>
</tr>
</tbody>
</table>

- Crop statistics, management system analysis, Horticulture.
- Forest area, type and density, biomass, grassland.
- Impact analysis, wetlands, pollution and abatement.
- Coastal land use, landforms, habitat processes.
- Potential fishing gene, forecast modeling, primary productivity.
- Road developmental planning route analysis.
- Land and water conservation and development, ground water targeting, snow melt, runoff recharge.
- Mineral targeting, oil exploration mapping-groundwater studies.
- Mapping development and planning.
- Integrated spatial and attribute data, query and modeling.

Table 5.4 Applications of Remote Sensing.
The success of these remote sensing applications can be improved considerably by taking multiple view approach to data collection methods. This may involve multistage sensing where data about a terrain are collected from multiple attitudes. In this approach, satellite data may be analyzed in conjunction with high altitude data, low altitude data, and ground observations. Here, more information is obtained by analyzing multiple views of the terrain than by analysis of any single view. Similarly, this may also involve multi-spectral sensing whereby data are acquired simultaneously in several spectral bands. For resources, monitoring, multi temporal sensing is required where data about a terrain are collected on more than one occasion; this records the changes in the ground condition occurring with time.

In any approach to apply remote sensing, not only must the right mix of data acquisition and data interpretation techniques be chosen, but also the right mixes of remote sensing and conventional techniques must be identified. The remote sensing data need to be integrated with the various other sources and types of physical and socio economic data in the computer based Geographic Information System (GIS) for further analysis. Visible (VIS): 0.4 to 0.9 Micrometer, Near-IR(NIR): 0.7 to 1.1 micrometer, Middle-IR(MIR): 1.55 to 1.75 micrometer and 2.08 to 2.3 micrometer, Thermal-IR(TIR): 8-14 micrometer and Microwaves: L, C and X bands.
**Spectral Responses** of Some Natural earth surface features.

**Soil:** Typical soil reflectance curve shows a generally increasing trend with wavelength in the visible and NIR regions. Some of the parameters, which influence soil reflectance, are the moisture content, the amount of organic matter iron oxide, relative percentages of clay, silt and sand and the roughness of the soil surface.

**Water:**

Water absorbs most of the radiation in the NIR and MIR regions. This properly enables easy delineation of even small water bodies. In the VIS region the reflectance depends upon the reflectance that occurs from the water surface, bottom material and other suspended materials in the water. Turbidity in water generally leads to increase in its reflectance. While dissolved gases and many inorganic salts do not manifest any changes in the spectral response of water.

**Vegetation:**

The spectral reflectance of vegetation is due to plant pigments, leaf structure and leaf water content.

In nature, generally the reflectance collected by the sensors is a mixture of all the above features. For ego the soil having moisture (water) content will stun a unique pattern (water logged soil), which will be distinctly different from salt affected soils. Due to the variations in the compositions of soil, the reflectance gets...
altered and it becomes easier to identify the variations in soil.

The same principle applies to water and pressure of particulate matters in the water. Vegetation on the surface of water also allures its reflectance.

Land utilization patterns depend on the soil/cover or water quality which in turn depends on the actions of natural agents like wind water and weathering effect. This is closely related to the LU/LC pattern of an area.

It is possible using remote sensing techniques to deliberate the LU/LC of an area. By studying the LU/LC pattern one can infer about the processes in action in any area.

Variation in spectral signatures of objects is sensed by sensors on board satellite and give explicit details of land use/land cover in different levels. The land use maps drawn from these sources can be considered as original information in the sense that they are generalized by first hand examination of direct evidence of land use patterns, rather than by compiling from secondary sources (Fox, 1991).
## CHAPTER 2: REMOTE SENSING

<table>
<thead>
<tr>
<th>THEME</th>
<th>APPLICATION</th>
<th>SPECTRAL RANGES EMPLOYED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture, Forestry and land use / cover</td>
<td>Crop identification &amp; acreage estimation</td>
<td>VIS, NIR, MIR, MW</td>
</tr>
<tr>
<td></td>
<td>Crop condition assessment and yield estimation</td>
<td>VIS, NIR, MIR, TIR</td>
</tr>
<tr>
<td></td>
<td>Soil moisture</td>
<td>STIR and Microwave (1&amp;C bands)</td>
</tr>
<tr>
<td></td>
<td>Drought monitoring</td>
<td>VIS, NIR, MIR</td>
</tr>
<tr>
<td></td>
<td>land use / cover mapping</td>
<td>VIS, NIR</td>
</tr>
<tr>
<td></td>
<td>Forest fire detection</td>
<td>3-4 Micrometer, TIR</td>
</tr>
<tr>
<td>Water resources</td>
<td>Mapping surface water bodies</td>
<td>VIS, NIR</td>
</tr>
<tr>
<td></td>
<td>Water quality monitoring</td>
<td>Narrow spectral bands in VIS and NIR, Thermal</td>
</tr>
<tr>
<td></td>
<td>Snow mapping - Aerial extent - Depth (water equivalent)</td>
<td>VIS, NIR, MIR Microwave</td>
</tr>
<tr>
<td></td>
<td>Flood mapping</td>
<td>VIS, NIR</td>
</tr>
</tbody>
</table>
| Marine resources and Coastal studies | Phytoplankton estimation  
Fluorescence studies for Chlorophyll-a estimation  
Sea surface temperature  
Wetland mapping  
Oil slicks | Narrow spectral bands (-10nm in the VIS, NIR at 685 nm with 5 nm resolution + NIR  
TIR Microwaves  
VIS, NIR, MIR  
UV, VIS, NIR and microwaves (19.1 and 31 GHz) |  
| | |  
| Geology / Mineral resources | Geology / Mineral  
Structural geology  
Rock type identification | VIS, NIR and Microwaves Narrow spectral bands in VIS, NIR, MIR & TIR |  
| | |  

*Table 5.6 Spectral ranges for different applications.*

### 5.1.3 Remote Sensing: Indian Program

Satellite based RS program in India began with the launch of Bhaskara-I on June 7, 1979 and the launch of Bhaskara-II in 1981 by the Indian Space Research Organization (ISRO). The Indian Earth Observation system became operational with the advent of Indian Remote Sensing satellites. The launch of first operational Remote Sensing Satellite, IRS-1A on March 17, 1988 was an important feather in the cap of ISRO.
CHAPTER 2: REMOTE SENSING

IRS-1A

- Launched in: March 17, 1988
- Out of service since: 1995
- Repeat Cycle: 22 Days
- Orbit Height: 904 Km
- Orbit Type: Sun Synchronous

IRS-1B

- Launched in: August 29, 1991
- Out of service since: 1996
- Repeat Cycle: 22 Days
- Orbit Height: 904 Km
- Orbit Type: Sun Synchronous
**IRS-1C and IRS-1D**

IRS-1C and IRS-1D are identical and were launched in December 1995 and September 1997, respectively, the latter by India’s Polar Satellite Launch Vehicle (PSLV). They carry three cameras, Panchromatic Camera (PAN), Linear Imaging Self Scanner (LISS-III) and Wide Field Sensor (WiFS).

**IRS-P2**

- Launched in: 1994
- Repeat Cycle: 24 Days
- Orbit Height: 817 Km
- Orbit Type: Sun Synchronous

Launched from Sriharikota aboard the PSLV-D2. The 5-metre panchromatic data is especially useful for urban planning and mapping, the 25-metre multi-spectral data is good for natural resource planning; and the 180 meter wide-field data band has a 740 km swath and 5-day repeat coverage, which is excellent for large-area vegetation monitoring.

**IRS P3**

The IRS-P3 satellite was launched from Sriharikota using PSLV-D3 on March 21, 1996. IRS-P3 was put in a polar, sun-synchronous orbit. IRS - P3 has an X-ray astronomy and two remote sensing payloads, namely WiFS and MOS. The mission caters to oceanography applications. IRS-P3 WiFS has the
inclusion of an additional band in the Middle Infra-red (MIR) region. This sensor is primarily meant for vegetation dynamic studies while MOS is meant for ocean related studies.

**IRS P4 (OCEANSAT-1)**

India entered in club of commercial satellite launching nations when their PSLV rocket blasted off from a southern seaport with two international payloads on May 26, 1999. It is the first Indian satellite dedicated fully for the study of oceans. It carries the Ocean Colour Monitor (OCM) and the Multi-frequency Scanning Microwave Radiometer (MSMR). The satellite is helpful in the study of oceanographic phenomenon such as sea temperature, sea surface height, rain over oceans and would be useful in measuring various ocean parameters.

**IRS-P6 (RESOURCESAT-1)**

The heaviest earth-observation spacecraft launched by ISRO so far, RESOURCESAT-1 was launched into an 817 km sun-synchronous polar orbit on board PSLV-C5 On October 17, 2003. RESOURCESAT-1 carries three sensors that deliver an array of spectral bands and resolutions ranging from 5.8 meters to 60 meters. Data products derived from P6 can be used for advanced applications in vegetation dynamics, crop yield estimates, disaster management support etc. In addition, it has 120 GB of on-board memory that allows for out-of-contact imaging. These include availability of 5.8 m spatial resolution in 3 bands from LISS-IV camera, improved LISS III with MIR band information at 23.5 m
resolution as other Visible and NIR bands. In addition, the AWiFS provides data in the same spectral channels as LISS-III at about 56m resolution with 10-bit radiometry, 5-day revisit and scene coverage of 740 km for regional studies.

**Technology Experiment Satellite (TES)**

TES was launched on board PSLV-C3 in October 2001. The satellite is intended to demonstrate and validate technologies that could be used in the future satellites of ISRO. TES carries a panchromatic camera with a spatial resolution of 1 m. Some features demonstrated in TES are light weight spacecraft structure; solid state recorder; X-band phased array antenna; improved satellite positioning system; miniaturized TTC and power system and, two-mirror-on-axis camera optics.

**IRS-P5 (CARTOSAT-1)**

IRS-P5 is planned for launch by PSLV in 2005. The satellite is primarily intended for advanced cartographic applications. It has two panchromatic cameras with a spatial resolution of 2.5 m and a swath of 30 km each. The data products are used for cartographic applications, cadastral mapping and updating, land use and other GIS applications. The satellite was placed in a sun-synchronous polar orbit of 617 km. It has a revisit capability of 5 days.

**CARTOSAT-2**

CARTOSAT-2 is an advanced remote sensing satellite with a panchromatic camera capable of providing scene-specific spot imageries for cartographic applications. The satellite has high
agility with capability to steer along and across the track up to $\pm 45$ degrees. It was placed in a sun-synchronous polar orbit at an altitude of 630 km. It has a revisit capability of 4 days. The panchromatic camera is designed to provide better than 1 m spatial resolution imageries with a swath of 10 km.

**Radar Imaging Satellite (RISAT-1)**

Radar Imaging Satellite (RISAT) mission envisages to support and augment the operational remote sensing program by enhancing agricultural and disaster related applications. RISAT has all-weather and day-night observation capability. It was launched in 2012 with a mission life of 5 years. RISAT will carry a C-band Synthetic Aperture Radar (SAR) operating in multipolarisation, multi-modes (ScanSAR, Strip, and Spot modes). The satellite is providing spatial resolutions of 3-50 meter with swaths varying from 10 km to 240 km. The RISAT is expected to be launched into a polar sun-synchronous orbit of 609 km.
The Earth Station: Data Receiving Center

Data from IRS satellites is received at the Earth Station of National Remote Sensing Agency (NRSA) at Hyderabad. A dedicated data reception facility forms the core of the acquisition chain. The data is processed after several stringent quality checks at various levels, and then supplied on user request on digital/photographic media. Payload programming support for IRS-1C/1D data is being provided for the Ground Stations in several countries and places including Norman and Alaska in USA, Ecuador, Germany, Spain, Taiwan, S. Korea, Saudi Arabia, Abu Dhabi, Thailand, Myanmar, Iran and to some mobile stations. IRS-
P4 data is being transmitted to stations in Korea, Germany and USA on request. IRS-P3 data is also being received at Germany and Spain.

[Courtesy: GIS development net & NRSA]
5.2 Introduction

Geography is the science of spatial relationships. Maps from a major constitute of geography, as they are a means of representing very large spatial relationships in a physically handleable size. The need for environmentally being and socially accountable development has put a heavy demand on the capabilities of planners. Therefore planning and execution now require more accurate, reliable and timely information and better tools for the management of such information. This require not only a variety of maps but a large amount of spatial information, commonly known as statistics, a means to handle this tools to selectively extract information relevant to the planning task. In sort, an information system for geographical data is needed. Any information system has four major components. There is an input module which accepts data, a data base module which organized and stores the data, an analysis module which selectively retrieves and manipulates the data and an output module which presents the analyzed information.

A Geographic Information System (GIS) is different in the sense that it handles both spatial and non-spatial data; consequently the corresponding module becomes more complex. Information system incorporates apart from database management
functions, a set of analysis modules which selectively retrieve and manipulate the data and output module which represents analyzed information in the context of given planning needs.

Input to an Information System is data, which is raw and does not convey any meaning unless analyzed and converted into meaningful information. Output from any Information System is the information, which conveys a meaning and prompts a set of action or decisions.

GIS (Geographical Information System) plays major role by providing linkage between the information domain and the technologies available for management and development planning. Geographical Information System is a particular form of information system is a set of processes, executed on raw data, to product information, which will be useful in decision making. Therefore an information system must have a full range of functions to achieve its purpose, including observation, measurement, description, explanation, forecasting and decision-making.

GIS, basically refers to science and technology dealing with the character and the structure of spatial information, its method of capture, organization, classification, analysis, measurement, display and dissemination as well as the infrastructure necessary for the optimal use of the information. With the increase in volume
and dimensionality of data it becomes essential to use automated GIS. Use of an automated system has become necessary as the data are maintain in a physically compact format (i.e. magnetic media), data can be retrieved with the greater speed, various computerized tools allow a variety of manipulation.

Alternatively, one could describe “Geographic Information System (GIS) as a system which provide a computerized mechanism for integrating various geo-referenced datasets analyzing them in order to generate information relevant to planning needs in a given context.”

GIS allows us to manipulate and display geographical knowledge in new and exciting ways.

**Geographic Information System (GIS)** is defined as an information system that is used to input, store, retrieve, manipulate, analyze and output geographically referenced data or geo-spatial data, in order to support decision making for planning and management of land use, natural resources, environment, transportation, urban facilities, and other administrative records.
The key components of GIS are a computer system, geospatial data and users, as shown in fig. 3.1

The sources of geospatial data are digitized maps, aerial photographs, satellite images, statistical tables and other related documents.

Geospatial data are classified into graphic data (or called geometric data) and attributes (or called thematic data) as shown in Fig.(3.2). Graphic data has three elements: point (or called node), line (or called arc) and area (or called polygon) in either vector or raster form which represent geometry of topology, size, shape, position and orientation.
CHAPTER 3: GIS

The roles of the user are to select pertinent information, to set necessary standards, to design cost-efficient updating schemes, to analyze GIS outputs for relevant purpose and plan the implementation.

5.2.1 Need of GIS

These are the following reasons why a GIS is needed.

- Geospatial data are poorly maintained
- maps and statistics are out of date
- data and information are inaccurate
- there is no data retrieval service
- there is no data sharing

Once a GIS is implemented, the following benefits are expected.
- Geospatial data are better maintained in a standard format
- revision and updating are easier
- geospatial data and information are easier to search, analyze and represent
- more value added product
- geospatial data can be shared and exchanged freely
- productivity of the staff is improved and more efficient
- time and money are saved
- Better decisions can be made

**GIS versus manual work**

Table 3.1 shows the advantages of GIS and the disadvantages of conventional manual works without GIS.

<table>
<thead>
<tr>
<th>Maps</th>
<th>GIS</th>
<th>Manual Works</th>
</tr>
</thead>
<tbody>
<tr>
<td>Storage</td>
<td>Standardized and Integrated</td>
<td>Different Scales on different Standards</td>
</tr>
<tr>
<td>Retrieval</td>
<td>Digital Data Base</td>
<td>Paper Maps, Census, Tables</td>
</tr>
<tr>
<td>Updating</td>
<td>Search by Computer</td>
<td>Manual Check</td>
</tr>
<tr>
<td>Overlay</td>
<td>Systematically Done</td>
<td>Expensive and Time Consuming</td>
</tr>
<tr>
<td>Spatial Analysis</td>
<td>Very Fast</td>
<td>Time &amp; Energy Consuming</td>
</tr>
<tr>
<td>Display</td>
<td>Easy</td>
<td>Complicated</td>
</tr>
<tr>
<td></td>
<td>Cheap and Fast</td>
<td>Expensive</td>
</tr>
</tbody>
</table>
Requirements of GIS

The environment in which a GIS operates is defined by hardware (the machinery including a hot computer), a digitizer or a scanner for converting the input data, a plotter for presentation processed outputs and video display unit for commanding the system by a user, the software (programs that tell the computer what to do) and the data.

Figure 3.3 Comparison of Geospatial Information Management with and without GIS
**Major Component of GIS**

1. Data Acquisition
2. Data Input
3. Data Storage and retrieval
4. Analysis
5. Information presentation
6. The end use or management

**About Maps**

The best-known models of the real world are maps. Maps have been used for thousands of years to represent information about the real world. Their conception and design has developed into a science with a high degree of sophistication. Maps have proven to be extremely useful for many applications in various domains.

A disadvantage of maps is that they are restricted to two-dimensional static representations, and that they always are displayed in a given scale. The map scale determines the spatial resolution of the graphic feature representation. The smaller the scale, the less detail a map can show. The accuracy of the base data, on the other hand puts limits to the scale in which a map can be sensibly drawn.

**Data Model**

The data model represents a set of guidelines to convert the real world (called entity) to the digitally and logically represented spatial objects consisting of the attributes and geometry. The
attributes are managed by thematic or semantic structure while the geometry is represented by geometric-topological structure.

There are two major types of geometric data model; vector and raster model.

**(a.) Vector Model**

Vector model uses discrete points, lines and/or areas corresponding to discrete objects with name or code number of attributes.

**(b.) Raster Model**

Raster model uses regularly spaced grid cells in specific sequence. An element of the grid cell is called a pixel (picture cell). The conventional sequence is row by row from the left to the right and then line by line from the top to bottom. Every location is given in two dimensional image coordinates; pixel number and line number, which contain a single value of attributes.

**5.2.2 Areas of GIS application**

Major areas of GIS applications can be grouped into five categories as follows:

**Facilities Management**

Large scale and precise maps and network analysis are used mainly for utility management. AM/FM is frequently used in this area.
**Environment and Natural Resources Management**
Medium or small scale maps and overlay techniques in combination with aerial photographs and satellite images are used for management of natural resources and environmental impact analysis.

**Street Network**
Large or medium scale maps and spatial analysis are used for vehicle routing, locating house and streets etc.

**Planning and Engineering**
Large or medium scale maps and engineering models are used mainly in civil engineering.

**Land Information System**
Large scale cadastre maps or land parcel maps and spatial analysis are used for cadaster administration, taxation etc.
### Table 3.2 Areas of GIS applications

<table>
<thead>
<tr>
<th>Area</th>
<th>GIS Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Facilities Management</td>
<td>Locating underground pipes &amp; cables</td>
</tr>
<tr>
<td></td>
<td>Planning facility maintenance</td>
</tr>
<tr>
<td></td>
<td>Telecommunication network services</td>
</tr>
<tr>
<td></td>
<td>Energy use tracking &amp; planning</td>
</tr>
<tr>
<td>Environmental and Natural Resources</td>
<td>Suitable study for agriculture cropping</td>
</tr>
<tr>
<td>Management</td>
<td>Management of forest, agricultural lands, water resources, wetlands etc.</td>
</tr>
<tr>
<td></td>
<td>Environment impact analysis</td>
</tr>
<tr>
<td></td>
<td>Disaster management and mitigation</td>
</tr>
<tr>
<td></td>
<td>Water facility site location</td>
</tr>
<tr>
<td>Street Network</td>
<td>Car navigation (routing &amp; scheduling)</td>
</tr>
<tr>
<td></td>
<td>Locating houses and streets</td>
</tr>
<tr>
<td></td>
<td>Site selection</td>
</tr>
<tr>
<td></td>
<td>Ambulance services</td>
</tr>
<tr>
<td></td>
<td>Transportation planning</td>
</tr>
<tr>
<td>Planning and Engineering</td>
<td>Urban planning</td>
</tr>
<tr>
<td></td>
<td>Regional planning</td>
</tr>
<tr>
<td></td>
<td>Route location of highways</td>
</tr>
<tr>
<td></td>
<td>Development of public facilities</td>
</tr>
<tr>
<td>Land Information System</td>
<td>Cadastre administration</td>
</tr>
<tr>
<td></td>
<td>Taxation</td>
</tr>
<tr>
<td></td>
<td>Zoning of land use</td>
</tr>
<tr>
<td></td>
<td>Land acquisition</td>
</tr>
</tbody>
</table>
COASTAL REGULATION ZONE

5.3 Coastal Regulation Zone

The coastal areas of almost all the maritime states of India are always under great pressure due to high population densities linked with urban growth. The uncontrolled developments in these areas are changing land use patterns and are making communities vulnerable to sea storms. In order to protect and conserve the coastal environment, the Ministry of Environment & Forests has defined Coastal Regulation Zone (CRZ).

With a view to protect the ecological balance in the coastal areas, the then Prime Minister is stated to have written a letter in November 1981 to the Chief Ministers of coastal States in which its stated as under:

"The degradation and misutilization of beaches in the coastal States is worrying as the beaches have aesthetic and environmental value as well as other values. They have to be kept clear of all activities at least up to 500 metres from the water at the maximum high tide. If the area is vulnerable to erosion, suitable trees and plants have to be planted on the beaches without marring their beauty. Beaches must be kept free from all kinds of artificial development. Pollution from industrial and town wastes must also be avoided totally."
Working groups were set up by the Ministry of Environment and Forests in 1982 to prepare environmental guidelines for development of beaches and coastal areas.

Notification under section 3(1)(v) of the Environment (protection) Act 1986, inviting objection against the declaration of coastal stretches as Coastal Regulation Zone (CRZ) and imposing restriction on industries operation and processes in the CRZ.

The central government hereby declares the coastal stretches of seas, bays, estuaries, creeks, rivers and backwater which are influenced by tidal action (in the landward side) up to 500 meters from the High Tide Line (HTL) and the land between the Low Tide Line (LTL).

The High Tide Line means the line on the land up to which the highest water line reaches during the springtime and shall be demarcated uniformly in the all parts of the country by the demarcation authority so authorized by the central government in consultation with Surveyor General of India.

[The distance from the HTL shall apply to both sides in case of river, creeks and backwaters.]

**Several Prohibited Activities in CRZ**

1. Setting up of new industries and expansion of existing industries.

2. Manufacture or handling or storage or disposal of hazardous substances as specified in the Notifications of the Government of India in the Ministry of Environment.
3. Disposal of effluents and discharge of untreated waste from industries, cities or towns and other human settlements or mining of sands, rocks or other minerals, except those rare minerals not available outside the CRZ.

4. Dumping of city or town waste for the purpose for land filling, dumping of ash or any other waste by the thermal power stations.

5. Land reclamation, bunding or disturbing the natural course of seawater with similar obstruction except those required for control of coastal erosion and maintenance.

**Several Permissible Activities in CRZ**

1. Clearance shall be given for any activity within the Coastal Regulation Zone only if it requires waterfront and foreshore facilities.

2. Construction activities related to Defense requirements for which foreshore facilities are essential (i.e. shipways jetties etc.), operational constructions for ports & harbors & lighthouses etc. (these both do not includes residential buildings, hospital, office workshops etc.)

3. Harvesting or draw of ground water and construction of mechanisms therefore within 200m of HTL; in the 200m to 500 m zone it shall be permitted only when done manually through ordinary wells for drinking, horticulture, agriculture and fisheries.
Moreover, these activities are also controlled in the area of Islands (CRZ IV), like new construction of building shall not permitted with 200 meters and between 200m to 500m building shall not have more than 2 floors (ground and 1st floor). There is also guideline for development of beach resorts\hotels in the designated areas of CRZ-III for temporary occupation of tourist\visitors with prior approval of the Ministry of Environment & Forests in this notification.

5.3.1 Classification of Coastal Regulation Zone

For regulating development activities, the coastal stretches within 500 meters of High Tide Line on the landward side are classified into four categories namely:

**CRZ-I**

(i) Areas that are ecologically sensitive and important such as national parks\marine parks, sanctuaries, reserve forest, wildlife habitats, mangroves, corals/coral reefs, areas close to breeding and spawning grounds of fish and other marine life, areas of outstanding natural beauty / historical / heritage areas, areas rich in genetic diversity, areas likely to be inundated due to rise in sea level consequent upon global warming and such other areas as may be declared by the central Government or the concerned authorities at the state. / Union territory level from time to time.
(ii) Area between the Low Tide Line and High Tide Line.

**CRZ-II**

The areas that have already been developed up to or close to the shoreline. The developed area is referred to as the area within the municipal limits or in other legally designated urban areas which are already substantially built up and which has been provided with drainage and approach roads and other infrastructure facilities, such as water supply and sewerage mains.

**CRZ-III**

Areas that are relatively undisturbed and those which do not belong to either category-I(CRZ-I) or II(CRZ-II). These will include coastal zone in the rural areas (developed or undeveloped) and also areas within Municipal limits or in other legally designated urban areas which are not substantially built up.

**CRZ-IV**

Coastal stretches in the Andaman & Nicobar, Lakshadweep and small islands except those designated as CRZ-I, CRZ-II or CRZ-III.
Brief Description of Coastal Regulation Zones

<table>
<thead>
<tr>
<th>CRZ-I</th>
<th>Ecologically sensitive &amp; important areas and areas between HTL &amp; LTL</th>
</tr>
</thead>
<tbody>
<tr>
<td>CRZ-II</td>
<td>Developed areas close to shore, mainly urban or built-up area</td>
</tr>
<tr>
<td>CRZ-III</td>
<td>Undisturbed areas &amp; areas which do not belong to either CRZ-I or CRZ-II</td>
</tr>
<tr>
<td>CRZ-IV</td>
<td>Coastal stretches in Andaman &amp; Nicobar, Lakshadweep &amp; small islands</td>
</tr>
</tbody>
</table>

Table 4.1 Brief description of CRZ

5.3.2 Monitoring & Enforcement

The ministry of Environment and Forests and the Government of State o Union Territory and such other authorities at the state or Union Territory levels as any be designated for this purpose, shall be responsible for monitoring and enforcement of the provisions of this notification within their respective jurisdiction.