PREFACE

With its grounding in the "guiding pillars of Access, Equity, Equality, Affordability and Accountability," the New Education Policy (NEP 2020) envisions flexible curricular structures and creative combinations for studies across disciplines. Accordingly, the UGC has revised the CBCS with a new Curriculum and Credit Framework for Undergraduate Programmes (CCFUP) to further empower the flexible choice based credit system with a multidisciplinary approach and multiple/ lateral entry-exit options. It is held that this entire exercise shall leverage the potential of higher education in three-fold ways – learner's personal enlightenment; her/his constructive public engagement; productive social contribution. Cumulatively therefore, all academic endeavours taken up under the NEP 2020 framework are aimed at synergising individual attainments towards the enhancement of our national goals.

In this epochal moment of a paradigmatic transformation in the higher education scenario, the role of an Open University is crucial, not just in terms of improving the Gross Enrolment Ratio (GER) but also in upholding the qualitative parameters. It is time to acknowledge that the implementation of the National Higher Education Qualifications Framework (NHEQF), National Credit Framework (NCrF) and its syncing with the National Skills Qualification Framework (NSQF) are best optimised in the arena of Open and Distance Learning that is truly seamless in its horizons. As one of the largest Open Universities in Eastern India that has been accredited with 'A' grade by NAAC in 2021, has ranked second among Open Universities in the NIRF in 2024, and attained the much required UGC 12B status, Netaji Subhas Open University is committed to both quantity and quality in its mission to spread higher education. It was therefore imperative upon us to embrace NEP 2020, bring in dynamic revisions to our Undergraduate syllabi, and formulate these Self Learning Materials anew. Our new offering is synchronised with the CCFUP in integrating domain specific knowledge with multidisciplinary fields, honing of skills that are relevant to each domain, enhancement of abilities, and of course deep-diving into Indian Knowledge Systems.

Self Learning Materials (SLM's) are the mainstay of Student Support Services (SSS) of an Open University. It is with a futuristic thought that we now offer our learners the choice of print or e-slm's. From our mandate of offering quality higher education in the mother tongue, and from the logistic viewpoint of balancing scholastic needs, we strive to bring out learning materials in Bengali and English. All our faculty members are constantly engaged in this academic exercise that combines subject specific academic research with educational pedagogy.We are privileged in that the expertise of academics across institutions on a national level also comes together to augment our own faculty strength in developing these learning materials. We look forward to proactive feedback from all stakeholders whose participatory zeal in the teaching-learning process based on these study materials will enable us to only get better. On the whole it has been a very challenging task, and I congratulate everyone in the preparation of these SLM's.

I wish the venture all success.

Professor. Indrajit Lahiri
Authorised Vice-Chancellor
Netaji Subhas Open University

Netaji Subhas Open University

Four Year Undergraduate Degree Programme

Under National Higher Education Qualifications Framework (NHEQF) &
Curriculum and Credit Framework for Undergraduate Programmes
Bachelor of Science (Honours) Geography (NGR)

Course : Skill Enhancement Course (SEC)

Course Code: NSE-GR-01

Application of Remote Sensing & GIS

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Application of Remote Sensing & GIS

: Writer :

Dr. Deb Prakash Pahari
Scientific Officer
The University of Burdwan

: Course Editor :

Dr. Biraj Kanti Mondal
Assistant Professor of Geography,
NSOU

: Format Editor :

Dr. Biraj Kanti Mondal
Assistant Professor of Geography, NSOU

Netaji Subhas Open University

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Application of Remote Sensing & GIS

Unit - 1 ❑ Principles of Remote Sensing (RS)

Structure :

1.0 Learning objectives

By the end of this unit, students would be able to :

- Understand the basic concept of Remote Sensing

- History of remote sensing
- Disciplines of Remote Sensing
- Stages of Remote sensing: data acquisition, data processing & data interpretation
- Types of Remote Sensing
- Major Components of Remote Sensing Technology
- Principles of Electromagnetic radiation (EMR)
- Spectral signatures & Band
- Advantage and Limitation of Remote Sensing

1.1 Understand the basic concept of Remote Sensing

Remote Sensing is a technique or a process to observe and acquiring information on the earth surface objects or the atmosphere from out of space using satellite or from the air using aircrafts without coming into physical contact with them.

Remote sensing techniques allow taking images of the earth surface in various wavelength region of the electromagnetic spectrum (EMS). One of the major characteristics of a remotely sensed image is the wavelength region it represents in the EMS. Some of the images represent reflected solar radiation in the visible and the near infrared regions of the electromagnetic spectrum, others are the measurements of the energy emitted by the earth surface itself i.e. in the thermal infrared wavelength region. Detection and discrimination of objects or surface features means detecting and recording of radiant energy reflected or emitted by objects or surface material (Fig. 1A). Different objects return different amount of energy in different bands of the electromagnetic spectrum, incident upon it. This depends on the property of material (structural, chemical, and physical), surface roughness, angle of incidence, intensity, and wavelength of radiant energy.

A Remote Sensing instrument collects information about an object or phenomenon within the instantaneous – field-of – view (IFOV) of the sensor system without being in direct physical contact with it. the sensor is located on a suborbital or satellite platform.

Remote sensing is the Science (and art) of acquiring information about an object, without entering in contact with it, by sensing and recording reflected or emitted energy and processing, analyzing, and applying that information.

Remote Sensing (RS) methods try to answer four basic questions:

1. What is Remote Sensing?
2. What is the Shape and Extent of ... ? (Area, Boundaries, Lineaments, ...)
3. Has it Changed?
4. What is the Mix of Objects?

1.2 Historial Overview

In 1859 Gaspard Tournachon took an oblique photograph of a small village near Paris from a balloon. With this picture the era of earth observation and remote sensing had started. His example was soon followed by other people all over the world. During the Civil War in the United States aerial photography from balloons played an important role to reveal the defence positions in Virginia (Colwell, 1983). Likewise other scientific and technical developments this Civil War time in the United States speeded up the development of photography, lenses and applied airborne use of this technology. Table 1 shows a few important dates in the development of remote sensing.

The next period of fast development took place in Europe and not in the United States. It was during World War I that aero planes were used on a large scale for photoreconnaissance. Aircraft proved to be more reliable and more stable platforms for earth observation than balloons. In the period between World War I and World War II a start was made with the civilian use of aerial photos. Application fields of airborne photos included at that time geology, forestry, agriculture and cartography. These developments lead to much improved cameras, films and interpretation equipment. The most important developments of aerial photography and photo interpretation took place during World War II. During this time span the development of other imaging systems such as near-infrared photography; thermal sensing and radar took place. Near-infrared photography and thermal-infrared proved very valuable to separate real vegetation from camouflage. The first successful airborne imaging radar was not used for civilian purposes but proved valuable for nighttime bombing. As such the system was called by the military 'plan position indicator' and was developed in Great Britain in 1941.

After the wars in the 1950s remote sensing systems continued to evolve from the systems developed for the war effort. Colour infrared (CIR) photography was found to be of great use for the plant sciences. In 1956 Colwell conducted experiments on the use of

CIR for the classification and recognition of vegetation types and the detection of diseased and damaged or stressed vegetation. It was also in the 1950s that significant progress in radar technology was achieved.

Table1 Milestones in the History of Remote Sensing

History of Remote Sensing

- 1783: The Marquis d'Arlandes and Pilatre made a voyage near Paris using a balloon.
- Photography using balloon, pigeon
- 1860: Aerial photos in Russia and the USA
- 1914-19: The first World War and the second World War (1939-45) had seen tremendous development in photography
- 1927: Robert Goddard launched the first liquid-fueled rocket.
- 1955: Work began on the Baikonur launch site in central Asia.
- 1957: Sputnik 1 launched from Baikonur (first satellite)
- 1961: Yuri Gagarin launched in the Vostok 1 capsule, becoming the first human in space.
- 1969: Neil Armstrong and Buzz Aldrin became the first humans to walk on the Moon.
- 1971: The first Space Station in history, the Russian Salyut 1
- 1972: (US Landsat1) the concept of imaging from satellites is introduced
- 1986: France launched the first stereo-image satellite (SPOT1)
- 1992: The space year (the maturity of remote sensing -20 years of operation)
- 1995 The Shuttle-Mir Program (1stphase of the International Space Station (ISS).
- 2000 The first 3 astronauts (2 Russian and one American) start to live in the ISS

1.3 Disciplines of Remote Sensing

The Remote Sensing is basically a multi-disciplinary science which includes a combination of various disciplines such as optics, spectroscopy, photography, computer, electronics and telecommunication, satellite launching etc. All these technologies are integrated to act as one complete system in itself, known as Remote Sensing System.

Remote Sensing is currently used more commonly to denote identification of earth features by detecting the characteristic electromagnetic radiation (EMR) that is reflected, emitted or scattered by the earth surface. Electromagnetic radiation, extending from the ultraviolet to the far infrared and microwave regions, provides the greatest potential in the context of earth resource survey.

1.4 Stages of Remote sensing : data acquisition, data processing & data interpretation

There are a number of stages in a Remote Sensing process, and each of them is important for successful operation.The important stages of remote sensing are as follows : (Fig. 1.B/C)

- Emission of electromagnetic radiation or EMR
- Transmission of energy from the source to the surface of the earth as well as absorption and scattering.
- Interaction of EMR energy with the earth surface emission
- Transmission of reflected / emitted energy from the surface to the sensor
- Detection of energy by sensor and conversion of it into photographic/electrical output
- Pre-processing of data for generation of data product
- Data transmission, processing and interpretation by the user
- Collection of Ground Truth
- Image interpretation and classification

Data Acqusition, Data Processing & Data Interpretation :

- **Energy source or illumination :** It is the source of electromagnetic radiation which is incident on the target of interest. The sensors can use the external source of illumination (i.e. the Sun) or can have their own source of illumination. Sensors which have their own energy source are called active remote sensors while the sensors which use the external source of energy are called the passive remote sensors. In most cases, sensors use the solar radiation reflected from the Earth.

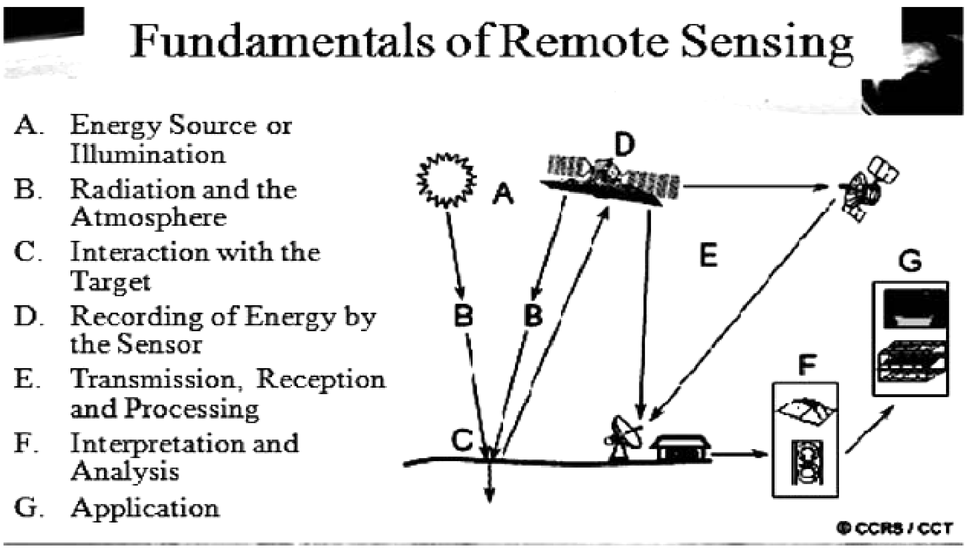
- **Interaction with the atmosphere :** The energy emitted from the source reaches the target passing through the earth's atmosphere which contains obstructions such clouds, haze, smog, etc.
- **Interaction with the target :** When the electromagnet radiations interact with the target, there are various possibilities in the way they behave. They can get reflected, refracted, absorbed & diffused.
- **Recording of energy by the sensor :** Once the energy has interacted with the target under study it is recorded by the sensor. Generally the reflectance values are recorded which vary with the type matter the EMR interacts with.
- **Transmission, Reception and Processing :** After recording the reflectance values, these are processed to remove any errors, converted to raster images and transmitted to ground station.
- **Interpretation & Analysis :** These raster images are then visually interpreted and analysed.
- **Application :** These are then used for numerous applications in various fields.

Fig. 1.1 A. Detection and Discrimination of Objects or Surface features.

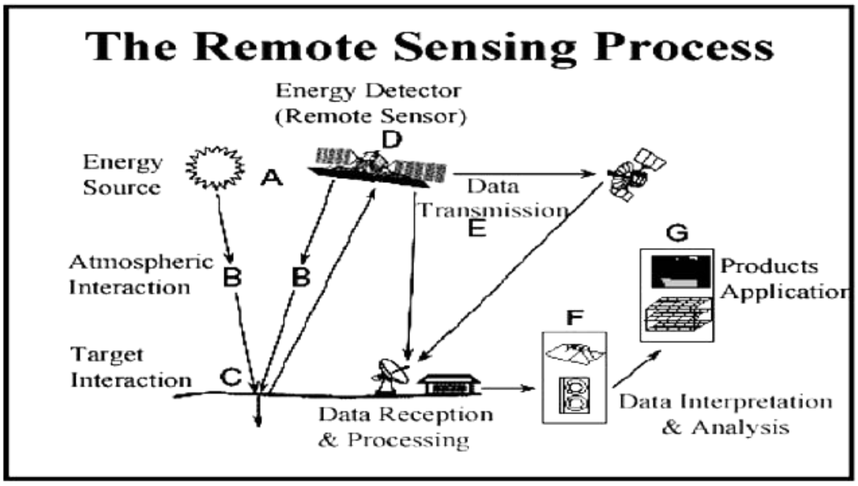
B. Stages of Remote Sensing.

C. Data acqusition, processing & interpretation.

A.



B.



C.

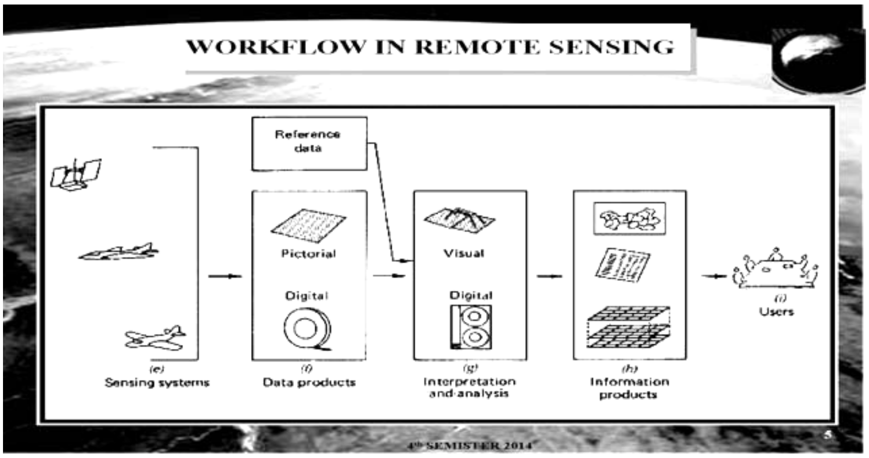


Fig. 1.1

1.5 Principles of Remote Sensing

1.5.1 Electromagnetic radiation

Electromagnetic radiation can be modelled in two ways: by waves or by radiant energy bearing particles called photons. The first publications on the wave theory date back to the 17th century. According to the wave theory light travels in a straight line (unless there are outside influences) with energy levels changing in a wave fashion. Light has two oscillating components; the energy constantly changes between electrical energy and magnetic energy. We call it, therefore, electromagnetic energy. The two components interact; an instance of positive electrical energy coincides with a moment of negative magnetic energy. The wave behaviour of light is common to all forms of EM radiation. All EM energy travels at the speed of light, which is approximately 300, 000 km/s. This is fast, but the distances in space are astronomical. It takes eight minutes for the sunlight to reach the Earth, thus when we see, *eg*, a sunrise, it actually occurred that much earlier. Because of the straight line travel we use the notion of light ray in optics.

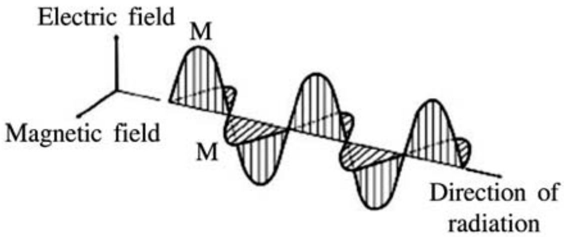


Fig. 1.2

1.5.2 Electromagnetic Radiation [EMR]

All sensors, employed on earth observation platforms (satellites) use *electromagnetic Radiation (EMR)* to observe the terrain features. The entire *Electromagnetic Spectrum (EMS)* is divided into different wave length regions which are broadly known by different names, *viz. Cosmic Rays, X-rays, Ultra-violet, visible Near-Infrared (NIR), Short-wave Infrared (SWIR), Middle Infra-red (MIR), Thermal Infrared (TIR), Microwave (MW)* etc.

1.5.3 Electromagnetic spectrum

We call the total range of wavelengths of EM radiation the EM *spectrum.* Figure 2.4 illustrates the spectrum of light, Figure 2.7 the total spectrum of EM radiation. We refer to the different portions of the spectrum by name: gamma rays, X-rays, UV radiation, visible radiation (light), infrared radiation, microwaves, and radio waves. Each of the these named portions represents a range of wavelengths, not one specific wavelength. The EM spectrum is continuous and does not have any clear-cut class boundaries.

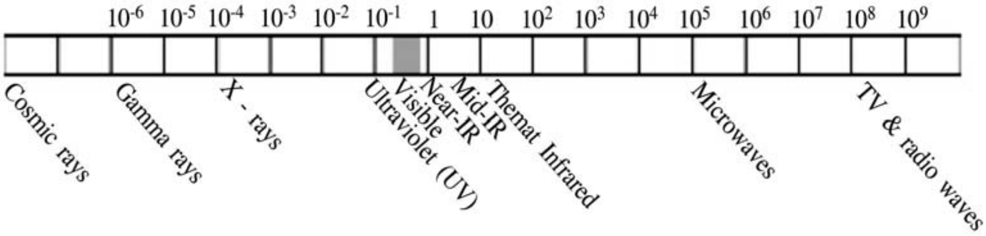


Fig. 1.3

Table 1.1 : Principal Divisions of the Electromagnetic Spectrum

Wavelenght	**Description**
Gamma rays	**Gamma rays**
X-rays	**X-rays**
Ultraviolet (UV) region 0.30 ¼m - 0.38 ¼m (1¼m = 10–5m)	This region is beyond the violet protion of the visible wavelength, and hence its name. Some earth's surface material primarily rocks and minerals emit visible UV radlation. However UV radiation is largely scattered by earth's atmosphere and hence not used in field of remote sensing.
Visible Spectrum 0.4 ¼m - 0.7¼m Violet 0.4¼m - 0.446¼m Blue 0.446¼m - 0.5¼m Green 0.5¼m - 0.578¼m Yellow 0.578¼m - 0.592¼m Orange 0.592¼m - 0.62¼m Red 0.62¼m - 0.7¼m	This is the light, which our eyes can detect. This is the only protion of the spectrum that can be assoctated with the concept of color. Blue Green and Red are the three primary colors of the visible spectrum. They are defined as such because no single primary color can be created from the other two, but all other colors can be formed by combining the three in varlous proportions. The color of an object is defined by the color of the light it reflects.
Infrared (IR) Spectrum 0.7¼m - 100¼m	Wavelenghs longer than the red protion of the visible spectrum are designsted as the infrared spectrum. British Astronomer William Herschel discovered this in 1800. The infrared region can be divided into two categroies based on their radiation properties. Reflected IR (.7¼m - 3.0¼m) is used for remote sensing. Thermal IR (3¼m - 35¼m) is the radiation emitted from earth's surface in the from of heat and used for remote sensing.
Microwave Regton 1mm - 1m	This is the longest wavelength used in remote sensing. The shortest wavelengths in this range have properties similar to thermal infrared region. The main advantage of this spectrum is its ability to penetrate through clouds.
Radio Waves (>1 m)	This is the longest portion of the spectrum mostly used for commercial broadcast and meteorology.

1.5.4 Electromagnetic Radiation and Electromagnetic Spectrum

EMR is a dynamic form of energy that propagates as wave motion at a velocity of c = 3 × 1010 cm/sec. The parameters that characterize a wave motion are wavelength (.), frequency (.) and velocity (c).

The relationship between the above is Electromagnetic energy radiates in accordance with the basic wave theory. This theory describes the EM energy as travelling in a harmonic sinusoidal fashion at the velocity of light. Although many characteristics of EM energy are easily described by wave theory, another theory known as particle theory offers insight into how electromagnetic energy interacts with matter. It suggests that EMR is composed of many discrete units called photons/quanta. The energy of photon is Q = hc / . = h . Where Q is the energy of quantum, h = Planck's constant

1.5.5 Spectral signatures and Band

A BAND denotes selective sensitivity of an imaging system to a particular wavelength of the electromagnetic spectrum. E.g., a sensor system may have four bands (Bands 1, 2, 3 and 4), sensitive to blue (0.4-0.5 ¼m), green (0.5-0.6 ¼m), red (0.6-0.7 ƒÝm) and infrared (0.7-0.8 ¼m). Systems like IRS LISS-2, this means four cameras, fitted with four different filters of blue, green, red and infrared. Thus, the remote sensing data of IRS LISS-2 are actually a set of four different datasets pertaining to three visible colours (blue, green and red) and one invisible colour (infrared). Similarly, Landsat TM data consists of three visible and four invisible colours (or bands).

Spectral Properties and Principal Application

Example in Landsat TM/ETM

Band	Wavelength (¼m)	Principal application
B-l	0.45-0.52 (Blue)	This band is useful for mapping coastal water areas, differentiating between soil and vegetation, forest type mapping, and detecting cultural features.
B-2	0.52 -0.60 (Green)	This band corresponds (o the green reflectance of healthy vegetation. Also useful for cultural feature identification.

B-3	0.63 -0.69 (Red)	This hand is useful for discriminating between many plant species. It is also useful for determining soil boundary and geological boundary delineations as well as cultural features.
B-4	0.76 - 0.90 (Near-Infrared)	This band is especially responsive to the amount of vegetation biomass present in a scene. It is useful for crop identification and emphasizes soil/ crop and land/water contrasts.
B-5	1.55- 1.75 (Mid-Infrared)	This band is sensitive to the amount of water in plants, which is useful in crop drought studies and in plant health analyses. This is also one of the few bands that can be used to discriminate between clouds^ snow, and ice.
1-6	10.4- 12.5	(Thermal Infrared) This band is useful for vegetation and crop stress detection, heat intensity, insecticide applications, and for locating thermal pollution. It can also be used to locate geothermal activity.
B-7	2.08 - 2.35 (Mid-Infrared)	This band is important for the discrimination of geologic rock type and soil boundaries, as well as soil and vegetation moisture content*

1.5.6 Spectral Reflectance Signature

The reflectance characteristics of the different features of the earth surface are measured by the incident energy that is reflected by the surface. This spectral reflectance of natural features are collected and stored by satellite sensors. Spectral reflectance of any object usually varies according to the wavelength of the EMR. A graph showing the spectral reflectance of an object for various wavelengths is known as a Spectral Reflectance Curve. It helps in selecting the wavelength bands for identifying the object. The radiation reflected as a function of the wavelength is called the spectral signature of the surface.

Spectral reflectance characteristics are the most important aspect for feature classification in any satellite imagery. Typical spectral reflectance curve for soil, vegetation, water are shown in above graph. Details of spectral behaviors of soil, water and vegetation.

1.6 Benefits of Remote Sensing (RS)

During last two decades the satellite remote sensing has been effectively utilized in acquiring and analyzing valuable information about the earth resources. Remote sensing has dramatically enhanced men's capabilities for resource exploration, mapping and monitoring of the earth resources environment on local as well as global scales. It has brought tremendous changes both quantitative and quantitative in various areas such as communication, television, radio broadcast, meteorology, agriculture, education, disaster management, environmental monitoring and natural resource inventory. These are important for strong database for planning, process and implementation of various programs and project both at the national and regional levels. Few benefits of Satellite remote sensing are listed below Data collected using satellite remote sensing can be used for following purposes

Advantages of Remote Sensing

- Synoptic view
- Repetitive coverage
- Continuous acquisition of data
- Coverage of inaccessible areas
- Up-to-date information, accurate and reliable data Quantifiable data
- New information
- Multi disciplinary applications
- Time, manpower saving
- Quick assessment of resources
- Service as a large archive of historical data

- Assessing and observing vegetation types
- Conducting soil surveys
- Carrying out mineral exploration
- Map making to facilitate easy study of information
- Constructing thematic maps based on requirement
- Planning and monitoring water resources
- Carrying out urban planning
- Assessing crop yields and other agriculture management
- Assessing and managing natural disasters, etc.
- Studying the various spatial features in relation to each other and delineation of regional features trends, phenomenon etc.

1.7 Advantages and Limitations

1.7.1 Advantages of remote sensing

- Large area coverage: Remote sensing allows coverage of very large areas which enables regional surveys on a variety of themes and identification of extremely large features.
- Remote sensing allows repetitive coverage which comes in handy when collecting data on dynamic themes such as water, agricultural fields and so on.
- Remote sensing allows for easy collection of data over a variety of scales and resolutions.
- A single image captured through remote sensing can be analyzed and interpreted for use in various applications and purposes. There is no limitation on the extent of information that can be gathered from a single remotely sensed image.
- Remotely sensed data can easily be processed and analyzed fast using a computer and the data utilized for various purposes.
- Remote sensing is unobstructive especially if the sensor is passively recording the electromagnetic energy reflected from or emitted by the phenomena of interest. This means that passive remote sensing does not disturb the object or the area of interest.
- Data collected through remote sensing is analyzed at the laboratory which minimizes the work that needs to be done on the field.
- Remote sensing allows for map revision at a small to medium scale which makes it a bit cheaper and faster.
- Color composite can be obtained or produced from three separate band images which ensure the details of the area are far much more defined than when only a single band image or aerial photograph is being reproduced.
- It is easier to locate floods or forest fire that has spread over a large region which makes it easier to plan a rescue mission easily and fast.
- Remote sensing is a relatively cheap and constructive method reconstructing a base map in the absence of detailed land survey methods.

1.7.2 Limitations of remote sensing :

- Remote sensing is a fairly expensive method of analysis especially when measuring or analyzing smaller areas.
- Remote sensing requires a special kind of training to analyze the images. It is therefore expensive in the long run to use remote sensing technology since extra training must be accorded to the users of the technology.
- It is expensive to analyze repetitive photographs if there is need to analyze different aspects of the photography features.
- It is humans who select what sensor needs to be used to collect the data, specify the resolution of the data and calibration of the sensor, select the platform that will carry the sensor and determine when the data will be collected. Because of this, it is easier to introduce human error in this kind of analysis.
- Powerful active remote sensing systems such as radars that emit their own electromagnetic radiation can be intrusive and affect the phenomenon being investigated.
- The instruments used in remote sensing may sometimes be un-calibrated which may lead to un-calibrated remote sensing data.
- Sometimes different phenomena being analyzed may look the same during measurement which may lead to classification error.
- The image being analyzed may sometimes be interfered by other phenomena that are not being measured and this should also be accounted for during analysis.
- Remote sensing technology is sometimes oversold to the point where it feels like it is a panacea that will provide all the solution and information for conducting physical, biological or scientific research.
- The information provided by remote sensing data may not be complete and may be temporary.
- Sometimes large scale engineering maps cannot be prepared from satellite data which makes remote sensing data collection incomplete.

1.8 Summary

Remote sensing technology has developed from balloon photography to aerial photography to multi-spectral satellite imaging. Radiation interaction characteristics of earth and atmosphere in different regions of electromagnetic spectrum.

- Remote sensing is the process of acquiring the real time information about earth futures without being into direct contact
- Remote sensing (RS) deals with inventory, monitoring and assessment of natural resources through the analysis of data obtained from remote sensing platforms.
- In case of dust cloud and fog all wavelengths in the visible band are equally scattered, that is why all looks white in color.
- The shorter wavelengths are scattered more than longer wavelengths. These types of scattering are seen more in ultra violet and blue. That's why sky appears in blue.
- The radiation reflected as function of the wavelengths is called as spectral signature of the surface.
- The reflectance from a feature depends on the atmospheric condition, season, time of a day, and physical & chemical properties of the feature.
- The reflectance of the vegetation depends on various factors such as leaf pigmentation, leaf cell structure, moisture, and crown architecture and plant physiology.
- The reflectance of the soil depends on soil moisture, texture, color, grain size, sand, silt and clay composition and mineral composition.
- The reflectance from water depends on depth, suspended particles, floating vegetation
- Pure clear water has a relatively high reflectance in the visible wavelength bands between 0.4 and 0.6 im because it absorbs all the energy therefore, it appears darker in color.

1.9 Keywords

Rewote sensing(RS), stages of RS, satellite, Sensor, Orbit, EMR, EMS, Bond, Spectral signatare, Adantages of RS, Limitations of RS.

1.10 Model Questions

1. What is Geo- spatial technology?
2. Describe different types of artificial Satellites and their characteristics
3. Explain advantages and limitations of Remote sensing techniques.
4. Define Electromagnetic spectrum
5. How EMR interact with earth surface features discuss with example?
6. Define spectral signature.
7. Sun is assumed to be a black body in which temperature?
8. Define Electromagnetic Spectrum with example.
9. What is spectral signature? How it is implemented in remote sensing
10. Define Pixel? Discuss with example.

1.11 References and Further Readings

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Unit - 2 ❑ Classification of Remote Sensing Satellites

Structure :

2.0 Learning Objectives

2.1 Classification of Remote Sensing

2.2 Major Components of Remote Sensing Technology

2.3 Summary

2.4 Keywords

2.5 Model Questions

2.6 References and Further Readings

2.0 Learning objectives

By the end of this unit, students would be able to :

- Understand the basic concept of Remote Sensing
- History of remote sensing
- Disciplines of Remote Sensing
- Stages of Remote sensing: data acquisition, data processing & data interpretation
- Types of Remote Sensing
- Major Components of Remote Sensing Technology
- Principles of Electromagnetic radiation (EMR)
- Spectral signatures & Band
- Advantage and Limitation of Remote Sensing

2.1 Classification of Remote Sensing

Remote sensing can be performed in verions ways which is discussed below :

A) Depend on Source of Energy :

Active : systems have their own source of energy (such as RADAR)

Passive : systems depend upon external source of illumination (such as SUN) or self-emission for remote sensing.

B) Depend on Satellite orbit characteristies :

Types of satellites can be classified by their orbit characteristics.

Low earth Orbits/satellites: Normally used in spy satellite (Military Purposes)

Sun-synchronous Orbits/satellites : a polar orbit where the satellite always crosses the equator at the same local solar time. most of the earth resources satellites are sunsynchronous orbit. Examples: IRS, Landsat, SPOT, IKONOS, QuickBird

Geostationary Orbits/Satellites: Satellites at very high altitudes, which view the same portion of the earth's surface at all times, especially used in meteorological applications.

C) Remote Sensing respect to wave length region :

- Visible and Reflective Intrared Remote Sensing.
- Thermal Infrared Remote Sensing.
- Microware Remote Sensing.

Spectral Bands	Spectral Regtons
0.4 - 0.7 ¼m	Visible (VIS)
0.7 - 1.1 ¼m	Near Infrared (NIR)
1.1 2.5 ¼m	Short wave Infrared (SWIR)
3.5 ¼m	MWIR (Mid wave Infrared)
8.14 ¼m	TIR (Thermal Infrared)
0.1 - 100 cm	Microwave

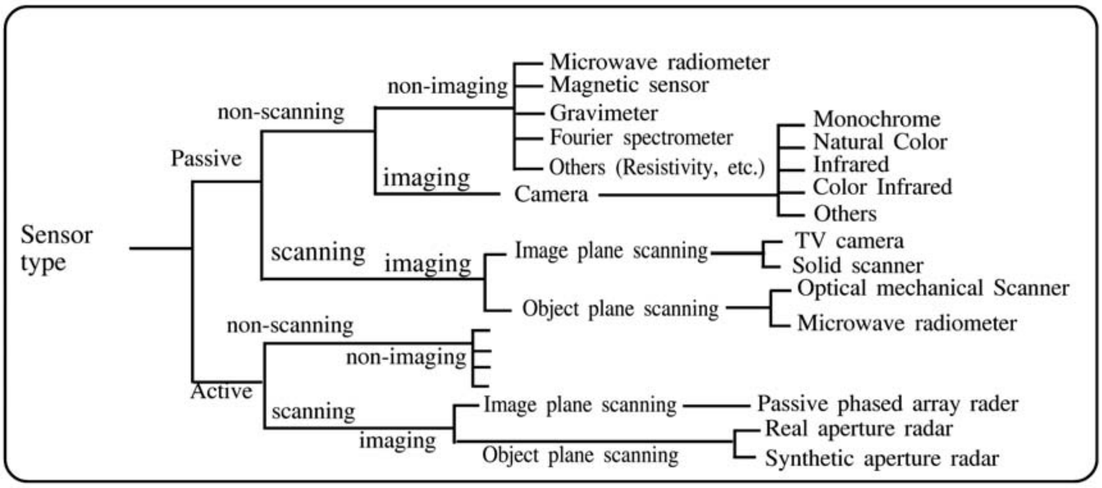

Fig- 2.1

D) Depends on Platforms :

Platform is the base from where the remote sensing is done. Out of the three (groundborne, air-borne and space-borne) main categories of platforms **Air Borne Platforms** (*Aircraft*) and **Space Borne Platforms** (*Satellites*) are the most important.

The vehicle which carries a sensor such as a truck, balloon, aircraft, space shuttle, satellite, etc.

2.2 Major Components of Remote Sensing Technology

Followings are the major components of RS Technology :

- Energy Source
- Platforms
- Sensors
- Orbits
- Detectors and Processing
- Institulization.

❑ **Orbit**

The monitoring capabilities of a satellite sensor are to a large extent determined by the parameters of the satellite's orbit. An *orbit* is a circular or elliptical path described by the satellite in its movement round the Earth. Different types of orbits are required to achieve continuous monitoring (meteorology), global mapping (land cover mapping), or selective imaging {urban areas). For earth observation purposes, the following orbit characteristics are relevant,

- *Orbital attitude* is the distance (in km) from the satellite to the surface of the Earth. It influences to a large extent the area that can be viewed *(ier* the 'spatial coverage') and the details that can be observed *(ier* the 'spatial resolution'). In general, the higher the altitude the larger is the spatial coverage but the lower the spatial resolution.
- *Orbital inclination angle* is the angle (in degrees) between the orbital plane and the equatorial plane. The inclination angle of the orbit determines, together with the field of view {FOV) of the sensor, the latitudes up to •which the Earth can be

observed. If the inclination is 60°, then the satellite flies over the Earth between the latitudes 60° north and 60° south. If the satellite is in a low-earth orbit with an inclination of 60°, then it cannot observe parts of the Earth at latitudes above 60s north and below 60° south, which means it cannot be used for observations of the polar regions of the Earth.

- *Orbital period* is the time (in minutes) required to complete one full orbit, For instance, if a polar satellite orbits at 806 km mean altitude, then it has an orbital period of 101 minutes. The Moon has an orbital period of 27.3 days. The speed of the platform has implications on the type of images that can be acquired, A camera on a low-earth orbit satellite would need a very short exposure time to avoid motion blur due to the high speed. Short exposure time, however, requires high intensity of incident radiation, which is a problem in space because of atmospheric absorption. It may be obvious that the contradicting demands on high spatial resolution, no motion blur, high temporal resolution, long satellite Lifetime and thus lower cost represent a serious challenge to satellite-sensor designers.
- *Repeat cycle* is the time {in days) between two successive identical orbits. The *revisit time (ie,* the time between two subsequent images of the same area) is determined by the repeat cycle together with the pointing capability of the sensor. *Point ing capability* refers to the possibility of the sensor-platform combination to look to the side, or forward, or backward, not only vertically down. Many of the modern satellites have such a capability. We can make use of the pointing capability to reduce the time between successive observations of the same area, to image an area that is not covered by clouds at that moment, and to produce stereo images.

The following orbit types are most common for remote sensing missions:

- *Stm-synchronous orbit,* This is a near-polar orbit chosen in such a way that the satellite always passes overhead at the same time, Most sun-synchronous orbits cross the equator at mid-morning at around 10:30 hour local solar time. At that moment the Sun angle is low and the resultant shadows reveal terrain relief.
- *Geostationary orbit.* This refers to orbits where the satellite is placed above the equator (inclination angle : 0o) at an altitude of approximately 36, 000 km. At this distance, the orbital period of the satellite is equal to the rotational period of

the Earth, exactly one sidereal day. The result is that the satellite is at a fixed position relative to the Earth. Geostationary orbits are used for meteorological and telecommunication satellites,

❑ **Sensors:**

SENSOR is a device, for recording information through reflected or emitted light from various objects. Human eyes and cameras are two examples of sensors. An ACTIVE SENSOR is the one, which sends a beam of light onto the object and detects the reflected light energy. RADAR (RAdio Detection And Ranging) is an example of this type. A PASSIVE SENSOR is the one that detects emitted or reflected electromagnetic radiation from natural sources. The earth receives light energy from the sun and emits or reflects part of it back into the atmosphere and space. Passive sensors obtain images of the earth with help of this emitted or reflected energy. Most of the remote sensing satellites use passive sensors to record data. (Fig. 2.2)

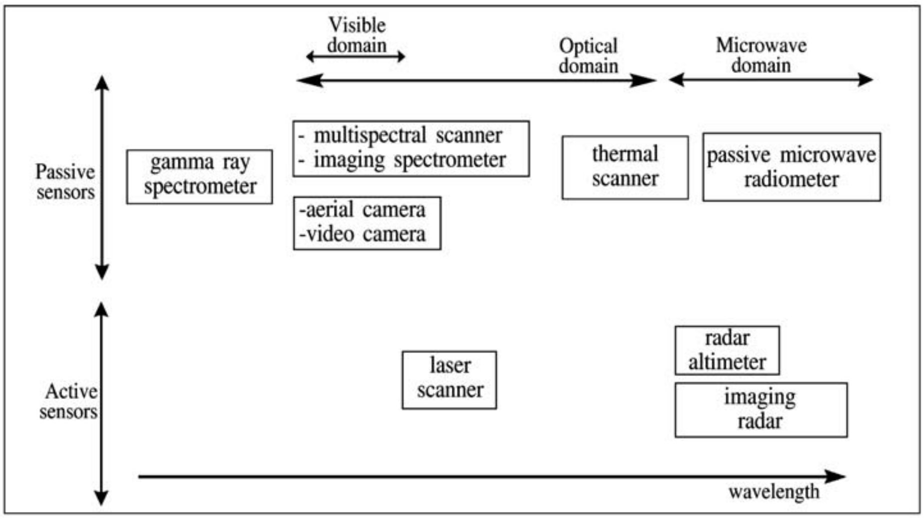

Figure 2.2 : Overview of the sensors

A sensor is basically a digital camera. In it, CHARGE COUPLED DEVICES or CCDs take the place of standard photographic films. The CCDs are arranged in a matrix, like grids of a graph paper, and each has a DIGITAL ADDRESS or DA, determined according to its position in lines and rows. The light (or electromagnetic waves) striking the CCDs generates an electrical impulse, the intensity of which depends on the intensity of the incedent light. In the commonly used 8-bit (28 or 256) imaging system, the intensity of the impulse is converted to a value between 0 (no reflection or emission) and 255 (maximum reflection or emission). These values are called grey levels or DIGITAL NUMBERS or DN. As a satellite transmits the digital addresses and digital numbers of all the CCDs of a particular band back to the earth, the image can be precisely regenerated using a remote sensing software. In the generated image the each CCD is referred to as a PIXEL. This arrangement of a DN values in rows and columns is called RASTER image format.

- **Detectors and processing :** Handle signal data can be photographic, digital, etc.

There are two main modes or methods of scanning employed to acquire multispectral image data.

(1) across-track scanning :

Scan the Earth in a series of lines. (A) Each line is scanned from one side of the sensor to other, using a **rotating mirror** (B) The incoming reflected or emitted radiation is separated into several spectral components that are detected independently. A bank of internal **detectors** (C) The **IFOV** and the altitude determine the **ground resolution cell** and spatial resolution (D). The **angular field of view** (E) is the sweep of the mirror and determines the width of the imaged **swath** (F).

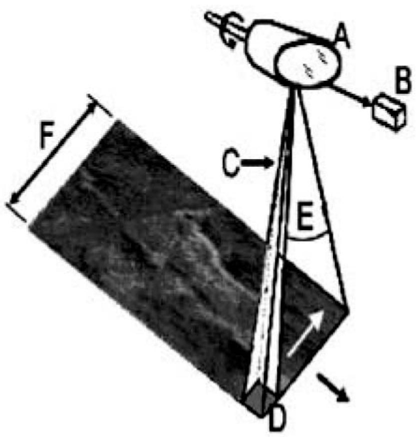

Fig. 2.3 Detector

(2) along-track scanning :

Use the forward motion of the platform to record successive scan lines and build up a two-dimensional image, perpendicular to the flight direction. Instead of a scanning mirror, they use a linear array of detectors (A) which are “pushed” along in the flight track direction (i.e. along track). Called **pushbroom scanners.** Each individual detector measures the energy for a single ground resolution cell (D) and thus the size and IFOV of the detectors determines spatial resolution. A separate linear array is required to measure each spectral band or channel.

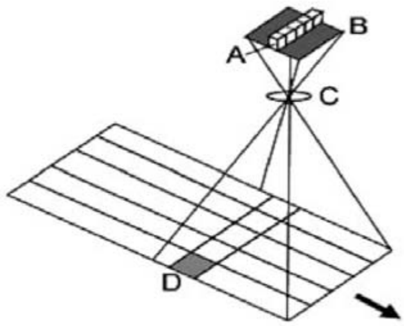

Fig. 2.4 : Scanner

Institutionalization: An organization for execution at all stages of remote sensing technology; international and national organizations, centers, universities

2.3 Summary

- The energy emitted from is called as electromagnetic radiation.
- A blackbody is an ideal body which absorbs all radiation without any reflection.
- All object matter that has temperature higher than absolute zero or -273 degrees emits EMR continuously
- Sun is the primary source of energy. The incoming radiation goes through various modes of energy interaction, for example, transmission, absorption, reflection and scattering.

2.4 Keywords

Remote sensing(RS), stages of RS, satellite, Sensor, Orbit, EMR, EMS, Bond, Spectral signatare, Adantages of RS, Limitations of RS.

2.5 Model Questions

1. Write down Major Components of Remote Sensing Technology.
2. Describe different types of resolution which are used in RS.
3. Give short note on the following:

   (a) Platforms in Remote sensing (b) Band (c) Sensor (d) Ground Swath (e) Path & Row reference map
4. Which Organization is responsible for the selling of satellite data?
5. Write the name of a high resolution Indian satellite sensor and its resolution.
6. How much altitudes are followed in a geostationary satellites orbit from the earth?

2.6 References and Further Readings

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Unit - 3 ❑ Remote Sensing Sensors: Sensor resolutions

Structure :

3.0 Learning objectives

By the end of this unit students would be able to:

- Understand the basic concept of Resolutions
- Know about Spatial Resolution
- Know about Spectral Resolution
- Know about Radiometric Resolution
- Learn about Temporal Resolution
- Understand Image Referencing Schemes
- Learn about Data procurement and data acqusition
- Know Indian Space Mission in details
- Learn about IRS and Landsat Mission

3.1 Types of Remote Sensing Sensors

Sensor means the seasing or recording device. There are several broad categories of basic sensor system types such as passive vs. active, and imaging vs. Non imaging. Passive vs. active refers to the illumination source of the system; imaging vs. Non imaging refers to the form of the data. A variety of different sensors fit in these categories, which are not mutually exclusive.

3.1.1 Passive vs. active sensors

Passive sensors measure light reflected or emitted naturally from surfaces and objects. Such instruments merely observe, and depend primarily on solar energy as the ultimate radiation source illuminating surfaces and objects. Active sensors (such as radar and lidar systems) first emit energy (supplied by their own energy source) and then measure the return of that energy after it has interacted with a surface. Use of data collected by passive sensors often requires accurate measurements of solar radiation reaching the surface at the time the observations were made. This information allows for the correction of "atmospheric effects" and results in data or images that are more represenrtative of actual surface characteristics.

3.1.2 Imaging vs. Non imaging sensors

Remote sensing data are the recorded representation of radiation reflected or emitted from an area or object. When measuring the reflected or emitted energy, either imaging or non imaging sensors can be used. Data from imaging sensors can be processed to produce an image of an area, within which smaller parts of the sensor's whole view are resolved visually. Non imaging sensors usually are hand held devices that register only a single response value, with no finer resolution than the whole area viewed by the sensor, and therefore no image can be made from the data. These single values can be referred to as a type of "point" data, however some small area is typically involved depending on the sensor's spatial resolution.

Image and non image data each have particular uses. Non-image data give information for one specific (usually small) area or surface cover type, and can be used to characterize the reflectance of various materials occurring in a larger scene and to learn more about the interactions of electromagnetic energy and objects. Image data provide an opportunity to look at spatial relationships, object shapes, and to estimate physical size based on the data's spatial resolution and sampling. Image data are desirable when spatial information (such as mapped output) is needed.

Images produced from remote sensing data can be either analog (such as a photograph) or digital (a multidimensional array or grid of numbers). Digital data can be analyzed by studying the values using Calculations performed on a computer, or processed to produce an image for visual interpretation. Image interpretation is used to decipher information in a scene. In the pest, image interpretation was done largely using subjective visual techniques, but with the development and ongoing advancement of computer technology, numeric or digital processing has become a powerful and common interpretation tool

In many cases, image interpretation involves the combination of both visual and digital techniques. These techniques utilize a number of image features including tone and color; texture, shape, size, patterns, and associations of objects. The human eye and brain are generally thought to more easily process the spatial characteristics of an image, such as shape, patterns and how objects are associated with one another, Computers usually are better suited for rapid analysis of the spectral elements of an image such as tone and color. Sophisticated computer software that perform like the human eye and brain may be more commonly available in the future.

3.2 Basic concept of Resolutions

Resolution is defined as the ability of the sensor to detect the information at the smallest meaningful element, in terms of distance (spatial), wavelength band of EMR (spectral), time (temporal) and radiation quality (radiometric).

Resolution of a sensor can be of four types: spectral, radiometric, spatial and temporal. Spectral Resolution what wavelengths do we use. Ability of sensor to separate EM into small intervals (bands) it refers to number of available bands. E.g., the IRS OCM sensor has eight bands and therefore a better resolution than the two-band IRS WiFS sensor.

Spatial Resolution Spatial what size we can resolve. The ground area represented by each pixel in an image. It means ability of an imaging system to record smallest possible object. E.g., the 1-m resolution of Ikonos PAN Sensor is finer than 5.8 m IRS PAN Sensor.

Radiometric Resolution degree of detail observed. Ability to discriminate slight differences in energy. refers to the availability of grey level or digital number range. E.g., the resolution of 12-bit (4, 096 grey levels) IRS OCM sensor is better than 8-bit (256 grey levels) IRS LISS-2 sensor.

Temporal Resolution how often do we observe, how often is the target sampled of a sensor is its revisit capacity over a given region. This generally varies from 11 (Ikonos-1) to 25 days (IRS-1D).

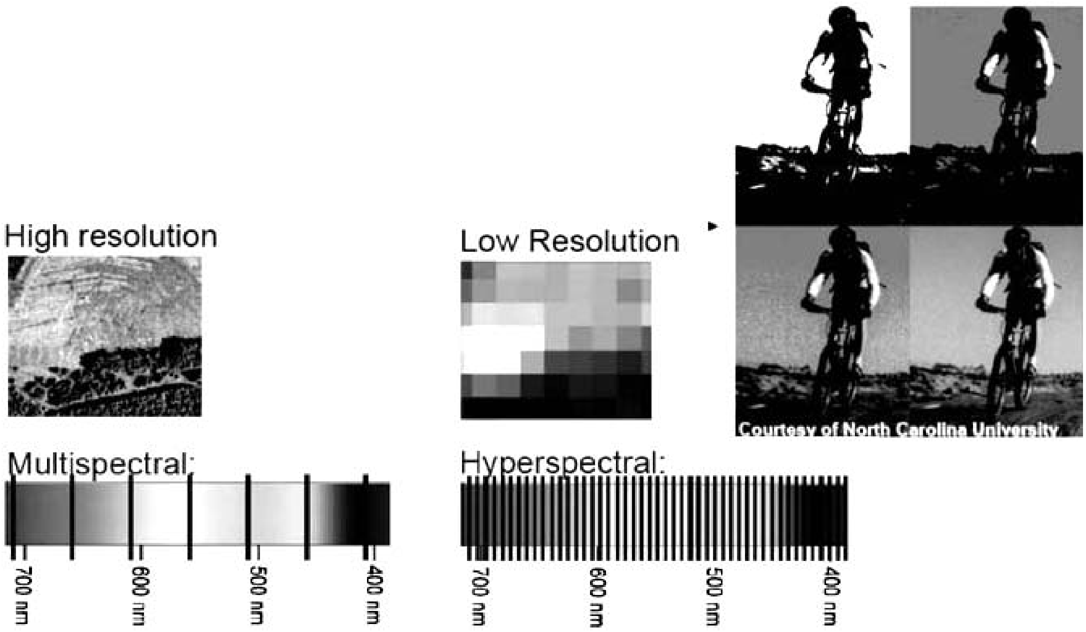


Fig. 3.1 : Types of resolution

3.3 Spatial Resolution

It is the minimum element area that the sensor can detect to measure. This resolution element is called Pixel. It refers to the size of the smallest object that can be resolved on the ground. It is a measure of the smallest area identification of a digital image, as a discrete, separate unit (typically pixels) or a measure of the smallest angular or linear separation between two objects that can be resolved by the sensor.

The detail discemible in an image is dependent on the spatial resolution of the sensor and refers to the size of the smallest possible features that can be detected. It is the minimum element area that the sensor can detect to measure.

Sensor	Pixel size (m)
LISS III Band 2 to 4	23.5
LISS III Band 5	70.5
WiFS	188.3
A WiFS	56
PAN	5.8
LISS IV	4.5
IKONOS	1
Cartosat-2	0.8
SPOT - MSS	30, 80

3.4 Spectral Resolution

It refers to the sensing and recording power of the sensor in the different bands of EMR. Spectral resolution describes the specific wavelengths that the sensor can record within the electromagnetic spectrum. Narrow bandwidth in certain regions of the EMR allow the discrimination of various features more easily. Spectral resolution describes the ability of a sensor to define fine wavelength intervals. the finer the spectral resolution, the narrower the wavelength range for a particular channel or band.

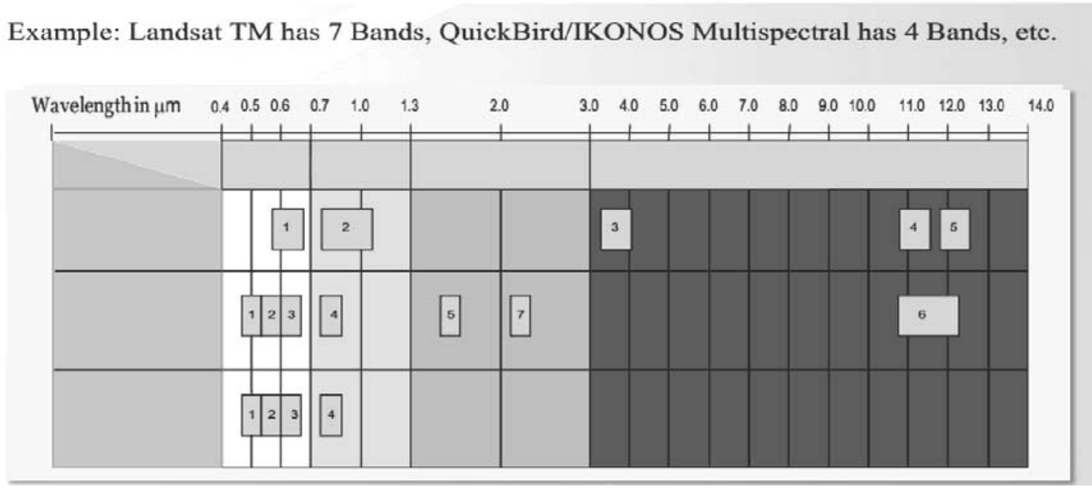
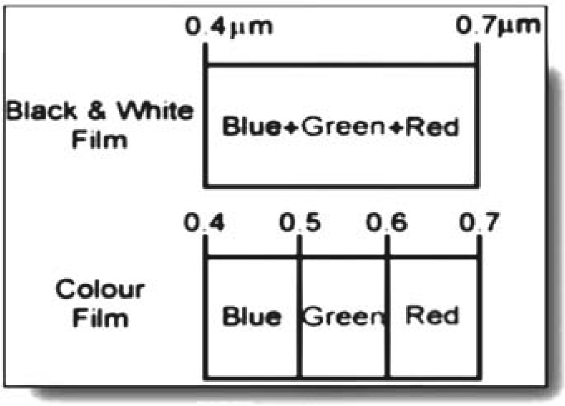


Fig. 3.2 : Bands of EMR

It refers to the sensing and recording power of the sensor in the different bands of EMR . the sensor can observe object separately in different bands and colour or in one band which is panchromatic (Black & Whie). For example Landsat MSS – 7 bands, SPO 4 bands, IRS 4 bands



LISS III	
Bands	**Wavelengths**
Band 2	0.52-0.59 µm
Band 3	0.62-0.68 µm
Band 4	0.77-0.86 µm
Band 5	1.55-1.70 µm
PAN	0.5-0.75 µm

Spectral Resolution of various Satellites

Fig. 3.3 : Different bands and colour

3.5 Radiometric Resolution

It is determined by the number of discrete levels into which signals may be divided. It is recorded in Digital Number (DN) for different bands of satellites. Radiometric Resolution refers to the smallest change in intensity level that can be detected by the sensing system . It is the capability to differentiate to the spectral reflectance/ remittance from various targets. This depends on the number of quantization levels within the spectral band. In other words, the number of bits of digital data in the spectral band will decide the sensitivity of sensor.

The Radiometric Resolution of an imaging system describes its ability to discriminate very slight difference in energy. It is the finer the radiometric resolution of a sensor, the more sensitive it is to detecting small differences in reflected or emitted energy. The spatial resolution specifies the pixel size of satellite images covering the earth’s surface.

The various examples are given in below table

Sensor	Radiometric Resoluion	Colour
LISS III	7 bit/128 levels	0 – 127 colours
WiFS	7 bit/128 levels	0 – 127 colours
PAN	6 bit/64 levels	0 – 64 colours
AWiFS	10 bit/1023 levels	0 – 1023 colours
CARTOSAT	7 bit/1023 levels	0 – 1023 colours
LANDSAT TM	8 bit	
SPOT	8bit	
IKONOS	11bit	

3.6 Temporal Resolution

Temporal Resolution is the ability to collect imagery of some area of the earth's surface at different periods of time is one of the most important elements of RS. Temporal resolution is also called as the repetitative cycle which is the capability of the satellite to record the same area at the same viewing angle at different periods of time.

Temporal resolution is a description of how often a sensor can obtain imagery of a particular area of interest. It is based on the repeat period of a particular satellite. Ideally, the sensor obtained data repetitively to capture unique discriminating characteristics of the phenomena of interest. it is also important to consider in a remote sensing system, refers to the length of time it takes for a satellite to complete one entire orbit cycle. the revisit period of a satellite sensor is usually several days except Geostationary satellite.

The various examples are given in the table given below.

Sensor	Revisit Period (No. of days)
IRS 1A/1B	22
IRS 1C/1D	24
PAN	5
WiFS	3
AWiFS	5
Landsat	16-18
SPOT	26

3.7 Summary and Conclusion

- There are four types of resolutions, these are, spatial, spectral, radiometric, and temporal
- The spatial resolution is the minimum element area that the sensor can measure. The resolution element is called pixel. For example LISS III has 23.5 m resolution, Pan 5.8 m
- Spectral resolution refers to sensing and recording power of the sensor in the different bands of EMR. For example Landsat — MSS 7 bands, IRS- 4 Bands.
- Radiometric resolutions recorded in digital number of different bands of sensors. For example LISS-III7 bit (128 levels) color is 0-127 colors.
- Temporal resolution obtains the spatial and spectral data at a certain time interval. For example IRS-1 A/1 B revisits the same at 22 days, where as Pan revisits at 5 days.
- Temporal resolution obtains the spatial and spectral data at a certain time interval. For example IRS-1 A/1 B revisits the same at 22 days, where as Pan revisits at 5 days.

3.8 Keywords

Resolution, Spatial Resolution, Temporal Resolution, Spectral Resolution, Radiometric Resolution, Data Procurement, IRS, IANDSAT, Image Referencing System Bands.

3.9 Model Questions

1. What is Resolution?
2. What is Spatial Resolution?
3. What is Temporal Resolution?
4. What is Spectral Resolution?
5. What is Radiometric Resolution?

6. What are the image Referencing Schemes?
7. What do you understand by data procurement?
8. State about the Indian Space mission in details.
9. What is LANDSAT Satellite system?
10. What is band?
11. State about the remote sensing data product.
12. What is a row?
13. What is a path?
14. What is orbital calendar?

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Unit - 4 ❑ Application of sensor resolutions with reference to IRS and LANDSAT missions

Structure :

4.0 Learning objectives

By the end of this unit students would be able to:

- Understand the concept and nature of resolutions
- Know about the application of resolutions
- Learn about the resolutions of IRS satellite
- Know about the resolutions of LANDSAT satellite

4.1 Image Referencing Schemes or System

Image referencing system (also referred to as Worldwide Reference System (WRS), which is unique for each satellite mission, is a means of conveniently identifying the geographic location of points on the Earth. It enables the user to inquire about satellite imagery over any portion of the world. This scheme is designated by Path and Rows. The Path-Row concept is based on the nominal orbital characteristics. This section describes the referencing scheme and related information.

4.1.1 Path :

An orbit is the course of motion taken by the satellite in space and the ground trace of the orbit is called a 'Path'. For example IRS Resourcesat-1 in a 24 day cycle, completes 341 orbits with an orbital period of 101.35 minutes. This way, the satellite completes approximately 14 orbits per day. Though the number of orbits and paths are the same, the designated path number in the referencing scheme and the orbit number are not the same. On day one (D1), the satellite covers orbit numbers 1 to 14, which as per the referencing scheme will be path numbers 1, 318, 294, 270, 246, 222, 198, 174, 150, 126, 102, 78, 54 and 30, assuming that the cycle starts with path 1. So orbit 1 corresponds to path 1, orbit 2 to path 318, orbit 3 to path 294 etc. The fifteenth orbit or first orbit of day two (D2), is path 6 which will be to the east of path 1 and is separated from path 1 by 5 paths. Path number one is assigned to the track which is at 29.7O West longitude. The gap between successive path is 1.055O. All subsequent orbits fall westward. During operation, the actual path may vary from the nominal path pattern due to variations in the orbit by perturbations. Therefore, the orbit is periodically adjusted after a specified amount of drift has occurred in order to bring the satellite back to an orbit that is nearly coincident with the initial orbit (IRS-P6, Data User's Manual, NRSA, Oct 2003).

4.1.2 Row

Row refers to the latitudinal centre line of a frame of imagery. As the satellite moves along its path, the observatory instruments are continuously scanning the terrain below. The instrument signals are transmitted to Earth and correlated with telemetry ephemeris data to form individual framed images. During this process, the continuous data are segmented into individual frames of data known as *scenes*. The scenes are framed in such a manner that one of the scenes' centre lies on the equator. For example, IRS Resourcesat-1 LISS-III scene, consisting of 6420 lines, is framed such that the centre of the scene lies on the equator. The uniformly separated scene centres are, such that, same rows of different paths fall at the same latitude. This is continued upto 81O North and 81O South latitude. The lines joining the corresponding scene centres of different paths are parallel to the equator and are called Rows (Figure 2). The uniformly separated scene centres are such that same rows of different paths fall at the same latitude. The row number 1 falls around 81O North latitude, row number 41 will be near 40O North and row number of the scene lying on the equator is 75. The Indian region is covered by row numbers 30 to 90 and path numbers 65 to 130 (IRS-P6, Data User's Manual, NRSA, Oct 2003).

The Path-Row referencing scheme eliminates the usage of latitude and longitudes and facilitates convenient and unique identification of a geographic location. It is useful in preparing accession and product catalogues and reduces the complexity of data products generation. The combination of a path number and a row number uniquely identifies a nominal scene centre. The path number is always given first, followed by the row number. The notation 127-043, for example, relates to path number 127 and row number 043.

Using the referencing scheme, the user can arrive at the number of scenes that covers his area of interest. However, due to orbit and attitude variations during operation, the actual scene may be displaced slightly from the nominal scene defined in the referencing scheme.

4.1.3 Orbital Calendar

Since the satellite covers different areas (or paths) on different days, an orbital calendar is required which tells us this information. An orbital calendar allows users to look up the calendar date on which a particular path will be followed by a satellite.

For example, in case of Resourcesat-1, for a chosen path, the ground track repeats every 24 days after 341 orbits. Therefore, the coverage pattern is almost constant. Therefore, on any given day, it is possible to determine the orbit which will trace a designated path. Once the path is known, with the help of referencing scheme, it is possible to find out the day on which data may be captured. Therefore, an orbital calendar, giving the details of paths, covered on different days is helpful to users to plan their procurement of satellite data products for several temporal analysis. Considering the typical path calendar of Resourcesat-1, assuming that path number 1 is covered on January 11, if data over a geographic area covered by path 108 is required, it is seen that this path is covered on days, 18th of January, 11th of February, 06th of March and so on. Thus, it is possible to know on which day the required data has been collected or is going to be collected.

4.2 Remote Sensing Data Products

Remote sensing data products are available in a wide variety of media and formats. The classification of products is generally based on the following:

- Level of processing / enhancement
- Output media/scale

The raw data acquired from satellite has radiometric and geometric distortions. This is corrected by processing the data on computer systems. The corrected data is then put in the required media. The typical different levels of processing are :

- ***Raw Data:*** No processing is done here and the relevant scene is extracted and put on the media. Generally, raw data are available only as digital product, because photographic printouts of uncorrected images are not interpretable.

- ***Partially Processed Data:*** Radiometrically corrected but geometrically uncorrected, or geometrically corrected but radiometrically uncorrected data are known as partially processed data.

- ***Processed or Standard Data:*** These data are both radiometrically and geometrically corrected.

- ***Geocoded Data:*** These products are north oriented and compatible to the Survey of India mapsheet. That means, overlay of this data with Survey of India map can be performed.

- ***Ortho rectified data:*** Orthoimages are geometrically corrected products with corrections for displacement caused by terrain and relief (refer Chapter-VIII). In other words, it is an image prepared in such a manner that the perspective aspect of the image has been removed.

- ***Special Data Products:*** Besides the above mentioned data, NRSA and other agencies also offer certain special/custom products to suit user requirements. These include mosaiced, merged and extracted data from different sensors in suitable scales.

4.3 Media for Digital Data Recording, Storage, and Distribution

Generally, satellite data received at a ground station are recorded in real time into high density digital tape (HDDT). The HDDT data is transferred to computer compatible tape (CCT) and/or other media (like floppy disks) for distribution. Recently, optical disks, for example, MO disk (magneto-optical disk with erasable function), compact disk-read only memory (CD-ROM) and digital versatile disk (DVD) are becoming popular. For distribution to public users, compatibility is the most important; CD-ROM and DVD are very convenient and also are low cost as mass media. For use in data centres, the factors of data storage, portability, cost, and durability are more important than compatibility. Recently, digital audio tape (DAT) or cartridge tape is replacing HDDT and CCT because of its compact size.

4.4 Procurement of satellite data and data interpretation

Procurement of satellite data, Import and export of digital data to working environment. Study of satellite image annotation (information) LANDSAT, SPOT and IRS and Referencing Scheme (Analog and Digital). The role of proprietary and open source software systems; desktop systems to mobile systems. Remote Sensing proprietary or commercial software

- **Open Source Software :**

  GLOBAL Mapper, Earth Explorar, Easytrace etc for spacific map making purpose.

  Open source remote sensing software includes GRASS GIS, GEO DA, QGIS, SAGA, OSSIM, ILWIS, Opticks (software) and Orfeo toolbox. Open source remote sensing data are available in www.USGS for ASTER data.

  GLCF for SRTM, Landsat, TM data, Bhuban for LISS III arcive data

For Procurement of satellite imagery this website is requirel :

Web site: www.nrsc.gov.in

How to use this site :

- Installed Java programming software
- Create a user account with password
- Follow the processing steep

Availability of image data

Image data requirements have been determined, depend on data availability, accessibility and coasts. The availability depends on the already acquired data stored in archives or data that need to be acquired data that need to be acquired at your request. The size and accessibility of image archives are growing at a fast rate. If uptodate data are required, these need to be requested through NRSC web site.

Availability and cost

Once you have determined your data requirements, you have to investigate the data availability, accessibility, and costs. The availability depends on data that were already acquired and stored in archives, or data that need to be acquired at your request. The size and accessibility of image archives is growing at an ever faster rate. If up-to-date data are required, these need to be requested through an aerial survey company or from a remote sensing data provider. In details cost and availibility of data is available in NRSC website.

4.4.1 Application of different spectral band

Table 4.1 : SpedraI band of Landsat-l MSS image and relative applications

Band	**Wavelength (Micrometer)**	**Nominal Speetral location**	**Principal Applications**
4	0.5-0.6	Blue	Water penetration, determination of turbidity in water bodies. to distinguish ureen veueunion from other surface cover, and to identify geological features.
5	0.6-0.7	Green	Useful for defining cultural and topograpbic features, for classitying different types of vegetation with full ground cover and twbidity variations in water bodies.
6	0.7-0.8	Red	Surface water mapping to differentiste conifer from deciduous forest cover, and determination of green biomass in vegetation.
7	0.8-1.1	Near Infrared	Effeelive for land/water boundary delineations, soil-crop contrasts, discrimination of open water bodies from wet soil, useful for detecting crop stress due to disease and pest attack.

(Source: NASA)

Table 4.2 : Spectral band of Landsat-4 TM image and relative applications

Band	Wavelength (Micrometer)	Nominal Speetral location	Principal Applications
1.	0.45-0.52	Blue	Designed for water body penetration, making it useful for coastal water mapping. Also useful for soil/vegetation discrimination, forest type mapping, and cultural feature identification.
2.	0.52-0.60	Green	Designed to measure green reflectance peak of vegeialion for vegetation discrimination and vigor assessment. Also useful for cultural feature identification.
3.	0.63-0.69	Red	Designed, to sense in a chlorophyll absorption region aiding in plant species differentiation. Also useful for cultural feature identification.
4.	0.76-0.90	Near Infrared (NIR)	Useful for detern1ining vegetation types, vigor, and hiomass content, for delineating water bodies and for soil moisture discrimination.
5.	1.55-1.75	Mid Infrared	Indicative of vegetation moisture content and soil moisture. Also useful for differentiation of snow from clouds.
6.	10.4-12.5	Thermal Infrared	Useful in vegetation stress auahsis. Soil moisture discrimination and thermal mapping applications.
7.	2.08-2.35	Mid Infrared	Useful for discrimination of mineral and rock types. Also sensitive to vegetation moisture content and for hydro-thennal mapping.

(Source: NASA)

Table 4.3 : Spectral band of IRS LISS III and relative applications

Band	Wavelength (Micrometer)	Nominal Speetral location	Principal Applications
1.	0.45-0.52	Blue	Coastal cmironmenlal studies. Soil/ vegetation differentiation. Coniferous/ deciduous vegetation discrimination.
2.	0.52-0.59	Green	Vegetation vigor assessment. Rock/soil discrimination. Studies in turbidity and bathymetry in shallow water.
3.	0.62-0.68	Red	Strong chlorophyll absorption leading to discrimination of plant species.
4.	0.77-0.86	Near Infrared (NIR)	Delineation of water features. Landform/ geomorphie studies.

(Source : NNRMS, 1991)

4.4.2 Application of different sensor resolution

Different sensors-are having different resolution, Some sensor has inferior or low resolution, whereas some sensor has superior or high resolution. Different applications are governed by quality of resolution. For example, in case of detail study of Urban area or city mapping, it better to use Pan data of IRS or the Cartosat data. On the other hand for study of forest resources or water bodies, use ofWiFS data would suffice purpose.

4.5 Summary and Conclusion

- There are four types of resolutions, these are, spatial, spectral, radiometric, and temporal
- The spatial resolution is the minimum element area that the sensor can measure. The resolution element is called pixel. For example LISS III has 23.5 m resolution, Pan 5.8 m

- Spectral resolution refers to sensing and recording power of the sensor in the different bands of EMR. For example Landsat — MSS 7 bands, IRS- 4 Bands.
- Radiometric resolutions recorded in digital number of different bands of sensors. For example LISS-III7 bit (128 levels) color is 0-127 colors.
- Temporal resolution obtains the spatial and spectral data at a certain time interval. For example IRS-1 A/1 B revisits the same at 22 days, where as Pan revisits at 5 days.
- Temporal resolution obtains the spatial and spectral data at a certain time interval. For example IRS-1 A/1 B revisits the same at 22 days, where as Pan revisits at 5 days.

4.6 Keywords

Resolution, Spatial Resolution, Temporal Resolution, Spectral Resolution, Radiometric Resolution, Data Procurement, IRS, IANDSAT, Image Referencing System Bands.

4.7 Model Questions

1. What is Resolution?
2. What is Spatial Resolution?
3. What is Temporal Resolution?
4. What is Spectral Resolution?
5. What is Radiometric Resolution?
6. What are the image Referencing Schemes?
7. What do you understand by data procurement?
8. State about the Indian Space mission in details.
9. What is LANDSAT Satellite system?
10. What is band?
11. State about the remote sensing data product.
12. What is a row?

13. What is a path?
14. What is orbital calendar?

4.8 References and Further Readings

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Unit - 5 ❑ Image referencing schemes; Remote sensing data acquisition

Structure :

5.0 Learning objectives

By the end of this Unit, students would be able to:

- Understand Structure of Remote Sensing data
- Learn about Digital Image Processing
- Differentiate between Analog and Digital Image Processing
- Know about Digital Image Processing Techniques : Image Restoration.
- Learn about Geometric correction
- Know about Radiometric correction
- Learn about feature extraction through Digital Image Classification

5.1 Introduction

Analysis of remote sensing data is done using various image processing techniques and methods that includes, Analog image processing and Digital image processing. The raw satellite images may contain a variety of errors in their geometry and radiometry. Hence it is important to rectify these images before starting their interpretation. This typically involves the initial processing of raw satellite image for correcting geometric distortions, radiometric corrections & calibration and noise removal from the data. Digital Image Processing is the manipulation of the digital data with the help of the computer hardware and software to produce digital maps in which specific information has been extracted and highlighted

Data Transmission to Earth

The earth-viewing sensor normally generates a frequency signal corresponding to its measurements, and this information is encoded as an analogue signal. Most satellite systems have now converted the analogue signal to a digital signal to earth in the binary coding. Such radiance is generally expressed in the gray level range orbit.

5.2 Structure of Remote Sensing data

A digital image consists of an array of tiny, equal areas, or picture elements, Arranged in regular rows and columns. The position of any picture element, or pixel, is determined on an 'xy' coordinate system. Each pixel also has a numerical value called a 'digital number' (DN) that records the intensity of electromagnetic energy measured for the -ground resolution cell represented by that pixel. Digital numbers range from zero to some higher number on a gray scale.

An image is a two-dimensional representation of objects in a real scene. Remote sensing images are representations of parts of the earth surface as seen from space. A digital image is a two-dimensional array of pixels. Each pixel has an intensity value (represented by a digital number) and a location address (referenced by its row and column numbers).

A digital image is the numerical representation of image or photographic data. It consists of a two dimensional matrix, i.e. in row and column form. Such a representation is referred to as *raster image*. Each element in the raster image is called a *pixel*, and it is associated with an *address of the matrix* (e.g. column number and row number). Again each pixel has a third dimension known as *grey value* or *grey level*. (Fig. 5.1) & (Fig. 5.2)

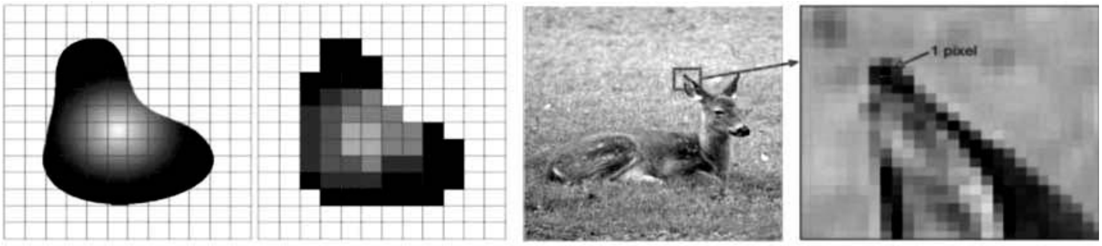

Fig. 5.1 : Raster image

Spectral Reflectance to DN (Digital Number)

Thus Digital Image is the visual product of remote sensing and mathematically this image can be defined as I (x, y) = v, where I is the intensity function and v is the grey value at x, y the location (Fig. 3.3). The size of a pixel is defined as the spatial resolution of the digital image. A high-resolution image has more number (with smaller in size) pixels than a low-resolution image. A high-resolution image exhibits finer details and better approximation of the input continuous tone image. The width and height of the pixels are kept equal for the sake of symmetry in the image.

The digital data are normally stored in one of the following three formats:

1. Band Interleaved by Pixel (BIP) in which data for each pixel element inall the three bands is written sequentially.
2. Band Interleaved by Line (BIL) where the data for all the bands are written line by line, and.
3. Band Sequential (BSQ) where all the data for each band is written as one file, and stored sequentially.

Each spectral wavelength represents as a single layer in remote sensing data called "Band" or "channel". The more bands or channels present, the more spectral properties in remote sensing data.

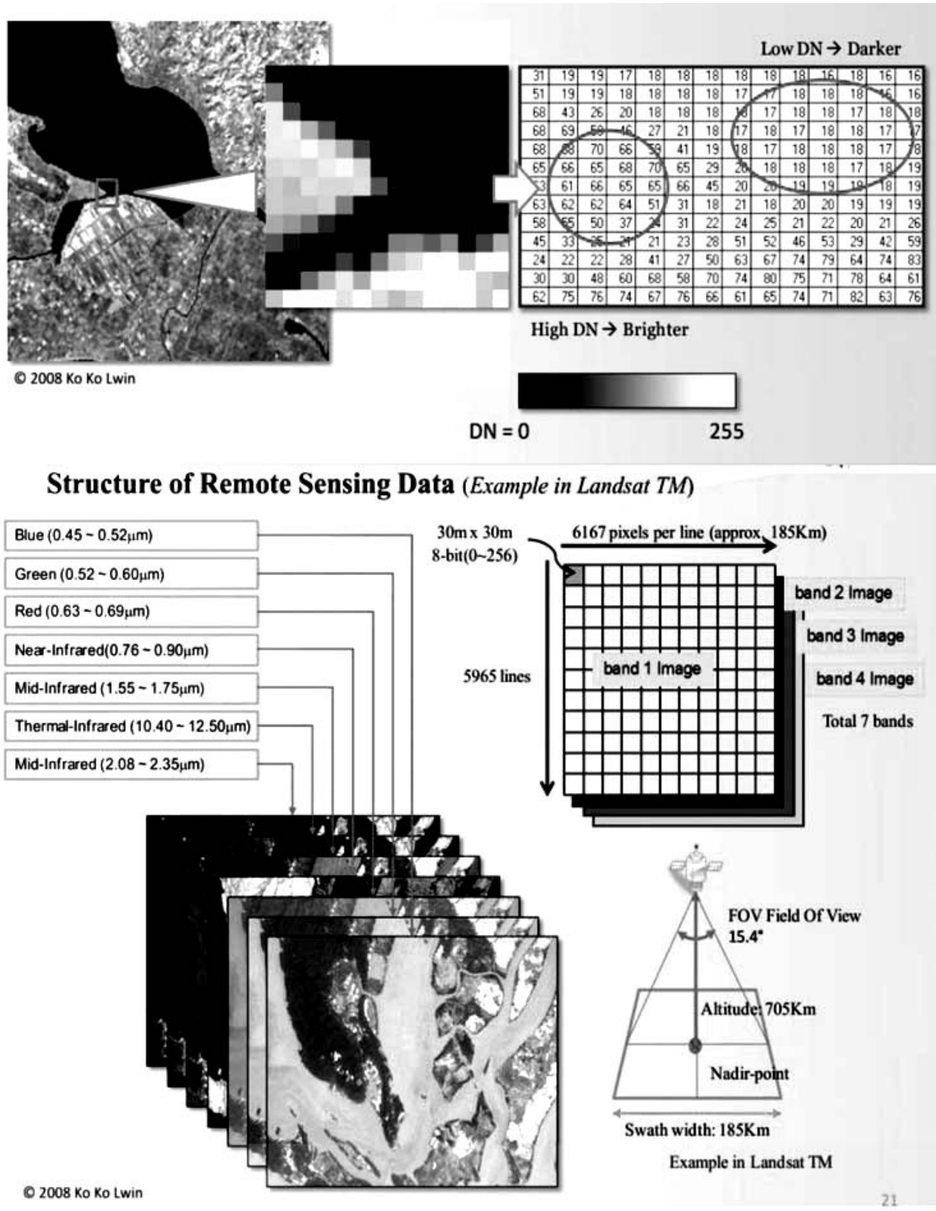

Fig. 5.3 : Bands

5.3 Digital Image Processing

Digital Image Processing System is the collection of algorithms processed by the computer system to enhance the quality of raw data in order to get enhanced images for further process of interpretation and data extraction.

The steps involved in DIP.

A. Image restoration

B. Statistical analysis

C. Image enhancement

D. Image classification

Image Restoration : It refers to correct the distorted or degraded image to represent original scene. The steps included in image restorations are;

(i) Geometric correction (Image Rectification)

(ii) Radiometric correction

(iii) Noise removal

Image restoration processes are designed to identify noise, geometric distortion introduced into the data during scanning, transmission & recording processes. The objective is to map the image resembled to original scene.

Various processing techniques are available for image analysis eg Radiometric transformation geometric correction, data presentation and compression, image enhancement, statistical analysis, clustering, feature extraction and classification for presentation of results.

5.4 Differentiate between Analog and Digital Image Processing

Flexibility :	Human: Very adaptable and flexable as to task and the type of input DIP : Rigid as to the task; it can only perform what It was designed for.
Sensitivity :	Human: Adapts easily to changes in e.g lighting conditions. DIP : It must be designed for.
Speed :	Human: Relatively slow. DIP : Fast
Complexity :	Human: Is able to navigate through a complex 3D scene without significant problems DIP : Can handle 3D tasks quite easy, but slow at 3D tasks

Reproducible : Human: Can estimate very well, but subjective
DIP : Good

Spectrum : Human: only sensitive to visible light
DIP : Electromagnetic sensors range from X ray to the Tharmal Infra Red sensor

5.5 Processing Overview : Remote sensing data acquisition

- **Image restoration techniques** this compensates for data error, noise, geometric distortions introduced during the scanning, recording, and playback operation. **Restoring periodic line dropouts**, **Restoring periodic line striping**, **Filtering of random noise**, **Correcting for atmospheric scattering**, **Correcting geometric distortions**
- **Image Enhancement techniques** - These alter the visual impact that the image has on the interpreter in a fashion that improves the information content. **Contrast enhancement, Density slicing. Edge enhancement, Principal component transformations**
- **Information extraction techniques** - These techniques utilize the decision making capability of the computer to recognize and classify pixels on the basis of their digital signature: **Supervised** and **Un-supervised** Classification techniques

5.6 Image Restoration Techniques

These operations aim to correct distorted or degraded image data to create a more faithful representation of the original scene. Image rectification and restoration procedures are often termed 'pre-processing' operations.

- **Restoring Periodic Line Dropouts**

  On some MSS images, data from one of the six detectors are missing because of a recording problem. Every 6th scane line was recorded as a string of zero that plots as a black line on the image. These are called periodic line dropouts. To restore these blank stripes. average DN value per scan line is calculated for the entire scene. The average DN value for each scan line is then compared with this scene average. Any scan line deviating from the average by more than a designated threshold value is identified as defective. The next step is to replace the defective lines. For each pixel in a defective line, an average DN is calculated using DN's for the corresponding pixel on the proceeding and succeeding lines. The average DN is substituted for the defective pixel.

- **Restoring Periodic Line Striping**

  The defect caused by the drifting of the detector response to higher or lower level results in recording of every scan line are brighter or lighter than the other lines. The general term for this defect is periodic line striping. Six histograms are plotted for the DNs recorded by each detector and the histograms are compared with the histogram for the entire scene. For each detector the mean and standard deviation are adjusted to match the values for the entire scene.

- **Filtering of Random Noise**

  Random noise typically occurs individual pixels with DNs that are much higher or lower than the surrounding pixels. In the image these pixels produce bright and dark spots on the image. The average of the surrounding eight pixels gives the new value of DN for the noise pixel. .

- **Correcting for Atmospheric Scattering**

  The atmosphere selectively scatters the shorter wavelengths of light. For Landsat MSS images, band 4 (0.5 to 0.6 _um) has the highest component of scattered light and band 7 (0.8 to 1.1 _um) has the least. Atmospheric scattering produces haze, which results in low image contrast. The contrast ratio is improved by correcting for this effect.

  To remove this haze, a scatter plot is made between band 4 and band 7, and straight line is fitted through the plot, using a least square technique. If there were no haze in band 4, the line would pass through the origin, because there is haze. the intercept is offset along the band 4 axis. Haze has an additive effect on scene brightness. To correct the haze effect on band 4. the value of the intercept offset is subtracted from the DN of each band-4pixel for the entire image.

5.7 Summary and Conclusion

- Most remote sensing data are recorded in digital format, virtually all image interpretation and analysis involves some element of digital processing. Digital Image Processing may involve numerous procedures including formatting and correction of the data, digital enhancement to facilitate better visual interpretation, or even automated classification of targets and features entirely by computers.

5.8 Keywords

Digital image, Analog image, DIP, Image Restoration, Geometric correction, Radiometric correction, ground control point (UCP)

5.9 Model Questions

- What is Digital Image?
- How satellite data are transmitted to Earth
- Explain different techniques of data structures in Digital Image Processing.

  Which are the radiometric errors that can be introduced due to malfunctioning of satellite sensors?

  What are the differences between line dropouts and line striping?

  Explain the procedure' for haze correction on remotely sensed data.
- Compare an image and map coordinate system (give figure with comment).
- What is the purpose of acquiring stereo pairs of image data?
- What are ground control points used for?
- Give the different steps of the process of image classification.
- What is the principle of image classification?
- What is a classification algorithm? Give two e:xamples.

5.10 References and Further Readings

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Unit - 6 ❑ Standard False Colour Composites

Structure :

6.0 Learning objectives

By the end of this Unit students would be able to:

- Understand the basic concept of Colour composition
- Learn about True colour composition, False colour composition (FCC) and Standard False colour composition (St. FCC)

6.1 Introduction

Identification of objects and their classification visually from the hard copy photographs prints based on the image characteristics, such as shape, size, tone, texture, pattern, location, association, shadow and aspect is commonly known as visual interpretation.

6.2 Understand the basic concept of Colour composition

Perception of colour

Colour perception takes place in the human eye and the associated part of the brain.

Colour perception concerns our ability to identify and distinguish colours, which in turn enables us to identify and distinguish entities in the real world. It is not completely known how human vision works, or what exactly happens in the eyes and brain before someone decides that an object is, *eg*, dark blue. Some theoretical models, supported by experimental results are, however, generally accepted. Colour perception theory is applied whenever colours are reproduced, for example in colour photography, TV, printing and computer animation.

6.3 True colour composition, False colour composition and Standard false colour composition

6.3.1 Red Green & Blue (RGB)

The RGB definition of colours is directly related to the way in which computer and television screens function. Three channels directly related to the red, green and blue dots are the input to the monitor. When we look at the result, our brain combines the stimuli from the red, green and blue dots and enables us to perceive all possible colours of the visible part of the spectrum. During the combination, the three colours are added. We see yellow when when green dots are illuminated in addition to red ones. This principle is called the *additive colour scheme*. In below Figure, illustrates the additive colours caused by bundles of light from red, green and blue spotlights shining on a white wall in a dark room. When only red and green light occurs, the result is yellow. In the central area there are equal amounts of light from all three the spotlights, so we experience 'white'.

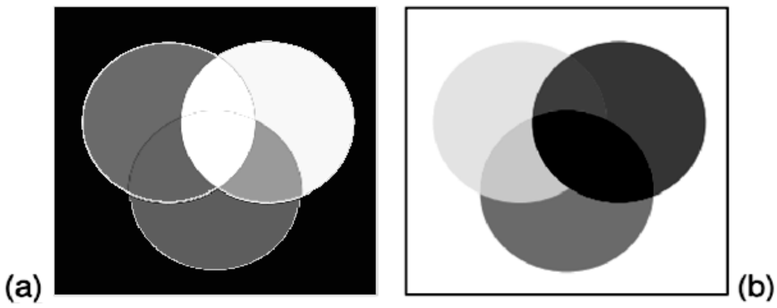

Fig. 6.1 RGB

6.3.2 False Colour Composition (FCC)

While displaying the different bands of a multispectral data set, images obtained in different bands are displayed in image planes (other than their own) the color composite is regarded as False Color Composite (FCC). High spectral resolution is important when producing color components. For a true color composite an image data used in red, green and blue spectral region must be assigned bits of red, green and blue image processor frame buffer memory.

6.3.3 Standard false colour Composition

A color infrared composite 'standard false color composite' is displayed by placing the infrared, red, green in the red, green and blue frame buffer memory (Fig. 12.1). In this healthy vegetation shows up in shades of red because vegetation absorbs most of green and red energy but reflects approximately half of incident Infrared energy. Urban areas reflect equal portions of NIR, R & G, and therefore they appear as steel grey.

The 'visible portion' of the spectrum with wavelengths causing colour is only a very small fraction of the entire EM wavelength range. We call objects 'green' when they reflect predominately EM energy of wavelength 0.54 ¼m. The intensity of solar radiation has its maximum around this wavelength and the sensitivity of our eyes is peaked at green-yellow, We know that colour effects our emotions and we usually experience green sceneries as pleasant. We use colour to discriminate objects and we can use it to estimate temperature. We also use colour to visualize EM energy we cannot see directly.

The radiation beyond red light towards larger wavelengths in the spectrum is referred to as infrared (IR). We can discriminate vegetation types and the stress state of plants by analyzing 'near-infrared' (and 'mid-infrared') radiation - much better then trying to so by colour. For example, deciduous trees reflect more near-infrared (NIR) energy than conifers do, so they show up brighter on photographic film that is sensitive to infrared. Healthy vegetation has a high reflectance in the NIR range, which decreases with increasing damage caused by a plant disease. Mid-IR is also referred to as short-wave infrared (SW1R). SW1R sensors are used to monitor surface features at night.

6.4 Summary and Conclusion

- Visual image interpretation is one of the methods to extract information from remote sensing image data. For that purpose, images need to be visualized on screen or in hard-copy. The human vision system is used to interpret the colours and patterns on the picture. Spontaneous recognition and logical inference (reasoning) are distinguished.
- Interpretation keys or guidelines are required to instruct the image interpreter. In such guidelines, the (seven) interpretation elements can be used to describe how to recognize certain objects. Guidelines also provide a classification scheme, which defines the thematic classes of interest and their (hierarchical) relationships. Finally, guidelines give rules on the minimum size of objects to be included in the interpretation.
- When dealing with a new area or a new application, no guidelines are available. An iterative approach is then required to establish the relationship between features observed in the picture and the real world.

6.5 Keywords

Colour composition, FCC, Stardard FCC, RGB, VIP, DIP, Analog interpretation, Preparation of LULC maps.

6.6 Model Questions

1. What is the relationship between image visualization and image interpretation?
2. Describe different types of image interpretation elements.
3. Describe how to recognize a road and a railway line on a saellte image
4. Give different reasons for field observation in the process of image interpretation.
5. Define land cover and land use with example.
6. Differentiate between Visual and Digital Image Processing

7. What is the Principle of preparing Standard FCC
8. Describe the basic concept of preparing colour composition
9. In a standard FCC image why vegetation is shown in red colour explain it.
10. How association is involved to identify features in a satellite image

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Unit - 7 ❑ Preparation of False Colour Composites from IRS LISS-3 and LANDSAT TM data

Structure :

7.0 Learning objectives

By the end of this unit students would be able to:

- Understand the basic concept of false colour composition
- Know about LANDSAT

- Know about IRS
- Know about applicability of different bands

7.1 IRS Satellite Mission

IRS-IC & ID

India puts much effort into remote sensing and has many operational missions and missions under development. The most important Earth Observation programme is the Indian Remote Sensing (IRS) programme. Launched in 1995 and 1997, two identical satellites, IRS-1C and IRS-1D, can deliver image data at high revisit times. IRS-1C and IRS-1D carry three sensors: the Wide Field Sensor (WiFS) designed for regional vegetation mapping, the Linear Imaging Self-Scanning Sensor 3 (LISS3), which yields multispectral data in four bands with a spatial resolution of 24 m, and the PAN.

In this subsection, the characteristics of the PAN sensor are given. For a number of years, up to the launch of IKONOS in September 1999, the IRS-1C and -ID were the civilian satellites with the highest spatial resolution. Applications are similar to those of SPOT and Landsat.

IRS ID Pan Characteristics

System	**IRS-1D**
Orbit	817 km, 98.6°, sun-synchronous, 10:30 AM crossing, 24 days repeat cycle
Sensor	PAN(PanchromaticSensor)
Swath width	70 km
Off-track viewing	Yes, ± 26° across-track
Revisit time	5 days
Spectral bands (¼m)	0.50-0.75
Spatial resolution	6 m
Data archive at	www.spaceimaging.com

Remarks

The multispectral scanner is a sensor that collects data in various wavelength bands of the EM spectrum. The scanner can be mounted on an aircraft or on a satellite. There are two types of scanners: whiskbroom and pushbroom scanners. They use solid state detectors and CCD-arrays respectively for measuring the level of energy. The resulting image data store the level of energy as Digital Numbers/ which are calculated during the quantization process. Multispectral scanners provide multiband data.

In terms of geometrically reliable data the pushbroom scanner performs best. In terms of measuring many spectral bands (including thermal infrared) the current whiskbroom scanners are the best.

7.2 LANDSAT Satellite mission

Landsat-7

The Landsat programme is the oldest Earth Observation programme. It started in 1972 with the Landsat-1 satellite carrying the MSS multispectral sensor. After 1982, the Thematic Mapper (TM) replaced the MSS sensor. Both MSS and TM are whiskbroom scanners. In April 1999 Landsat-7 was launched carrying the ETM+ scanner. Today, only Landsat-5 and -7 are operational.

System Landsat-7

Orbit	705 km, 98.2°, sun-synchronous, 10:00 AM crossing, 16 days repeat cycle
Sensor	ETM+ (Enhanced Thematic Mapper
Swath width	185km (FOV = 15°)
Off-track viewing	No
Revisit time	16 days
Spectral bands	0.45-0.52(1), 0.52-0.60(2), 0.63-0.69(3), 0.76-0.90(4), 1.55-1.75(5), 10.4-12.50(6), 2.08-2.34(7), 0.50-0.90JPAN)
Spatial resolution	15 m (PAN), 30 m (bands 1-5, 7), 60 m (band 6)
Data archive at	earthexplorer.usgv.gov

There are many applications of Landsat Thematic Mapper data: land cover mapping, land use mapping, soil mapping, geological mapping, sea surface temperature mapping, *et cetera*. For land cover and land use mapping Landsat Thematic Mapper data are preferred, e.g., over SPOT multispectral data, because of the inclusion of middle infrared bands. Landsat Thematic Mapper is the only non-meteorological satellite that has a thermal infrared band. Thermal data are required to study energy processes at the Earth's surface, for instance, the crop temperature variability within irrigated areas. Table 5.4 gives the principle applications of the various TM bands.

Principal application of the Landsat TM bands

Band	Wavelength (μm)	Principal Applications
1	0.45-0.52	Designed for water body penetration, making it useful for coastal water mapping. Also useful for soil-vegetation discrimination and forest type mapping.
2	0.52-0.60	Designed to measure green reflectance peak of vegetation for vegetation discrimination and vigour assessment.
3	063.0.69	Designed to sense in a chlorophyll absorption region aiding in plant species differentiation.
4	0.76-0.90	Useful for determining vegetation types, vigour, and bio-mass content, for delineating water bodies, and for soil moisture discrimination.
5	1.55-1.75	Indicative of vegetation moisture content and soil moisture. Also useful for differentiation of snow from clouds.
6	10.4-12.5	Useful in vegetation stress analysis, soil moisture discrimination, and thermal mapping applications.
7	2.08-2.35	Useful for discrimination of mineral and rock types. Also sensitive to vegetation moisture content.

7.3 Applicability of LISS / WIFS / TM Bands

Band 1 (*0.42-0.52 ¼m: Visible Blue*): Maximum penetration of water is achieved in this band. Useful for coastal mapping, suspended sediment estimations as well as soil/ vegetation and deciduous/coniferous differentiation.

Band 2 (*0.52-0.59 ¼m: Visible Blue-Green*) This band is centred on the first peak of the vegetation reflectance curve and is useful for discrimination of vegetation and suspended sediment analysis. This band along with red and near IR regions forms the core data of most remote sensing satellites.

Band 3 (*0.62-0.68 ¼m: Visible Red*): This band is centred on the chlorophyll absorption region of vegetation. Strong correlation exists between spectral reflectance in this region and chlorophyll content. A reduction in the amount of chlorophyll can occur when the plant is stressed. This results in less chlorophyll absorption and an increase in red reflectance. This band along with the near IR band is used widely for deriving spectral indices like ratio and Normalised Difference Vegetation index (NDVI) which have been found to be very good indicators of crop vigour and biomass. Also useful for plant species differentiation.

Band 4 (*0.77-0.86 ¼m: Near Infrared*): The high reflectance plateau region of the vegetation reflectance is in this band. Plant reflectance in this region is highly governed by the internal structure of plant leaves. This band shows high reflectance for healthy vegetation and is useful for green biomass estimation and crop vigour. Because of strong absorption of NIR by water, this band is ideal for land-water discrimination.

Band 5 (*1.55-1.70 ¼m: Short Wave or Middle Infrared*): The middle infrared region from 1.3–2.5 ¼m is sensitive to leaf water content. It has been shown that 1.55–1.70 ¼m is best-suited in 0.7–2.5 ¼m region for monitoring plant canopy water status. Major applications of this band include discrimination of crop types, canopy water status, forest type separation and damage assessment. Crop classification accuracy can be improved by 1–15% when this band is included with other bands. It is also useful for discrimination between snow and cloud and between different rock types.

Band 6 (*10.4-12.5 ¼m: Thermal Infrared*): Useful for plant heat stress measurements and thermal mapping of the earth surface. Also used to estimate soil moisture content.

Band 7 (*2.08–2.35 ¼m: Thermal Infrared*): Useful for hydrothermal mapping, identification of rocks, mineral deposits and geological structures.

* 1.75 in TM

7.4 Applicability of IRS-P4 (OCEANSAT) OCM Bands

Band 1 *(0.402–0.442 ¼m: Visible Blue)* : Used in detection of yellow substances and turbidity

Band 2 *(0.433–0.453 ¼m: Visible Blue)* : Chlorophyll absorption is maximum in this band

Band 3 *(0.480–0.500 ¼m: Visible Blue)* : Used to detect chlorophyll and other pigments

Band 4 *(0.500–0.520 ¼m: Visible Green)* : Used in detection of turbidity and suspended sediment.

Band 5 *(0.545–0.565 ¼m: Visible Green)* : Used in detection of chlorophyll and suspended sediment

Band 6 *(0.660–0.680 ¼m: Visible Red)* : Used in detection of chlorophyll absorption

Band 7 *(0.745–0.785 ¼m: Near Infra Red)* : Used in detection of oxygen absorption.

Band 8 *(0.845–0.885 ¼m: Near Infra Red)* : Used in detection of aerosol optical thickness, vegetation, water vapour.

MSMR is used for observing water vapour and liquid water content in the atmospheric column, through suitable modelling. The brightness temperature of ocean surface is a function of surface roughness, which, in turn, is a function of wind speed. Thus the data collected by MSMR are also used to determine wind speed over oceans.

7.5 Preparation of False Colour Composite

Any combination ofbands not representing the true colour of the objects in the output image is termed as FCC. They are generated with the purpose of better interpretation of the multi-band satellite data.

In case of standard false colour composite, the combination of bands and the respective colour assignments are well defined. Hence they are known as standard FCC. The most commonly seen standard false colour images display the very near infrared as red, red as green and green as blue.

In case of IRS LISS-III, the following band combinations are used for preparation of standard FCC:

Table : 3.1 Preparation of FCC from IRS LISS III data

Band	Spectral range (μ)		Additive Primary Colour (Light Beam)
2	0.52-0.59	Green	Blue
3	0.62-0.68	Red	Green
4	0.77-0.86	Near Infrared	Red

On the other hand, in case of Landsat TM. the following band combinations are used for preparation of standard FCC:

Table: 3.2 Preparation of.FCC from Landsat TM data

Band	Spectral range (μ)	Additive Primary Colour (Ligbt Beam)
2	0.52-0.60	Green Blue
3	0.63-0.69	Red Green
4	0.76-0.90	Near Infrared Red

7.6 Indian Space Research Organisation (ISRO) : Programme Highlights :

7.6.1 Early programmes

- Aryabhatta satellite, weighing 360 kg was launched by Soviet Intercosmos rocket on 19 April, 1975. The objectives of this project were to indigenously design and fabricate a space-worthy satellite system and evaluate its performance and to set up ground-based receiving, transmitting and tracking systems as well as to establish infrastructure for the fabrication of spacecraft systems.

- 1975-76 saw large-scale experiments in the field of space communication named Satellite Instructional Television Experiment (SITE).
- During 1977-79, Satellite Telecommunication Experiment Project (STEP) was conducted, using a Franco-German 'Symphonie' satellite
- Bhaskara-1, the first remote sensing satellite developed by India, was launched in 1979
- Rohini-1 and Rohini-2 were two satellites that were put into space by indigenously developed SLV rockets in 1980 and 1983 respectively.
- Ariane Passenger Payload Experiment (APPLE) satellite, weighing 650 kg, was launched by an Ariane rocket into a geosynchronous orbit in 1981.

7.6.2 Indian National Satellite System (INSAT) Programme (Communication Purpose)

- Established in 1983 with commissioning of INSAT-1B. It is a joint venture of Department of Space (DoS), Department of Telecommunications, India Meteorological Department, All India Radio and Doordarshan. DoS is responsible for establishment and operation of INSAT space segment.
- INSAT space segment at present consists of INSAT-1D, last of the INSAT-1 series launched in 1990 and three ISRO-built satellites—INSAT-2A launched in July 1992, INSAT-2B launched in July 1993 and INSAT-2C, launched on December 7, 1995.
- INSAT-2DT was acquired from ARABSAT.
- INSAT-2E was launched on April 3, 1999.
- ISRO has leased eleven 36 MHz equivalent units of C-band capacity on board INSAT-2E to INTELSAT organisation
- INSAT-3A was launched on March 22, 2000.
- INSAT-3C was launched on January 24, 2002 through Ariane5 -V147
- INSAT-3A was launched on April 10, 2003
- INSAT-3E was launched on Septembe 28, 2003
- INSAT-4B was launched on March 12, 2007 through Ariane5

- INSAT-4C was launched on July 10, 2006 through GSLV-F02
- INSAT-4A was launched on December 12, 2005
- INSAT-4A was launched on December 12, 2005
- INSAT-4CR was launched on September 02, 2007
- INSAT-3D was launched on Jul 26, 2013, through Ariane-5 VA-214 for Chinate & Enverment Disaster Management System purpose.
- INSAT-3RD was launched on Sep 08. 2016 through launch vehicle GSLVF05 for Climate & Environment, Disaster Management System purpose.

7.6.3 Indian Remote Sensing Satellite (IRS) System Programme

- Commissioned with the launch of IRS-1A in March 1988
- The IRS system, under National Natural Resources Management System (NNRMS), is co-ordinated at national level by the Planning Committee of NNRMS (PC-NNRMS).
- IRS-1C launched in December 1995 and IRS-1D launched on September 29, 1997 and IRS-P4 (Oceansat), launched on 26 May, 1999.
- IRS-P3 and IRS-1D were launched by India's Polar Satellite Launch Vehicle (PSLV). on 21, may 1996 & 29 Sep. 1997, respectively.
- IRS-P4 with an Ocean Colour Monitor (OCM) and a Multi-frequency Scanning Microwave Radiometer (MSMR) was launched by PSLV-C2. on 26th may 1999.
- IRS-P6 (Resourcesat-1) for agricultural applications was launched in 17 October 2003 on board PSI V C5.
- Cartosat-1 with a High Resolution Panchromatic camera for eartographic application launched on board PSLV-C6 in 05 May 2005.
- Cartosat-2 with a Very High Resolution Panchromatic camera for eartographic application launched on board PSLV-C7 in 07 January 2007.
- Cartosat-2A with a Very High Resolution camera for eartographic application launched on board PSLV-C9 in 28 April 2008.
- Risat-2 Earth observation satellite launched on board PSI V-C12 in 20 Apil 2009.

- Oceansat-2, Climate & Environment, Earth Observation satellite launched on board launched on board PSLV-C15 in 12 July 2010.
- Resourcesat-2 Earth observation satellite launched on board PSLV-C16 in 20 April 2011.
- Risat-1 Earth observation atellite launched on board PSLV-C16 in 26 April 2012.
- Saral Climate & Environment, Earth Observation satellite launched on board PSLV-C20 — 25, 2013.
- Cartosat-2 Series Satellite Earth Observation satellite launched on board PSLV-C34 in Jun 22. 2016.
- Resourcesat-2A, Earth Observation satellite launched on board PSLV-C36 in Dec. 07, 2016.
- Cartosat-2 Series Satellite, Earth Observation satellites was launched on board PSLV-C37, PSLV-C38, PSLV-C40 in dated Feb. 15, 2017, Jun 23, 2017 and Jan 12, 2018 simultaneously.
- Risat-2B Disaster Management System. Earth Observation satellite launched on board PSLV-C46 in May 22, 2019.
- Cartosat-3, Disaster Manager at System, Earth Observaton satellite launched on board PSLV-C48 in Dec. 11, 2019.
- EOS-01, Disaster Management System, Earth Observation satellite launched on board __ Nov. 07, 2020.

PSLV-C51/Amazonia-1 is the first dedicated commercial mission of New Space India Limited (NSIL), a Government of India Company under Department of Space, India's polar Satellite Launch Vehicle PSLV-C51 successfully launched Amazonia- 1 along with 18 co-passenger satellites today (February 28, 2021) from Satish Dhawan Space Centre SHAR, Sriharikota.

7.6.4 Polar Satellite Launch Vehicle (PSLV) Programme

- SLV-3 was the first satellite launch vehicle developed by India and was used to put Rohini-1 satellite into orbit in 1980.
- PSLV was developed to place 1000 kg class Indian remote sensing satellites into Polar Sun Synchronous Orbit (SSO). Since the first successful flight conducted in

October 1994, the capability of PSLV has been enhanced from 805 kg to 1200 kg into 820 km SSO. PSLV also has the capability to launch 3500 kg satellites into 400 km Low Earth Orbit and 1000 kg satellites into Geo-synchronous Transfer Orbit.

- The metallic bulbous heat-shield of PSLV, 3.2 m in diameter, is of isogrid construction and protects the spacecraft during the atmospheric regime of the flight. PSLV control system includes
- PSLV was used to launch IRS-1D on September 29, 1997. IRS-P4 (Oceansat) and two small satellites (KITSAT of Korea and TUBSAT of Germany) were launched on May 26, 1999 by PSLV-C2.
- PSLV was used to lunch Kalpana-1 on Sep. 12 by PSLV-C4
- SLV-3 was the first satellite launch vehicle developed by india and was used to put Rohini-1 satellite into orbit in 1980.
- Developmental flights of PSLV completed with successful third developmental launch in March 1996.
- Now available for launching 1, 000-1, 200 kg class of remote sensing satellites into polar sun-synchronous orbit.
- PSLV was used to launch IRS-ID on September 29, 1997, IRS-P4 (Occansat) and two small satellites (Kitsat of Korea and IUbsat of Germany) were launched on May 26, 1999) by PSLV-C2.
- PSLV was used to launch Kalpana-1 on Sep. 12, 2002 by SPLV-C4 Use of PSLV-C5 to PSLV-C51 has been discussed above.

7.6.5 Geosynchronous Satellite Launch Vehicle (GSLV) Programme

- GSLV is designed for launching 2, 500 kg class of communication satellites into GTO.
- GSLV is a three-stage vehicle. STAGE-1 is a 129-tonne solid propellant core motor with four liquid propellant strap-ons with 40-tonne propellant each, STAGE-2 is a liquid propulsion system with 37.5-tonne propellant and STAGE-3 consists of a cryogenic engine with 12 tonnes of liquid oxygen and liquid hydrogen.

- GSLV is under development for launching 2, 500 kg class of communication s\atellites into geosynchronous transfer orbit.
- GSLV is be a three stage vehicle. Stage-1 is a 129-tonne solid propellant core motor with four liquid propellant strap-ons with 40 tonne propellant each stagf-2 is a liquid propulsion — 37.5 tonne propellant and —.
- GSLV-D2 was used to launch GSAT-2 on May 08, 2003.
- GSLV-F01 was used to launch EDUSAT (GSAT-3) satellite on Sep. 20, 2004.
- GSLV-F04 was used to launch INSAT-4CR satellite on Sep. 02, 2007.
- GSLV-D5 was used to launch GSAT-14 satellite on Jan. 05, 2014.
- GSLV-D6 was used to launch GSAT-14 satellite on Aug 27, 2015.
- GSLV-F05 / INSAT-3RD Sep. 08, 2016
- GSLV-F09 / GSAT-9 MAY 05, 2017
- GSLV-F08 / GSAT-6A Mission Mar 29, 2018
- GSLV-F11 / GSAT-7A Mission Dec. 19, 2018

7.6.6 Navigation Satellites

Satellite Navigation service is an emerging statellite based system with commercaial and — applications. To meet the Civil Aviation requirements. ISRO is working jointly with Airport Authority of India (AAI) in establishing the GPS Aided Geo Augmented Navigation (GAGAN) system. To meet the user requirements of the positioning. navigation and timing services based on the indigenous system. ISRO is establishing a regional satellite navigation system called Indian Regional Navigation Satellite System (IRNSS). The IRNSS constellation was named as 'NavIC' (Navigation with Indian Constellation).

The eight operational statellites in the IRNSS series namely IRNSS-1A, 1B, 1C, 1D, 1E, 1F, 1G and 11 were launched on July 02, 2013; Apr 04, 2014 : Oct 16, 2014 ; Mar 28, 2015 : Jan 20, 2016 : Mar 10, 2016, Apr 28, 2016 : and Apr 12, 2018 respectively. The PSLV-39 / IRNSS-1H being unsuccessful : the satellite could not reach orbit.

University / Academic Institute Satellites

IRSO has influenced educational institutions by its activities like making satellites for communication, remote sensing and astronomy. Educational institutions can propose the payloads developed by them to be flown on ISRO's small statellites. The designs and test results will be reviewed by ISROteam. After launch, the collected data will be archived and disseminated by university/ institution.

List of University / Academic Institute Satellites

ANUSAT	Apr 20, 2009	PSL V-C12 / RISART-2
STUDSAT	Jul 12, 2010	PSLV-C15 / CARTOSAT-2B
SRMSat	Oct. 12, 2011	PSLV-C18/Megha-Tropiques
SATHYABAMASAT	Jan. 22, 2016	PSLAV-C34/CARTOSAT-2 Series Satellite
SWAYAM	Jan. 22, 2016	Jan. 22, 2016 PSLAV-C34/ CARTOSAT-2 Series Satellite
PRATHAM	Sep. 16, 2016	PSLV-C35 / SCATSAT-1
NIUSAT	Jan. 23, 2017	PSLV-C38 / Cartosat-2 Series Satelite
Kalamsat-V2	Jan. 21, 2019	PSLV-C14
UNITY sat	Feb. 28, 2021	PSLV-C51/Amazonia-1
Satish Dhawan SAT (SDSAT)	Feb. 28, 2021	PSLV-C51 / Amazonia-1

Source : www.nrsc.gov.in

7.7 Summary and Conclusion

False color refers to a group of coiourrenderlng methods used to display images in color which were recorded in the visible or non-visible parts of the electfomagnetic spectrum. A false-color image is an image that depicts and object in colours that differ from those a photograph would show. In this image, colors have been assigned to three different wavelengths that our eyes cannot normally sec. FCC can be prepared using three band data-from IRS LISS-3 or Landsat sensors.

7.8 Keywords

False Colour Composite (FCC), Landsat, IRS, TM, LISS III

7.9 Model Questions

1. What are the different additive primary colours? What do you mean by FCC? How to prepare Standard False Colour Composite? Prepare a FCC with the help of three band data provided with you.

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Unit - 8 ❑ Principles of Image Rectification; Image Enhancement

Structure :

8.0 Learning objectives

By the end of this Unit, students would be able to:

- Understand Structure of Remote Sensing data
- Learn about Digital Image Processing
- Differentiate between Analog and Digital Image Processing
- Know about Digital Image Processing Techniques : Image Restoration.
- Learn about Geometric correction
- Know about Radiometric correction
- Learn about feature extraction through Digital Image Classification

8.1 Geometric Correction or Rectification

To **Georeference** something means to define its existence in Physical space. That is, establishing its location in terms of map projection or coordinate system.

Raw digital images contain geometric distortions, which make them unusable as maps. These geometric distortions can be caused by such things as earth curvature, atmospheric refraction, and panoramic distortion. The goal of geometric corrections to correct for these distortions to produce an image with the geometric integrity of a map. A map can be defined as a flat representation of part of the earth's spheroidal surface, such that any measurements made on the map will agree accurately with the corresponding measurements made on the ground. A map should conform to an internationally accepted type of cartographic projection.

In order for remote sensing data to be useful to resource and environmental managers, it must be geometrically corrected (geocoded) and transformed into the standard cartographic projection and scale for the area under study, so that the data can be overlaid in perfect registration with other cartographic information. This state of perfect registration allows the manager to compare cartographic data.

8.1.1 Types of Geometric Error

Remotely sensed data usually contains two types of Geometric error. That arise from Earth curvature, platfrom motion, relief displacement, non-linearities in scanning motion, Earth rotation.etc.

- **Systematic error :** Geometric-systematic distortions are those effects that are constant and can be predicted in advance.
- **Non-Systematic error :** It is manipulated by user.
- These Errors occur in a remote sensed data due to Tow factor Internal & External

Internal: Scan skew, Mirror Scan velocity, Profile detector sampling delay

External: Panaromic or cross track distortion, Scan skew Earth rotation, Spacecraft velocity, Perspective geometry, Attitude (Yew, roll, pitch), Altitude, Projection (UTM).

8.1.2 Geometric Error Correction

Remotely sensed data usually contains two types of Geometric Correction.

- **Systematic Correction**: This distortion are well understood and easily corrected by applying formulas derived by modeling the source of distortions mathematically or statistically.

- **Non-systematic correction:** It is corrected by matching image coordinates of physical features recorded by the image to the geographic coordinates of the same features collected from a map or using GPS.

8.1.3 Image Rectification

In computer vision, sets of data acquired by sampling the same scene or object at different times, or from different perspectives, will be in different coordinate systems.

Image registration is the process of transforming the different sets of data into one coordinate system. Registration is necessary in order to be able to compare or integrate the data obtained from different measurements.

Rectification is the process by which the geometry of an image area is made planimetric. After rectification each pixel can be referenced not only by its Row & Col. Position but also in Degrees, feet or meters in standard map projection. The rectified image not only helps the user to identify the feature of interest but also helps him to reach the location on earth.

The geometric errors in image occur due to perspective of the sensor, scanning system, the motion of platform and curvature & rotation of the Earth. Because of these the image exhibits some sorts of scaling, skewing, rotation errors. This correction procedure is called as geometric corrections or rectification.

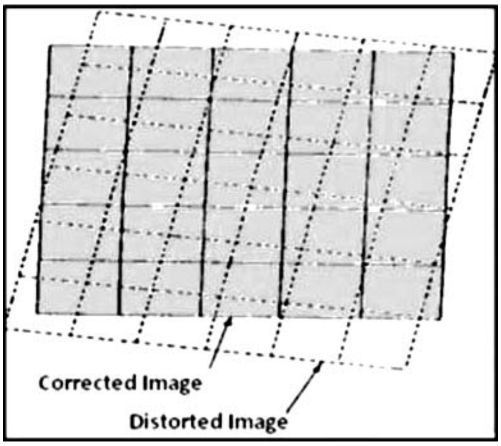

Fig. 8.1 An example for Geometric Correction

Rectification is the process of assigning the geo locations to the Image / Photograph to remove the geometric distortion. The figure shows an example of corrected and distorted image.

The rectification process become essential when

- A large scale maps are to be generated based on image.
- A mosaic of images are to prepared
- The multitemporal data are to be registered
- The images of different resolution are to be brought to the same scale

8.2 Radiometric Correction

Analysis of remote sensing data is done using various image processing techniques and methods that includes, Analog image processing and Digital image processing. The raw satellite images may contain a variety of errors in their geometry and radiometry. Hence it is important to rectify these images before starting their interpretation. This typically involves the initial processing of raw satellite image for correcting geometric distortions, radiometric corrections & calibration and noise removal from the data. Digital Image Processing is the manipulation of the digital data with the help of the computer hardware and software to produce digital maps in which specific information has been extracted and highlighted.

Data Transmission to Earth

The earth-viewing sensor normally generates a frequency signal corresponding to its measurements, and this information is encoded as an analogue signal. Most satellite systems have now converted the analogue signal to a digital signal to earth in the binary coding. Such radiance is generally expressed in the gray level range orbit.

Radiometric correction

The reflectance of the ground features varies as the time and location vanes. While mosicking two different images acquired at different time and location it is necessary to apply sun elevation and earth sun distance corrections to normalize Hie reflectance of the image. This process is called radiometric corrections.

8.3 Image Enhancement

- **Image Enhancement Techniques**

  These techniques are applied to image data in order to more effectively display or record the data for subsequent visual interpretation. Image enhancement increases the visual distinctions between features in a scene. The resultant images (after applying image enhancement techniques) carry increased amount of information that can be visually interpreted from the data.

- **Linear Contrast Stretching**

  Linear contrast stretching increases the original input brightness values to the total range of the output device. The analyst examines the image histogram and determines the minimum and maximum brightness values in the image, which helps in generating an appropriate output image using the equation for linear stretching. Piece-wise Linear contrast stretching is a special case of the above mentioned technique which is useful in stretching the data having Multi-modal histogram.

  Histogram equalization : a non-linear contrast enhancement technique is a most Commonly used technique. This is implemented by redistributing the image pixel values into output dynamic range (0-255), such that the frequency of occurrence of gray value range is almost the same throughout the dynamic range. Histogram equalization applies the greatest contrast enhancement to the most populated range of the brightness values in the image.

- **Density Slicing**

  Density slicing converts the continuous gray tone of an image into a series of density intervals, or slices, each correspond to a specified digital range. Digital slices may be displayed as separate colors or as areas bounded by contour lines. This technique emphasizes subtle gray-scale differences that may be imperceptible to the viewer.

- **Edge Enhancement**

  Typical geometrically shaped edges are of great interest in geoscientific application. The edge enhancement is one such operation, which helps the analyst in achieving edge highlighted image. The edge enhancement operation delineates the edges and thereby maps the shapes and details comprising the image more conspicuous and easier to analyze. Edges can be enhanced using linear or non-linear techniques. Digital filters have been developed specifically to enhance edges in images and fall into two categories: directional and non directional.

- **Principal component transformations**

  Principle Components Analysis is a ***statistical procedure*** designed to ***reduce the data redundancy*** and put as much information from the image bands into fewest number of components. The intent of the procedure is to produce an image which is easier to interpret than the original.

8.4 Radiometric Correction

- Radiornetric corrections constitute an important step in the pre-processing of remotely sensed data. They comprise of cosmetic corrections to reduce the influence of atmospheric and illumination parameters.
- Atmospheric corrections are particularly important for generating image mosaics and for comparing mul-titemporal remote sensing data. However, such corrections should be applied with care, after understanding the physical principles behind these corrections,
- Digital image classification is a technique to derive thematic classes from image data. Input are multi-band image data; output is a raster file containing thematic (nominal) classes, in the process of image classification the role of the operator and additional (field) data is significant.
- The operator needs to provide the computer with training data and select the appropriate classification algorithm. The training data are defined based on knowledge (derived by field work, or from secondary sources) of the area being processed. Based on the similarity between pixel values (feature vector) and the training classes a pixel is assigned to one of the classes defined by the training data.

8.5 Keywords

Digital image, Analog image, DIP, Image Restoration, Geometric correction, Radiometric correction, ground control point (UCP)

8.6 Model Questions

- What is Digital Image?
- How satellite data are transmitted to Earth
- Explain different techniques of data structures in Digital Image Processing.

  Which are the radiometric errors that can be introduced due to malfunctioning of satellite sensors?

  What are the differences between line dropouts and line striping?

  Explain the procedure' for haze correction on remotely sensed data.
- Compare an image and map coordinate system (give figure with comment).
- What is the purpose of acquiring stereo pairs of image data?
- What are ground control points used for?
- Give the different steps of the process of image classification.
- What is the principle of image classification?
- What is a classification algorithm? Give two e:xamples.

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Unit - 9 ❑ Principles of image interpretation

Structure :

9.0 Learning objectives

By the end of this Unit, students would be able to:

- Understand Structure of Remote Sensing data
- Learn about Digital Image Processing
- Differentiate between Analog and Digital Image Processing
- Know about Digital Image Processing Techniques : Image Restoration.
- Learn about Geometric correction
- Know about Radiometric correction
- Learn about feature extraction through Digital Image Classification

9.1 Image Interpretation

Image interpretation is the art and science of examining image to identify the objects and evaluates their significance. Interpretation of satellite images can be done in two ways: visually or digitally. When dealing with image data, visualized as pictures, a set of terms is required to express and define characteristics present in a pictures. These characteristics are called *interpretation elements* and are used, for example, to define *interpretation keys,* which provide guidelines on how to recognize certain objects.

9.1.1 Visual Image Processing

Identifying features in remotely sensed image are based on following. For visual interpretation, False Colour Composites (FCCs) are generated from satellite data. It basically is an image that shows three chosen data bands in three primary colours of red, green and blue (RGB). A *standard* FCC shows visible green band in blue, visible red band in green and invisible near infrared band in red. Any other combination of bands and colours can also be used to bring out some specific feature of the earth's surface. An FCC is interpreted using the criteria of ● tone & colour, ● size, ● shape, ● pattern & texture and ● association of earth objects.

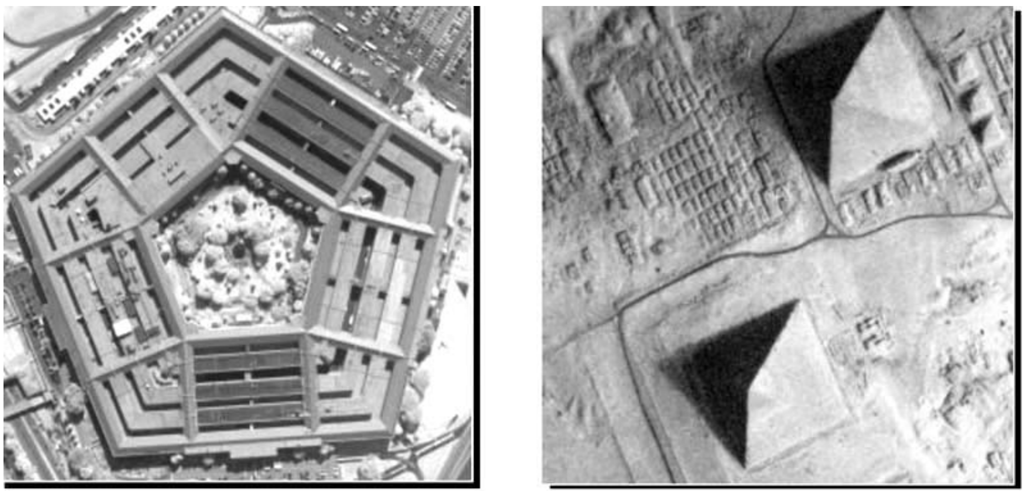

Fig. 9.1 : Visual image

- Many natural and human-made features have unique shapes.
- Often used are adjectives like linear, curvilinear, circular, elliptical, radial, square, rectangular, triangular, hexagonal, star, elongated, and amorphous.

a) Tone

Tone refers to the relative brightness (color) of objects in an image. The term is used for each distinguishable shade from black to white, such as dark, medium, light gray as shown in picture. Tone is the important element for identifying different features. Variations in tone also help identification of shape, texture, and pattern of objects. For example dry sand will appear in light shades of grey, while wet sand appears in dark shades of grey. In figure road looks brighter than the wet field.

Tonal Variation in an Image
Source: CCRS

Fig. 9.2

b) Shape

Shape refers to the general form, structure, or outline of individual objects. Shape is an important element for interpretation. Straight edge shapes represent urban or agricultural fields. Natural features, such as forest edges, are generally more irregular in shape. Farm or cropland irrigated by rotating sprinkler systems would appear as circular shapes. Many geomorphologic shapes are identified, such as sand dunes lakes, volcanic cones etc. For example in the above figure (4) the tennis court is visible.

Indentified feature based on Shape
Courtesy: J.M Piwowar

Fig. 9.3

- *Shape* or form characterizes many terrain objects visible in the image. Shape also relates to (relative) height when dealing with stereo-images, Height differences are important to distinguish between different vegetation types and also in geomorphological mapping. The shape of objects often helps to determine the character of the object (built-up areas, roads and railroads, agricultural fields, *et cetera).*

c) Size

"The size of a feature is also significant element in image interpretation. Size of objects in an image is a function of scale. Size when considered along with shape and association, helps in easy identification of the features. Ror example in this figure large buildings such as factories or warehouses would suggest commercial property, whereas small buildings would indicate residential use.

- *Size of objects can be considered in relative or absolute sense. The width of a road can be estimated, for example, by comparing it to the size of the cars, which is generally known. Subsequently this width determines the road type, e.g., primary road, secondary road, et cetera.*

Element	***Common Adjectives (quantitative and qualitative)***
X,Y location	• x,y coordiates : longitude and latitude or meters, easting and northing in a UTM map grid.
Size	• length, width,, perimeter, area • small, medium (intermediate), large
Shape	• an object's geometric characteristics : linear, curvilinear, circular, elliptical, radial, square, rectangular, triangular, hexagonal, pentagonal, star, amorphous, .etc.
Shadow	• a silhouette caused by solar illumination from the side.
Tone /colour	• rev, tone: light (bright), intermediate (grey), dark (black) • colour-. IHS = intensity, hue (colour), saturation; RGB = red, green and blue.
Texture	• characteristic placement and arrangement of repetitions of tone or colour; smooth, intermediate (medium), rough (coarse), mottled, stippled

Pattern	• the spatial arrangement of objects on the ground; systematic, unsystematic or random, linear, curvilinear, rectangular, circular, elliptical, parallel, centripetal, serrated, striated, braided.
Height/depth/volume/ slope/aspect	• z-elevation (height), depth (bathymetry), volume, slope, aspect
Site/situation /association	• Site: elevation, slope, aspect, exposure, adjacency to water, transportation, utilities • Situation: objects are placed in a particular order or orientation relative to one another • Association: related phenomena are usually present

Table : Typical adjectives associated with interpretation elements

d) Pattern

Pattern refers to the spatial arrangement of visibly separate objects. An orderly repetition of similar tones and textures will produce a distinctive and recognizable pattern. Urban streets with regularly spaced houses are good and orchards with evenly spaced trees as shown in figure are good examples of pattern.

- o Pattern is the spatial arrangement of objects on the landscape.
- o General descriptions include random and systematic; natural and human-made.
- o More specific descriptions include circular, oval, curvilinear, linear, radiating, rectangular, etc.

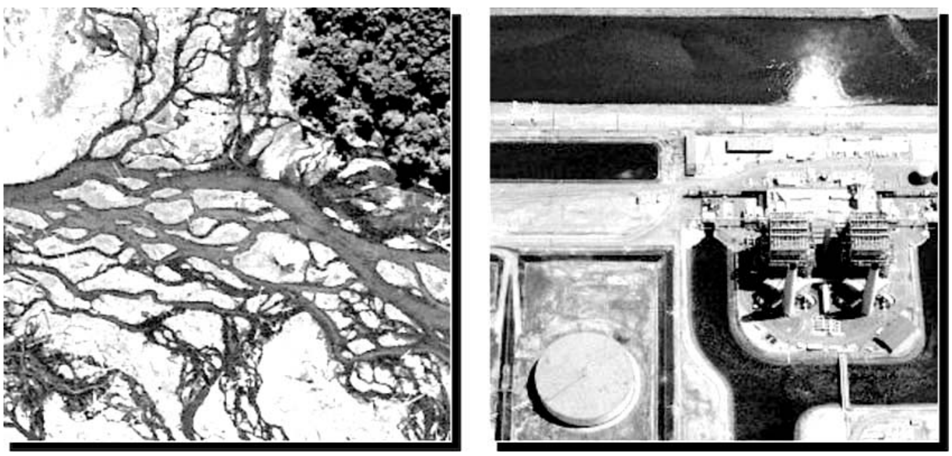

Fig. 9.4 : Visual pattern

e) Texture

Texture is closely associated with tone. This includes smooth, and rough surfaces. Rough surfaces have a spotted tone where the grey levels change abruptly in a small area. For example forest canopy shows rough texture in an image. Smooth surfaces have very little tonal variation. For example fields or grasslands appear smooth and uniform in image.

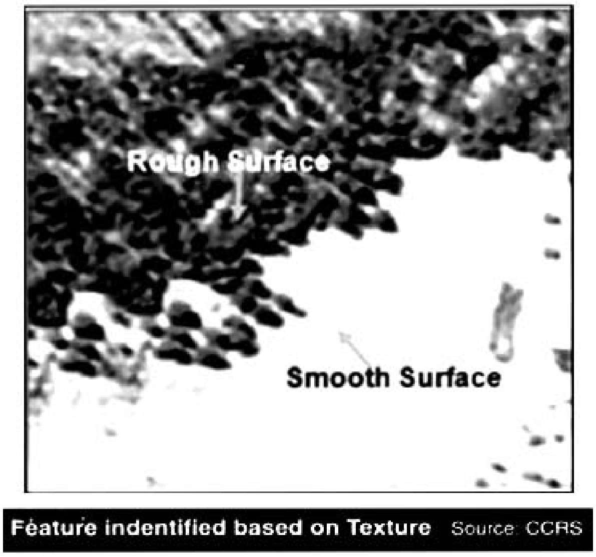

Fig. 9.5

Texture:

- o Texture refers to the arrangement of tone or color in an image.
- o Useful because Earth features that exhibit similar tones often exhibit different textures.
- o Adjectives include smooth (uniform, homogeneous), intermediate, and rough (coarse, heterogeneous).

f) Shadow

Shadow is an important element for Image interpretation. It makes identification easier because it provides profile of the features. Shadow length can be used for height measurements. Shadows reduce interpretation in that area because of non visibility of features. Shadow is useful for identifying topography and landforms. Figure shows that the shadows of the tall building which covers the features from other side of the building which cannot be seen due to this information cannot be derived.

Fig. 9.6

- o Shadow reduction is of concern in remote sensing because shadows tend to obscure objects that might otherwise be detected.
- o However, the shadow cast by an object may be the only real clue to its identity.
- o Shadows can also provide information on the height of an object either qualitatively or quantitatively.

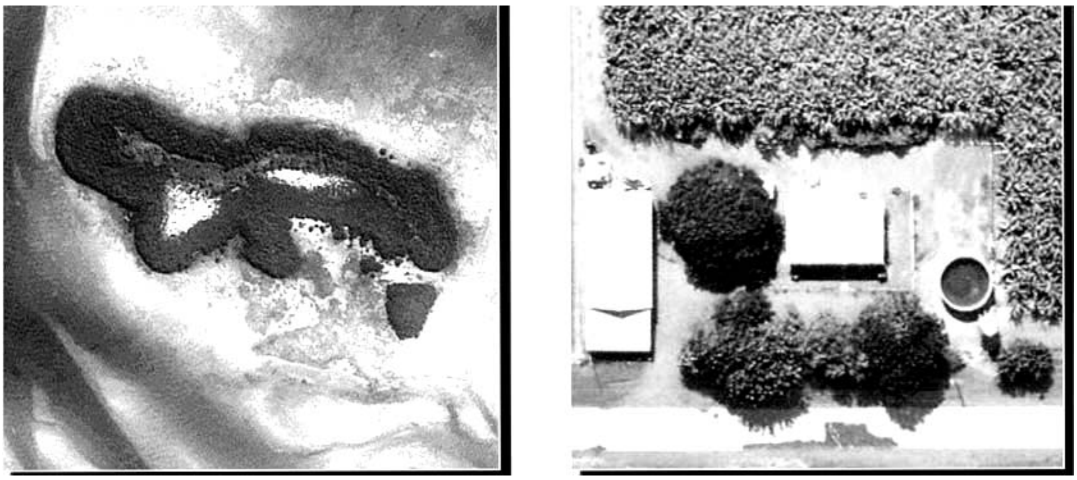

Fig. 9.7

Tone and Color:

- o A band of EMR recorded by a remote sensing instrument can be displayed on an image in shades of gray ranging from black to white.
- o These shades are called "tones", and can be qualitatively referred to as dark, light, or intermediate (humans can see 40-50 tones).
- o Tone is related to the amount of light reflected from the scene in a specific wavelength interval (band).

g) Association

Association of objects is one of the most important elements of image interpretation. It takes into consideration the relationship between other objects which are near to the target. For example commercial properties may be associated with major transportation routes, whereas in residential areas if *we* see an open space it would be associated with schools, playgrounds, and sports fields. In above figure, a lake is associated with boats, a marina, and adjacent recreational land.

Features are indentified by their association
Source: CCRS

Fig 9.8

- *Association* refers to the fact that a combination of objects makes it possible to infer about its meaning or function. An example of the use of 'association' is an interpretation of a thermal power plant based on the combined recognition of high chimneys, large buildings, cooling towers, coal heaps and transportation belts. In the same way the land use pattern associated with small scale farming will be characteristically different to that of large scale farming.
- *Site* relates to the topographic or geographic location, A typical example of this interpretation element is that backswamps can be found in a floodplain but not in the centre of a city area. Similarly, a large building at the end of a number of converging railroads is likely to be a railway station—we do not expect a hospital at this site.

9.1.2 Digital Image Processing

The remotely sensed data from the satellites are analyzed for extracting information on surface features and deducing their properties for identifying objects on the earth, based on the observation made on the reflected or scattered energy from the earth in different spectral bands. Remote sensing derived data is transformed into information using analog or digital image processing techniques, if appropriate logic and methods are used. Remote sensing derived information is critical to the successful modeling and monitoring of numerous natural (eg.watershed run-off) and cultural processes (eg. land use conversion at the urban fringe.

Principles of Preparing Standard False Composition (St. F.C.C)

Are the colour images generated by combination of images from different bands in a multi bands (Spectral) image data, such that the different bands of images are represented in different primary colours (red, green, blue) either in the form of a colour photographic paper print, transparent film or on a colour (RGB) monitor. The band image is displayed in the colour (red, green or blue), which may not necessarily by the actual color of the band being displayed. The final image may therefore not present the true colour of image. It is therefore known as false colour composition as the displayed colour will depend totally on the choice of the user (operator) while selecting a particular colour for a particular band.

Schematic representation of forming FCCs using bands from IRS sensors

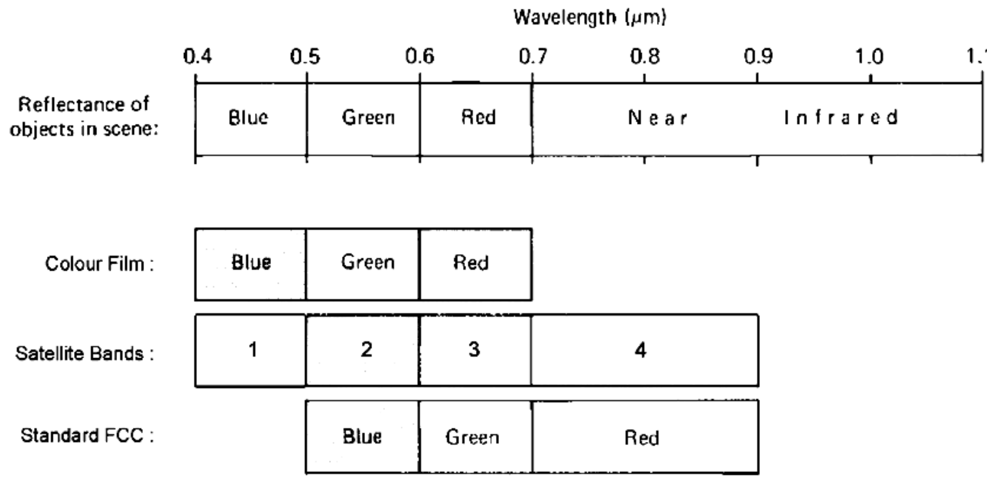

Fig. 9.10

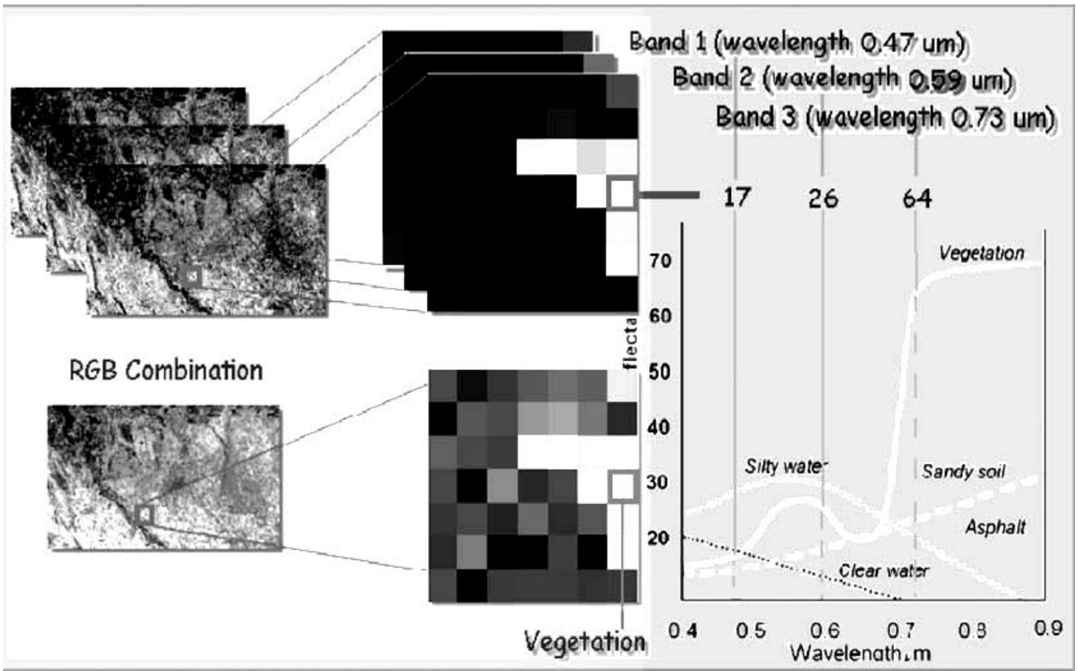

Fig. 9.11 : Spectral Signature response of different bands in different objects

Some landuse types and their spectral signatures on the standard FCC are the following:

Types of Landuse	*Signatures on Standard FCC*
Dense Forest	Deep Red
Degraded Forest	Scoured Red
Green Paddy	Reddish
Yellow Paddy (before harvest)	Dark red
Wetland (Marshy Land)	Deep Sky-Blue
Water body	Deep Blue
Wasteland (Lateritic)	Green
Built-up (Settlement) area	Coarse Greenish Blue

BURDWAN CITY & SURROUNDINGS

VIEWED IN THREE IRS LISS-3 BANDS AND IN STANDARD FALSE COLOUR COMPOSITE (FCC)

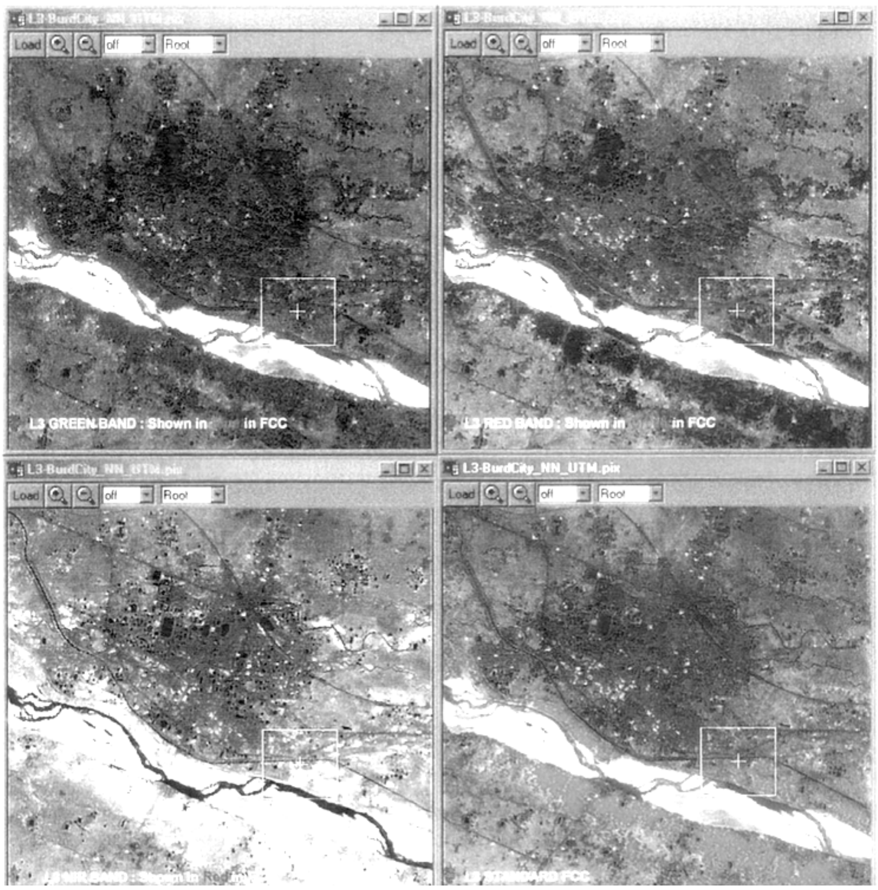

Fig. 9.12 : Preparation of standard False Colour Composite from satellite data

9.2 Summary and Conclusion

- Visual image interpretation is one of the methods to extract information from remote sensing image data. For that purpose, images need to be visualized on screen or in hard-copy. The human vision system is used to interpret the colours and patterns on the picture. Spontaneous recognition and logical inference (reasoning) are distinguished.
- Interpretation keys or guidelines are required to instruct the image interpreter. In such guidelines, the (seven) interpretation elements can be used to describe how to recognize certain objects. Guidelines also provide a classification scheme, which defines the thematic classes of interest and their (hierarchical) relationships. Finally, guidelines give rules on the minimum size of objects to be included in the interpretation.
- When dealing with a new area or a new application, no guidelines are available. An iterative approach is then required to establish the relationship between features observed in the picture and the real world.

9.3 Keywords

Colour omposition, FCC, Stardard FCC, RGB, VIP, DIP, Analog interpretation, Preparation of LULC maps.

9.4 Model Questions

1. What is the relationship between image visualization and image interpretation?
2. Describe different types of image interpretation elements.
3. describe how to recognize a road and a railway line on a saellte image
12. Give different reasons for field observation in the process of image interpretation.
5. Define land cover and land use with example.
6. Differentiate between Visual and Digital Image Processing
7. What is the principal of preparing Standard FCC

8. Describe the basic concept of preparing colour composition
9. In a standard FCC image why vegetation are shown in red colour explain it.
10. How association are involved to identify features in a satellite image

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Unit - 10 ❑ Features extracted from satellite image

Structure :

10.0 Learning objectives

By the end of this Unit, students would be able to:

- Understand Structure of Remote Sensing data
- Learn about Digital Image Processing
- Differentiate between Analog and Digital Image Processing
- Know about Digital Image Processing Techniques : Image Restoration.
- Learn about Geometric correction
- Know about Radiometric correction
- Learn about feature extraction through Digital Image Classification

10.1 Image Classification

The overall objective of image classification is *to* automatically categorize all pixels in an image into land cover classes *or* themes. Normally, mutispectral data are used to perform the classification and, the spectral pattern present within the data for each pixel is used as the numerical basis for categorization. The final output of the classification process is a type *of* digital image, specifically a map of the classified pixels The classification process compresses the image data *by* reducing the large number of gray levels in each *of* several spectral bands into a few numbers of classes in a single image.

> Image classification is a process of automatically categorization of all pixels in an image into different land cover classes or itemes

The objective of image classification is to identify different features occurring in an image to identify different land features. These groups are caled as classes. Based *on* DN values we create the classes like Vegetation, Water body. Barren Land, Buildup Area etc.

10.2 Approaches for Image Classification

- Unsupervised classification
- Supervised classification
- Unsupervised Image Classification

10.2.1 Unsupervised classification

In Unsupervised classification spectral classes are grouped first, based on the numerical information in the data. Clustering algorithms are used to determine the natural classes in the data. Algorithms examine the unknown pixels in an image and group them into a number of classes. Unsupervised Classification method does not utilize training data as the basis for classification. Based on the reference data, area knowledge and experience, user compare the classified data and identify the features and name them as shown in the figure. There are numerous clustering algorithms that can be used to determine the natural spectral groupings present in data set. The most used algorithm is “K-means” approach also called as ISODATA (Interaction Self-Organizing Data Analysis Technique). Unsupervised classification is not complete without human involvement.

Unsupervised classification is popular in industries involved in long term GIS database maintenance because it uses clustering procedures which are extremely fast.

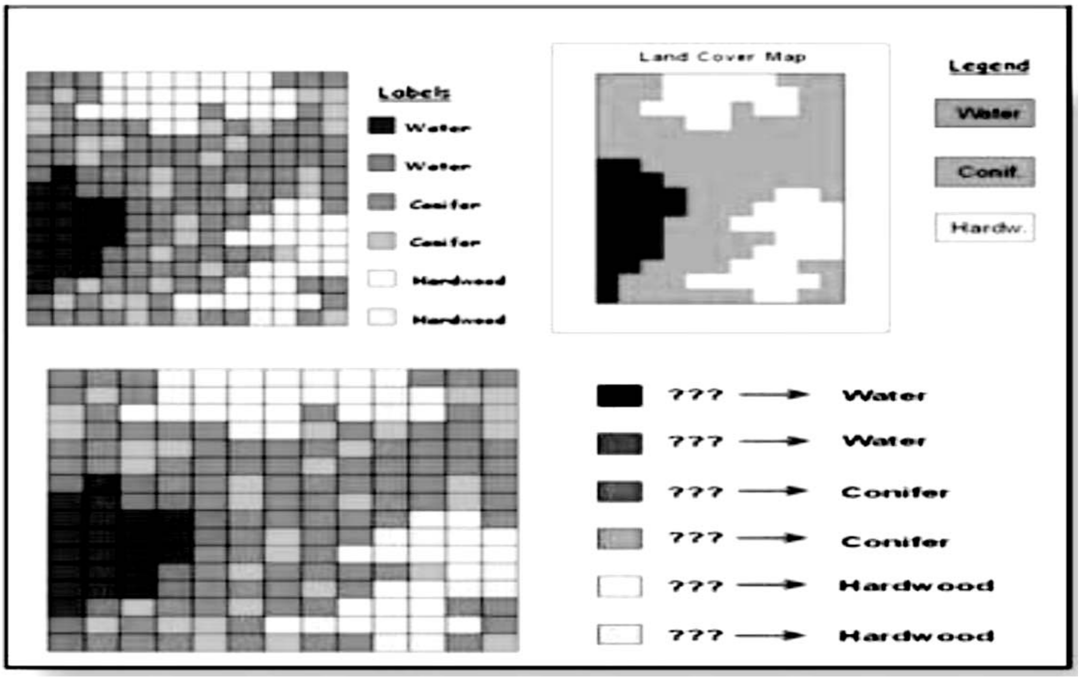

Fig. 10.1 Unsupervised classification :

10.2.2 Supervised Image Classification

Supervised classification is more accurate for mapping classes, but it depends heavily on the area knowledge and skis of the analyst. The analyst should recognize classes in an Image based on prior knowledge and assign them class names. These are caled as training sites. The training sites areas representing known land cover category that appear homogeneous on tne image. Image processing software categorizes of the reflectance of each class. This process is called "signature analysis". The entire image is classified based on this signature assigned. Most frequently used algorithms for supervised classification are parallelepiped, minimum distance and maximum likelihood. The basic steps involved in a typical supervised classification procedure are as given below.

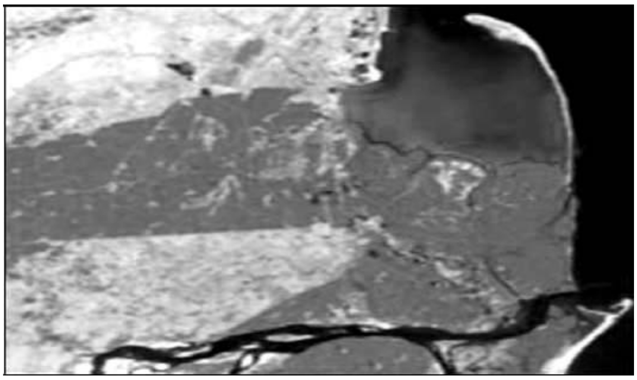

Fig. 10.2 Supervised classification :

(i) Defining training site

(ii) Featuring selection (signature analysis)

(iii) Selection of appropriate classification algorithm

(iv) Post classification smoothening

(v) Accuracy assessment

(vi) Classified Image (Result)

(vii) Statistical report generation for different landuse and landcover

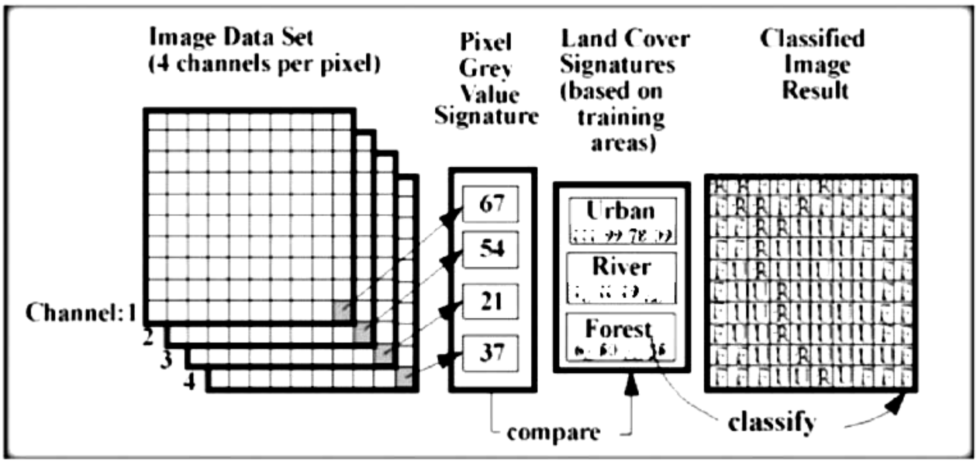

Fig. 10.3 Supervised classification :

Fig. 3.7 : Steps in Supervised Classification Fig. 3.8 : Source : www.sc.chula.ec.th

In the figures given below the iraining sites are shown and names are assigned sucti as Turbid Water, Deep Water, Shallow Water, Wet Land, Barren Land. Agriculture and Foresl. Based on these training sites the raw Image is classified and final output is shown Previons Figure.

10.3 Accuracy assessment

Accuracy assessment is a must for any classified output. Accuracy assessment has to be done at two stages: (1) training set data, and (2) final classified maps. Training set data is evaluated by computing confusion matrix, divergence and ellipsoidal plotting. Final classification is evaluated by selecting random samples all over the image followed by a post classification ground verification. This helps in accuracy evaluation of the classification results.

10.4 Change Detection

Change detection involves the use of multi-temporal data sets to discriminate areas of land cover change between dates of imaging. The types of changes that might be of interest can range from short-term phenomena, sllch as snow cover or flood water to long term phenomena, such as urban fringe development or desertification. Ideally, change detection procedures should involve data acquired by the same (or similar) sensor and be recorded using the same spatial resolution, viewing geometry, spectral bands and time of day. Often anniversary dates are used to minimize sun angle and seasonal differences. Accurate spatial registration of the various dates of imagery is also a requirement for effective change detection.

10.5 Summary and Conclusion

- Most remote sensing data are recorded in digital format, virtually all image interpretation and analysis involves some element of digital processing. Digital Image Processing may involve numerous procedures including formatting and correction of the data, digital enhancement to facilitate better visual interpretation, or even automated classification of targets and features entirely by computers.

- Radiornetric corrections constitute an important step in the pre-processing of remotely sensed data. They comprise of cosmetic corrections to reduce the influence of atmospheric and illumination parameters. Atmospheric corrections are particularly important for generating image mosaics and for comparing multitemporal remote sensing data. However, such corrections should be applied with care, after understanding the physical principles behind these corrections,
- Digital image classification is a technique to derive thematic classes from image data. Input are multi-band image data; output is a raster file containing thematic (nominal) classes, in the process of image classification the role of the operator and additional (field) data is significant. The operator needs to provide the computer with training data and select the appropriate classification algorithm. The training data are defined based on knowledge (derived by field work, or from secondary sources) of the area being processed. Based on the similarity between pixel values (feature vector) and the training classes a pixel is assigned to one of the classes defined by the training data.

10.6 Keywords

Digital image, Analog image, DIP, Image Restoration, Geometric correction, Radiometric correction, ground control point (UCP)

10.7 Model Questions

- What is Digital Image?
- How satellite data are transmitted to Earth
- Explain different techniques of data structures in Digital Image Processing.

Which are the radiometric errors that can be introduced due to malfunctioning of satellite sensors?

What are the differences between line dropouts and line striping?

Explain the procedure' for haze correction on remotely sensed data.

- Compare an image and map coordinate system (give figure with comment).
- What is the purpose of acquiring stereo pairs of image data?
- What are ground control points used for?
- Give the different steps of the process of image classification.
- What is the principle of image classification?
- What is a classification algorithm? Give two e:xamples.

10.8 References and Further Readings

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- Remote Sensing in Geology Siegal, B.S. and AR Gillespie, Wiley, New Yor

Unit - 11 ❑ Preparation of inventories of landuse and land cover (LULC) features from satellite images

Structure :

11.0 Learning objectives

By the end of this Unit, students would be able to:

- Understand Structure of Remote Sensing data
- Learn about Digital Image Processing
- Differentiate between Analog and Digital Image Processing
- Know about Digital Image Processing Techniques : Image Restoration.
- Learn about Geometric correction
- Know about Radiometric correction
- Learn about feature extraction through Digital Image Classification

11.1 Land use and land cover (LULC)

11.1.1 Water

Water absorbs light, so it is usually black or dark blue. Sediment reflects light and colors the water. When suspended sand or mud is dense, the water looks brown. As the sediment disperses, the water's color changes to green and then blue. Shallow waters with sandy bottoms can lead to a similar effect.

Sunlight reflecting off the water's surface makes the water look gray, silver or white. This phenomenon, known as sunglint, can highlight wave features or oil slicks, but it also masks the presence of sediment or phytoplankton.

Frozen water—snow and ice—is white, gray and sometimes slightly blue. Dirt or glacial debris can give snow and ice a tan color.

11.1.2 Plants

Plants come in different shades of green, and those differences show up in the truecolor view from space. Grasslands tend to be pale green, while forests are dark green. Land used for agriculture is often much brighter in tone than natural vegetation.

In some locations (high and mid latitudes), plant color depends on the season. Spring vegetation tends to be paler than dense summer vegetation. Fall vegetation can be red, orange, yellow and tan; leafless and withered winter vegetation is brown. For these reasons, it is helpful to know when the image was collected.

In the oceans, floating plants—phytoplankton—can color the water in a wide variety of blues and greens. Submerged vegetation like kelp forests can provide a shadowy black or brown hue to coastal water.

11.1.3 Bare Ground

Bare or lightly vegetated ground is usually some shade of brown or tan. The color depends on the soil's mineral content. In some deserts, such as the Australian Outback and the Southwestern United States, exposed earth is red or pink because it contains iron oxides like hematite (Greek for blood-like). When the ground is white or pale tan, especially in dried lakebeds, it is because of salt-, silicon- or calcium-based minerals.

Volcanic debris is brown, gray or black. Newly burned land is also dark brown or black, but the burn scar fades to brown before disappearing over time.

11.1.4 Cities

Densely built areas are typically silver or gray from the concentration of concrete and other building materials. Some cities have a more brown or red tone, depending on the materials used for rooftops.

11.1.5 Atmosphere

Clouds are white and gray, and they tend to have texture just as they do when viewed from the ground. They also cast dark shadows on the ground that mirror the cloud's shape. Some high, thin clouds are detectable only by the shadow they cast.

Smoke is often smoother than clouds and ranges in color from brown to gray. Smoke from oil fires is black. Haze is usually featureless and pale gray or a dingy white. Dense haze is opaque, but you can see through thinner haze. The color of smoke or haze usually reflects the amount of moisture and chemical pollutants, but it's not always possible to tell the difference between haze and fog in a visual interpretation of a satellite image. White haze may be natural fog, but it also may be pollution.

Dust ranges in color, depending on its source. Dust is often slightly tan, but, like soil, can be white, red, dark brown and even black due to different mineral content.

Volcanic plumes also vary in appearance, depending on the type of eruption. Plumes of steam and gas are white. Ash plumes are brown. Resuspended volcanic ash is also brown.

11.1.6 Colors in Context

Looking at a satellite image, you see everything between the satellite and the ground (clouds, dust, haze, land) in a single, flat plane. This means that a white patch might be a cloud, but it could also be snow or a salt flat or sunglint. The combination of context, shape and texture will help you tell the difference.

For example, shadows cast by clouds or mountains can be easy to mistake for other dark surface features like water, forest or burned land. Looking at other images of the same area taken at another time can help eliminate confusion. Most of the time, context will help you see the source of the shadow—a cloud or mountain—by comparing the shape of the shadow to other features in the image.

	Band-4	**Band-5**	**Band-6**	**Band-7**	**4,5,7 (BGR)**	**4,5,7 (RGB)**
Snow	PW	PW	PW	PW	PW	PW
Cloud	W	W	W	W	W	W
Haze	W	W	-	-	W	W
Forest	DGR	BL	w	W	R	G
Grass	GR	DG	W	w	P	BY
Bare land	GR	W	w	w	W	W
Wet land	GR	W	GR	DGR	LB	RP
Urban	GR	W	GR	DGR	LB	RP
Water	DGR	BL	BL	BL	B	BP
Shadow	BL	BL	BL	BL	BL	BL
Codes :	PW : pure white GR : grey R : red BY : brandish yellow BP : bluish purple		W : white BL : black G : green LB : light blue		DGR : dark grey P : pink B : blue RP : reddish purple	

Table 11.2 : Landsat-MSS image interpretation keys

11.2 Interpretation of LULC

Interpretation keys of land cover and land use identification is presented in Table 9-5 for all IRS LISS sensors' infrared colour composjte (B=2.G=3.R=4h The IRS LISS sensors' bands 2,3,&4 are approximately equivalent to Landsat-TM bands 2,3 & 4. So the same knowledge base can also be used to interpret TM based standard false colour composite image with little variation.

Table 11.2 : Interpretation keys for infrared colour composites of all IRS LISS sensors (Source : Prasad and Sinha, 2002)

Land Cover/land use	**Image Characteristics**
1. Settlements	Light Gary clustering with particular patterns for the urban area. There may be brownish maroon patches for in between vegetation. For the rural settlement there occurs no particular patterns of such image Characteristics.
2. Agriculture	Identify rabbi if the month of data acquisitionis January or February or March and color is brown red. For the kharif crops same characteristics in image occur if the image data are acquired in the month of September, October or November.(b) Fallow land Fallow land is identified by light gray color within cropped area (red color).(c) Plantation occurs as brownish maroon patches.
3. Forest	
(a) Dense forests	Dense forests are identified by dark red color patterns.
(b) Degraded forest	In the case of degraded forest the dark red colour patterns
(c) Forest blank	contain small brown or white patches. The blanks in the
(e) Forest plantation	forest show creamy patches in the dark red/ background. Forest plantations are identified by dark red colour sign of particular pattern.
4. Waste Land	
(a) Muddy water logging	Muddy water logging occurs as blackish or deep blue
(b) Clear water logging	spots while clear water logging area is identified by

(c) Temporary water logging (d) Permanent water logging (e) Marshy area water logging (f) Gullied land (g) Land with scrub (h) Land without scrub (i) Sandy area	dark/bright blue patches. Comparing the images of rainy season and out of rainy season identifies temporary and Permanent water logging. Marshy area is recognized as a sign of vegetation (red/pink spots) in the water logged (blackish blue/bright blue) area. Gullied land occurs as white/gray spot. The image of land with scrub contains white patches in the land area. Sandy area is classified as bright white coloration along the course of river.
5. Water bodies (a) River/stream (b) Canal (c) Lake/ Reservoirs (d) Embankments	River/stream is identified as long non-linear path colored with dark blue/ bright blue line in white background. Canals are identified as line segments sign of water. Lake/reservoirs are identified as patterns along the river. Embankment occurs as light gray structure along the river.
6. Others	Grasslands are identified as uneven appearance characterized by red (light to medium gray tones) snow is identified as white patches on the hills.

11.3 Summary

- In all interpretation and mapping processes the use of ground observations is essential to (i) acquire knowledge of local situation, (ii) gather data for areas that cannot be mapped from the images (iii) to check the result of the interpretation,
- The quality of the result of visual image interpretation depends on the experience and skills of the interpreter, the appropriateness of the image data applied and the quality of the guidelines being used.

11.4 Keywords

Colour Composition, FCC, Stardard FCC, RGB, VIP, DIP, Analog interpretation, Preparation of LULC maps.

11.5 Model Questions

1. What is the relationship between image visualization and image interpretation?
2. Describe different types of image interpretation elements.
3. describe how to recognize a road and a railway line on a saellte image
12. Give different reasons for field observation in the process of image interpretation.
5. Define land cover and land use with example.
6. Differentiate between Visual and Digital Image Processing
7. What is the principal of preparing Standard FCC
8. Describe the basic concept of preparing colour composition
9. In a standard FCC image why vegetation are shown in red colour explain it.
10. How association are involved to identify features in a satellite image

11.6 References and Further Readings

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Unit - 12 ❑ Concept, Components of GIS

Structure :

12.0 Learning objectives

12.1 Concept of GIS

12.2 Components of GIS

12.3 Key Components of GIS Software

12.4 Summary

12.5 Keywords

12.6 Model Questions

12.7 References

12.0 Learning objectives

This unit discuss the conceptual details of the followings and the students able to:

- Understand the basic concepts of GIS
- Know about the components of GIS
- The key components of GIS software

12.1 Concept of GIS

A Geographic Information System (GIS) is a computer-based tool that allows for the capture, storage, analysis, and visualization of spatial data. Here are the concept and components of GIS: GIS is a system that integrates spatial data (geographic information) with non-spatial data (attribute information) to analyze and understand relationships. patterns. and trends. The concept ofGIS involves:

1. Spatial Analysis: Analyzing spatial data to identify patterns, relationships, and trends.

2. Geographic Visualization: Visualizing spatial data on maps. 3D models. and other graphical representations.
3. Data Integration: Integrating spatial data with non-spatial data to provide a comprehensive understanding of the data.

12.2 Components of GIS

A GIS typically consists of the following components:

1. Hardware: Computers, serversm and other equipment that support the GIS software.
2. Software: GIS software, such as ArcGIS, QGIS, or GRASS, that provides the functionality to capture, store, analyze, and visualize spatial data.
3. Data: Spatial data (geographic information) and non-spatial data (attribute information) that are used in the GIS.
4. People: Users, analysts, and administrators who work with the GIS to capture, analyze, and interpret spatial data.
5. Procedures: Standard operating procedures (SOPs) and workflows that guide the use of the GIS.

12.3 Key Components of GIS Software

1. Spatial Database Management System (DBMS): Manages spatial data and provides functionality for data storage, retrieval, and manipulation.
2. Spatial Analysis Tools: Provides functionality for spatial analysis, such as buffering, intersecting, and unioning spatial data.
3. Map Composition Tools: Allows users to create maps and other graphical representations of spatial data.
4. Geoprocessing Tools: Provides functionality for geoprocessing tasks, such as data conversion, projection, and transformation.

5. User Interface: Provides a user-friendly interface for users to interact with the GIS software.

12.4 Summary

In summary, GIS is a system that combines hardware, software, data, people, and methods to understand spatial relationships and patterns, providing valuable insights for various fields such as urban planning, environmental management, and resource allocation.

12.5 Keywords

GIS, Components, Hardware, software

12.6 Model Questions

- What does GIS stand for, and what is its primary purpose?
- Name the three main components of a GIS.
- How does spatial data differ from attribute data in GIS?
- What is the role of hardware in a GIS system?
- What is the purpose of GIS software?
- What type of data does a GIS typically use to represent geographic locations?
- Explain the difference between raster and vector data in GIS.
- How does a GIS database contribute to the system's functionality?
- What are GIS applications used for in urban planning?
- How do GPS and GIS work together to collect and analyze spatial data?

12.7 References

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Unit - 13 ❑ Functions of GIS

Structure :

13.0 Learning objectives

The students able to understand the followings by the end of this unit:

- The basic concepts of G IS functions
- Know about the various functions of GIS
- Know about Principles of image Processing: Visual and Digital
- Understand Visual or analog interpretation of satellite data or visual image processing

13.1 Functions of GIS

Digital Image Processing involves the manipulation and interpretation of images obtained in the digital form with the aid of computers. The digital data can be treated. with various algorithms for enhancing the ground features for better interpretability and analysis. Initial understanding of the image data is obtained by displaying the satellite data on the interactive display monitor, either by generating a three band color composite called the False Color Composite (FCC) or displaying each spectral band data separately in black and white.

A Geographic Information System (GIS) performs various functions to analyze and interpret spatial data.

Here are some of the primary functions of GIS:

13.1.1 Data Input Functions

1. Data Capture: Collecting spatial data from various sources, such as satellite imagery, GPS, and maps.
2. Data Conversion: Converting data from one format to another, such as converting raster data to vector data.
3. Data Editing: Editing spatial data to correct errors, update information, and ensure data consistency.

13.1.2 Data Storage and Management Functions

1. Data Storage: Storing spatial data in a database management system, such as a relational database or an object-oriented database.
2. Data Retrieval: Retrieving spatial data from the database for analysis and visualization.
3. Data Management: Managing spatial data, including data backup, data security, and data integrity.

13.1.3 Data Analysis Functions

1. Spatial Analysis: Analyzing spatial data to identify patterns, relationships, and trends.
2. Spatial Modelling: Creating spatial models to simulate real-world phenomena, such as climate modelling or urban planning.

3. Network Analysis: Analyzing network data, such as transportation networks or utility networks.

13.1.4 Data Visualization Functions

1. Mapping: Creating maps to visualize spatial data, including 2D and 3D maps.
2. Charting: Creating charts and graphs to visualize non-spatial data associated with spatial data.
3. 3D Visualization: Creating 3D visualizations to represent complex spatial data, such as buildings or landscapes.

13.1.5 Data Output Functions

1. Map Production: Producing maps for various purposes, such as urban planning, emergency response, or environmental monitoring.
2. Report Generation: Generating reports to summarize spatial data analysis results.
3. Data Export: Exporting spatial data to other formats, such as CSV, Excel, or shapefiles.

13.1.6 Other Functions

1. Geocoding: Converting addresses to spatial coordinates.
2. Geoprocessing: Performing spatial analysis and modelling tasks, such as buffering, intersecting, or unioning spatial data.
3. Spatial Querying: Querying spatial data to extract specific information, such as locations within a certain distance or areas with specific characteristics.

13.2 Summary

In short, the functions of GIS enable the collection, management, analysis, and visualization of geographic data, providing users with powerful tools to support decision-making across various fields.

13.3 Keywords

GIS, Functions of GIS, Data Input, Data output

13.4 Model Questions

- What is the primary purpose of the data capture function in GIS?
- How does GIS store spatial and attribute data?
- What is meant by spatial analysis in GIS?
- How does GIS help in visualizing geographic data?
- What is the role of querying in GIS?
- What types of maps can be created using GIS?
- How does GIS perform overlay analysis?
- How does GIS assist in decision-making processes?
- What is the significance of mode ling and simulation in GIS?
- How does GIS support decision-making in urban planning or environmental management?

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Unit - 14 ❑ Application of RS and CIS

Structure :

14.0 Learning objectives

The students able to understand the followings by the end of this unit:

- The nature of RS and G IS for their application
- Know about the various applications of RS
- Know about the various applications of G IS

14.1 Application of RS and CIS

Remote Sensing (RS) and Geographic Information System (GIS) are powerful tools used in various fields for data collection, analysis, and decision-making. Here are some applications of RS and GIS:

14.1.1 Environmental Applications

1. Land Cover Classification: RS and GIS are used to classify land cover types, such as forests, grasslands. and urban areas.
2. Climate Change Monitoring: RS and GIS help monitor climate change impacts, such as sea level rise, glacier melting. and changes in vegetation patterns.
3. Natural Disaster Management: RS and GIS are used for disaster risk reduction, response, and recovery, including flood, drought, and wildfire management.

14.1.2 Urban Planning and Management

1. Urban Land Use Planning: RS and GIS help identify suitable areas for urban development. infrastructure planning. and zoning regulations.
2. Transportation Planning: RS and GIS are used to plan and manage transportation networks. including road, rail, and public transportation systems.
3. Urban Environmental Management: RS and GIS help monitor and manage urban environmental issues, such as air and water pollution.

14.1.3 Natural Resource Management

1. Forest Management: RS and GIS are used to monitor forest health. detect deforestation, and plan sustainable forest management practices.
2. Water Resource Management: RS and GIS help manage water resources, including groundwater monitoring, watershed management, and flood control.
3. Agricultural Management: RS and GIS are used to monitor crop health, detect pests and diseases, and plan precision agriculture practices.

Remote Sensing (RS) and Geographic Information System (GIS) are powerful tools used in various

fields for data collection. analysis. and decision-making. Here are some applications of RS and GIS:

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1. Land Cover Classification: RS and GIS are used to classify land cover types, such as forests, grasslands, and urban areas.
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3. Agricultural Management: RS and GIS are used to monitor crop health. detect pests and diseases, and plan precision agriculture practices.

14.1.7 Infrastructure Development

1. Road Network Planning: RS and GIS help plan and manage road networks, including route planning, road maintenance, and traffic management.
2. Building Construction: RS and GIS are used to plan and manage building construction, including site selection, design, and monitoring.
3. Utility Mapping: RS and GIS help map and manage utility networks, including electricity, water, and sewage systems.

14.1.8 Disaster Response and Recovery

1. Damage Assessment: RS and GIS help assess damage to infrastructure, buildings, and environment after a disaster.
2. Emergency Response Planning: RS and GIS are used to plan and manage emergency response efforts, including search and rescue operations.
3. Recovery and Reconstruction Planning: RS and GIS help plan and manage recovery and reconstruction efforts, including infrastructure rebuilding and environmental restoration.

14.1.9 Other Applications

1. Archaeological Site Mapping: RS and GIS help map and manage archaeological sites, including site identification, excavation planning, and cultural resource management.
2. Wildlife Habitat Mapping: RS and GIS are used to map and manage wildlife habitats. including species identification, habitat fragmentation analysis, and conservation planning.
3. Geological Mapping: RS and GIS help map and manage geological features, including rock formations, mineral deposits, and geological hazards.

14.2 Summary

In summary, the integration of RS and GIS offers a versatile toolkit for analyzing and managing spatial data, and their applications span various industries, from environmental conservation to urban planning, agriculture, and defense. The benefits of combining RS and GIS:

- Enhanced Decision-Making: The combination of spatial data from RS with analytical capabilities of GIS leads to more informed decisions.
- Improved Resource Management: Helps optimize land. water. and infrastructure resources.
- Timely Disaster Response: Enables quicker assessment and management of disaster areas.

14.3 Keywords

Land Use and Land Cover Mapping; Environmental Monitoring; Disaster Management; Urban Planning and Management; Agriculture and Precision Farming; Forestry and Biodiversity Conservation; Climate Change and Modelling; Water Resource Management; Natural Resource Management; Soil Erosion and Conservation; Coastal Zone Management; Hydrological Modelling; Geospatial Analysis; Transportation and Infrastructure Planning; Wildlife Habitat Mapping; Energy Resource Assessment; Hazard Mapping (e.g., Floods. Landslides); Geospatial Data Integration.. Deforestation and Desertification; Ecosystem Services Mapping; Agricultural Yield Prediction; Air Quality Monitoring; Public Health and Disease Surveillance; Cartography and Mapping; Risk Assessment and Management

14.4 Model Questions

- How is Remote Sensing used in land-use/land-cover classification?
- In what ways does GIS help in urban planning and development?
- What role does RS play in monitoring deforestation and forest health?
- How can GIS be used to predict flood-prone areas?
- What is the importance of RS and GIS in agricultural crop monitoring?
- How is GIS utilized in disaster management and response?

- How can RS data be used to assess the impact of climate change on coastal areas?
- What is the role of GIS in wildlife habitat mapping and conservation?
- How does RS assist in identifying and managing water resources?
- How can GIS be applied to transportation network planning and analysis?

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Unit - 15 ❑ RS and GIS and their use in preparing a project report

Structure :

15.0 Learning objectives

15.1 Practical application of Remote Sensing to prepare a field report

15.1.1 Geospatial Data Collection

15.1.2 Key Elemets

15.2 Satellite sensors and their practical application in different field of study

15.3 Satellite data procurement system

15.4 Visual image Processing: Practical application

15.5 Digital Image Processing : Practical application

15.6 Survey and its implication of project report preparation

15.7. Preparation of a Project Report

15.7.0 Structure of the Project Report

15.7.1 Title Page

15.7.2 Certificate

15.7.3 Acknowledgement

15.7.4 Contents page

15.7.5 List of Tables

15.7.6 Figures and Plates

15.7.7 Bibliography

15.7.8 Abbreviations

15.7.9 Abstract

15.7.10 CHAPTER-1

15.7.10.1 Introduction

15.7.10.2 Project Study Area

15.7.10.3 Objectives

15.0 Learning objectives

By the end of this unit, students would be able to:

- Understand the practical application of Remote Sensing to prepare a field report
- Have an idea of satellite sensors and their practical application in different field of study.
- Know about Satellite data procurement system
- Learn about Visual image Processing: Practical application
- Understand Digital Image Processing: Practical application
- Learn about survey and its implication of project Report Preparations
- Know about structure or formats while writing a Project Report

15.1 Understand the Practical application of Remote Sensing to prepare a field report

The techniques of Geo-informatics (RS, GIS and GNSS) are having multiple applications in various major disciplines like. Project planning, Geological and Geomorphological Studies, Agricultural uses, Soil Surveys, Mineral Resources, Forest Resources, Water Resources, Land Use, Environmental Studies, monitoring disasters and natural calamities and guiding civil, defence people. Remote Sensing techniques added a new dimension to the surveying capabilities for the accelerated pace of map making and map revision. The techniques have found wide applications in finding thematic information of diverse types, on a regional scale expeditiously, economically and efficiently.

One of the most important steps in any remote sensing projects is to make proper field measurements or observations of the special phenomenon being studied.

Ground base, air base and space borne platforms are utilised in different purpose to solve different problem. Different types of active and passive sensors are utilised for collecting spatial data.

The Geographic database has two basic components: spatial data and tabular or non-spatial data.

15.1.1 Geospatial Data Collection :

Spatial Information or data collection Through Remote Sensing Survey Technique, Aerial Photos, Toposheets, Lidar Data, Radar Data and data related to topology, Direction, relative position between objects and Coordinate system.

Spatial Information or data collected through Remote Sensing Survey Technique

- Digital Photogrammetry Techniques, Satellites, UAV... RADAR, GNSS Satellites
- UAV (Unmanned Aerial Veachile) or Drone Technique
- RADAR & LIDER Technique
- GNSS (Global Navigation Satellite System) Technique

Non-Spatial Information or tabular data or attributes Collected Through Household Survey from Government offices📪 websites, questionnaire Survey.

Spatial & Non-Spatial Information or data Integration through GIS (Geographical Information System) Technology

15.1.2 Key Elemets :

Followings are the very essential key elements for preparing a field report which is available through geo-informatics techniques.

- **Open source Maps and data :** Now a day's satellite data is easily accessed online through various mapping applications like Google maps, open street maps, Bing maps, NASA's Globe view, etc. using this technique low cost, up-to date maps can be produced efficiently. **(Annexure - I)**
- **An authentic and uptodate base map of the study area :** Collect analog or paper maps from different organisations (source of data **Annexure I)**
- **Type of software:** For satellite image processing there are two types of software's are available commercial and open sources. in the other hand for generate a project report using satellite image, Digital Image Processing software is required and for Geographical Information System a specific GIS software's are suitable**. (See Annexure-II)**
- **File type and compatibility:** In separate software compatible files are require for conversion of scan maps to image files, different types of file format is suitable for individual software. (**Annexure -III**)
- **Homogeneity of Spatial and Non spatial data:** A unit of measurement or counting must be unambiguously defined and uniformity is maintained in total process. Before collection of spatial and non spatial data, the unites may be defined clearly. The characteristics of data unites are:
- The unit is suitable to the purpose of the project enquiry
- The unit must be simple and easily understandable.
- It is standard uniform and precise
- The unit must have comparability

- **Concept about METADATA source & structure:** Data about data is called metadata. Metadata is also known as Image Support Data (ISD). This file specifies the basic characteristics of an image. It contains all the information regarding the product/ Image like the date and time of acquisition, angle, number of Rows, number of columns, number of bands, spatial, radiometric resolution, order number, file type etc., Metadata file of imagery come with in the CD or website along with the satellite imagery product ordered in MTL format. This file helps us in knowing about the satellite image and for calculating the reflectance for every pixel.

- **For finding out the accurate result, Ground truth verification of digital analysis is must:** Each and every project related to remote sensing application for finding out the accurate result, Ground truth verification of digital analysis is required, otherwise findings the final output for planning is represent faulty.

- **Data validity or authenticity, Use update and latest database:** in a wide sense, authentic data must accordingly represent a real world scene and even if some processing has been probably applied the meaning of the scene must not be modified. In remote sensing application or any project update and latest real time data base is now available, so use real-time data for this purpose.

15.2 Satellite sensors and their practical application in different field of study

For utilized satellite data in different field of study some basic requirements are necessary to follow, this are discuss in below

- How to procure or purchase real time satellite data or latest data
- In a passive sensor image cloud free data and data availability is very much essential
- For active sensor image processing specific image processing software is required, application of active sensor data is also complicated and special training is required for interpreted this data
- Four resolution characteristics of a sensor are played important roles.

- Date of pass (DoP) is another important requirement for digital image classification
- Projection and earth model is very essential for geo-referencing
- Create Geo-database

Visually interpret this study area and identified features:

- For feature identification the standard false colour composite (std.FCC) was prepared from satellite data and take colour print on it.
- Using a tracing paper different cultural and physical features are identified and pick out
- Interpret this features depends on different visual interpretation keys like Size, Shape, Pattern, Tone, Texture, Association etc.
- Using Google earth pro web site different temporal data or images in this study area is save by using historical keys. Chronologically arranged these images to find out the changes of the area.

15.3 Satellite data procurement system

Integrated Multi Mission Ground Segment for Earth Observation Satellites (IMGEOS) facility is established in ISRO NRSC Shadnagar campus. This facility is equipped with state of the art data acquisition systems which receive data from various satellites. Payload programming requests are consolidated at the respective sub systems based on the feasibility of tracking a particular satellite and acquisition schedules generated for each of the antenna in ground station.

NRSC is the nodal centre for hosting Satellite Data Products from more than 13 IRS satellites right from the first IRS optical mission namely IRS-1A and SAR imaging missions. Satellites are primarily tasked to cover India and surroundings in a programmatic manner or on-demand as required by user as per mission capability. NRSC also acquires and archives data of global regions for disasters, calibrations and specific studies. Near real time data products from IRS weather sensors is delivered for climate and weather models for a global coverage. Georeferenced, Orthokit, Orthorectified products are provided in standard formats like Geotiff, HDF.

For Procurement of satellite imagery : Web site: www.nrsc.gov.in

15.4 Visual image Processing: Practical application

Satellite images are like maps—they're full of useful and interesting information as long as you have a key. Imagery can show how much a city has changed, how well crops are growing, where a fire is burning or when a storm is coming. To unlock the rich information comprising a satellite image, you need to begin with five basic steps:

- Look for a scale.
- Look for patterns, shapes and textures.
- Define colors (including shadows).
- Find north.
- Consider your prior knowledge.

15.5 Digital Image Processing : Practical application

Preparation of a Project Report followed mainly three stages beginning preparatory works or pre-field study, that include studying, comparing and interpreting the existing literatures, maps and images; backed up by field surveys and, post-field analysis for report writing through statistical analysis of collecting opinion survey data and samples. An outline of preparation of a project report is discussed below :

15.6 Survey and its implication of project report preparation

Survey is a process of collection of data. It is not only a particular technique of collecting information; questionnaires, structured and in-depth interviews, observation, content analysis are widely used. For collecting data and preparation of final report there are many stages are involved. These stages are summarised in the following points:

A. Clear objectives for the project report : The planning of objectives will depend in large measures on the expected result or the nature of the final product. Whether the result is a map or a report describing a biophysical model, preliminary planning is essential. Comprehensive statement of objectives should include the following items:

1. Location and size of area 2. Scale of final map 3. Accuracy of the final result 4. Purpose and end-users of the final product 15. Anticipated legend of the final map 6. Types of image data, maps, photes, and other reference materials to be used 7. Field methods to be used.

B. Scope : Scope of the project enquiry should be decided with reference to the space, time, and number of event or items to be covered. If it is not clear before starting the project it causes either delay in finishing the work or drawing wrong conclusion.

C. Source of data : There are two sources of information: Primary: data collected for the project first time and Secondary: the data that have already been collected and used by some agency. the selection of source depends upon (a) purpose and scope of enquiry (b) availability of time (c) finance (d) accuracy required

D. Reliability of Data : the reliability of data can be tested by finding out the agency that collects this data. Without knowing the meaning and limitations use of secondary data is very difficult.

E. Methods of data collection : A valid sampling plan is required to success a project. Map accuracy depends greatly on the degree to which sampled data truly represent the land surface. Data analysis should understand how to choose a classification programme and how to demonstrate that their data are suitable for that programme.

F. Standard of accuracy : The standard of accuracy is to be maintained in the project to be planned beforehand.

G. Type of enquiry : There are different types of enquiry to be undertaken—confidential or non confidential, direct or in direct, census or sample.

H. Inadequate reference materials : Reference materials, other than field data, include all archival data such as air photos, maps, satellite images and any other complied data that are referenced to map locations like GPS data, Census data, and weather record etc. properly mentioned this reference in a report reference list.

I. Summary of GPS survey and mapping in a field report

- Select a base map of study area and its coordinate system
- Determine the level of accuracy needed depands on spacific application
- Investigates satellite visibility for the dates and times of field trip.

- Determine the location of control points of known coordinates
- Create a geo-referenced image with an overlay of line,points and polygon layers in different earth surface features.

15.7. Preparation of a Project Report

After the spatial and non spatial data have been analysed, a report is drafted to show the findings or result of the investigation of the survey. Generally in a report the following aspect are found:

15.7.0 Structure of the Project Report

Following formats should be followed chronologically while writing a Project Report

15.7.1 Title Page :

The title page of a project report is the page at the front which displays its project title, subtitle, name of the students with roll number, name of supervisor, name of the institution that you are writing the paper with, and published month and year.

15.7.2 Certificate :

Project Completion Certificate means the certificate issued by the supervisor upon completion of the Project guidance and the institution where facilities in accordance with the Approved Project Implementation Plan.

15.7.3 Acknowledgement :

Acknowledgement in project writing is a section where the write acknowledges and show appreciation to everyone who has helped in the project. Acknowledgement is also included in research project writing to recognize and thank everyone who was involved in the research. After finishing acknoledgement writing full signature with date of candidates is required

15.7.4 Contents page :

This should list the main chapters and (sub) sections of your dissertation. Choose selfexplanatory chapter and section titles and use double spacing for clarity. If possible you should include page numbers indicating where each chapter/section begins.

15.7.5 List of Tables :

A List of Tables is a reference tool that allows your readers to quickly and easily navigate to data in your thesis or dissertation. Construction of the list is similar to creating a Table of Contents.

15.7.6 Figures and Plates :

A list of figures is to quickly find the illustrations, diagrams, tables, and charts in your report. Figures are illustrations, drawings, photographs, graphs, and charts.

15.7.7 Bibliography :

The term Bibliography means description of books or report. A bibliography is a listing of the books, magazines, literatures and Internet **sources** that you use in designing, carrying out, and understanding your project. It is used at the end of any project report.

15.7.8 Abbreviations :

It is a shortened form of a written word or phrase used in place of the whole word or phrase. This term originates from the Latin word *"brevis"* which means short. Abbreviations may be used to save space and time, to avoid repetition of long words and phrases, or simply to conform to conventional usage.

Some abbreviations are formed by omitting all but the first few letters of a word; such abbreviations usually end in a period: *Oct.* for *October*, *univ.* for *university*, and *cont.* for *continued*.

15.7.9 Abstract :

The abstract is a very brief summary of the project report contents. It should be about 300 words or less than long. Somebody unfamiliar with your project should have a good idea of what it is about having read the abstract alone and will know whether it will be of interest to them.

15.7.10 Chapter 1

15.7.10.1 Introduction :

An **introduction** is the first paragraph of a written research paper, or the first thing you say in your experience about your **project**. The **introduction** gives the summarised concept of the project report It also discusses the moral theme of the entire project. Historical background of the study area, previous work on study area also discusses in introduction.

15.7.10.2 Project Study Area :

Study areas are geographic boundaries created to define the extent of your analysis. These are created when starting a project to ensure your data and analyses are confined to a specified area. The Project Study Area is the area within which field data is collected to identify all known environmental resources.

15.7.10.3 Objectives:

Project objectives are what you plan to achieve by the end of your project. Project objectives should be attainable, time-bound, **specific goals** you can measure at the end of your project.

Project objective describes the status, which should be achieved at the end of the project. It represents an information management, according to the three dimensions of the magic triangle (quality, time and costs). The objects are necessary for the planning, monitoring and control of the projects.

15.7.10.4 Literature review :

A literature review is a survey of scholarly sources on a specific topic. It provides an overview of current knowledge, allowing you to identify relevant theories, methods, and gaps in the existing research. It is a comprehensive overview of all knowledge available on a specific topic till date.

- Project related works in India:
- Project related works in West Bengal:
- Project related works in the specific study area: village, town, block, subdivision, district, watershed region etc.

15.7.10.5 Statement of the Problem :

A problem statement is usually one or two sentences to explain the problem your process improvement project will address. In general, a problem statement will outline the negative points of the current situation and explain why this matters.

A problem statement is a concise description of the problem or issues a project seeks to address. The problem statement identifies the current state, the desired future state and any gaps between the two. A problem statement is an important communication tool that can help ensure everyone working on a project knows what the problem they need to address is and why the project is important.

There are four key elements you should include when writing a problem statement:

- Ideal situation
- Reality
- Consequences
- Proposal

How to write a problem statement

- Identify the problem.
- Begin your statement with your ideal situation.
- Describe current gaps.
- State the consequences of the problem.
- Propose addressing the problem.

15.7.10.6 Methodology :

Methodology is a structured set of methods, specific processes, procedures or techniques used to fulfil objectives or aims of the project report. The methodology is the general research strategy that outlines the way in which research is to be undertaken and, among other things, identifies the methods to be used in it. These methods, described in the methodology, define the means or modes of data collection or, sometimes, how a specific result is to be calculated. The methodology does not define specific methods, even though much attention is given to the nature and kinds of processes to be followed in a particular procedure or to attain an objective.

A methodology is a model, which project managers employ for the design, planning, implementation and achievement of their project objectives. There are different project management methodologies to benefitting different projects.

The purpose of project methodology is to allow for controlling the entire management process through effective decision making and problem solving, while ensuring the success of specific processes, approaches, techniques, methods and technologies**.**

15.7.10.7 Pre Field Study

A detailed survey of the existing literatures on the study area was made and an inventory for the field work was prepared. Gaps in existing knowledge were identified and objectives of the project were framed accordingly.

Study of Background History

The history of the situation of the study area has been studied from existing literatures and statistical reports from Government and non-government organisation. For creation of secondary database in any report the following table has been helped (**Annexure I**).

Study of Population Attributes or demography of the study area

The major trends of population characteristics of the area and its surrounding mouzas has been studied using data of Census of India. Some of the trends obtained from the study are projected to obtain data base.

Estimation of Regional Trend of Evolution or change in land-use pattern

For this purpose, different series of maps and satellite images were used. The materials would include: (i) 1:3,960 Mouza maps, (ii) 1:63,360 Police Station maps; (iii & iv) Survey of India (SoI) topo maps of 1:63,360 and 1:50,000 series, maps and (v) Geocoded satellite images in different sensor and temporal scale. (vi) google earth or any digital globe data in different times. These maps and images were consulted to get a trend of evolution and land use changes of the project area. Source of map, image and field data used in a project is shown in Table below (**Annexure-I**).

15.7.10.8 Field work

- *Socio economic survey (The Target Groups)*

An opinion survey among the local people or residents was undertaken in the field on the basis of different sets of predetermined questionnaires. (Samples of these have been appended at the end of this report.) Their perception on the local issues is also important as they, being residents of surrounding villages probably have a better understanding of the problems the area faces. Exclusive details like amenity profile, pollution status, environmental profile, economic profile of the project area had been collected from local residents through questionnaires survey.

The opinion of the senior most members of a family or a group was taken into consideration. Residents of the mouzas adjacent to the study area have been surveyed. The sample was chosen from the neighbourhood of different communities depending upon the economic class of the residents.

Physical or Instrumental Survey

- *Differential Global Positioning System (DGPS) Survey:*

DGPS survey was conducted in the study for two purposes: Firstly, for generation of linear vectors directly from the field for determining the exact position of every physical and cultural feature. Secondly, detailed Differential Global Positioning System (DGPS) survey has been conducted in the field and the resultant vectors— representing positions of all infrastructures, communication system, administrative setup, households in the study area and it is transferred on the base map prepared from the maps and satellite images.

- *Detailed Plot to Plot Manual Survey: Using Hand-Held GPS*

Detailed plot to plot manual survey and rough sketching has been conducted in the field—representing positions of all physical or cultural or anthropological features or establishment, roads, recreation centre, administrative centre etc. of the study area. It is transferred on the base map prepared from the base maps or high resolution images.

- *Surveys Related to height determination or elevation profiling in project area*

To study elevation profiling in a area digital dumpy level and for determining height of any features Total Station (Digital Theodolite) surveys were simultaneously run at different locations and superimposed this profile in base maps or images.

- *Study of Environmental Perception of the Resorts:*

For the purpose of opinion surveys prior to field investigation, four sets of questionnaires were prepared. The survey was carried out among selected samples comprising the local hoteliers, residents, tourists, and tourism-linked economic activities.

- *Surveys Related to Residents in Surrounding Locality:*

Opinion surveys were conducted among local residents of study area and surroundings region on the basis of prepared questionnaire. Their perceptions were recorded and diagrams were prepared on their opinion.

- *Surveys Related to different Economic Activities:*

The major and minor economic activities were identified and a few of these, like retail, hawkers, transport etc. have been studied The primary transport on road is public and private buses, trekkers, and private cars. The local vehicles include motor-van and van rickshaw. Waterways comprise the boats, ferry service, and barge. data collected from various offices of Bus Owners' Association and Bus Syndicate, RTO, stand manager, SBSTC, Surface Transport Corporation, CSTC, the Panchayat Samiti and Rickshaw Pullers' Association etc.

15.7.10.9 Post-field Analysis

This phase of work involved computation, tabulation, and analysis of primary and secondary data, and satellite image processing.

Phase I : Conversion of hard copy maps to image files

All the maps which are used to prepare a project were initially scanned at 300 dots per inch (DPI) resolution and converted into computer-readable Tagged Image File Format (.tif) files.

- Next, they were brought into the Image Processing software environment by transforming them as bitmap layers in a separate software compatible files.
- The maps stored as bitmaps were subsequently converted to image layers with pixels of 5 m or any lower pixel dimension.

Phase II : Geocoding or Registration of Maps and Images mosaicing, layering and subsetting

In the first phase, all of the available 15',„e15' maps, prepared from SoI sheets of various editions, as well as the PS maps were individually geocoded into files of longitude/ latitude (Everest ellipsoid) frame of reference.

In the second phase, these were layered into different mosaic files. In the third phase, all the mosaiced files were reprojected to Universal Transverse Mercator (Zone 45-

North). The most recently surveyed metric maps were geocoded first using graticule intersections. These formed the basis of subsequent geocoding of the rest of the maps and Pan Scenes. For the images, additional control points, generated from GPS survey, were used.

Phase III : Preparation of FCC

The standard false colour composite was prepared from Image like IRS LISS-3 data by ascribing visible colours *blue green* and *red* to IRS bands *2* (green), *3* (red) and *4* (near infrared) respectively.

Phase IV : Digitisation

Digitisation of selected features like major roads, railways, canals, rivers and riverbanks were carried out.

Phase V : Classification

To digitally prepare a landuse / land cover map of the study area, training areas were first delineated in the standard FCC generated from satellite image data. The selected training areas and their ground truth characteristics are shown as an overlay, training areas were first delineated in a standard False Colour Composite (FCC) generated from Image.

- Using software these training areas were then transferred to a specially created image channel as graphic (bitmap) masks.
- Supervised classification of the data, using satellite image was subsequently performed using the maximum likelihood algorithm and the resultant PCT was stored in a separate image channel.
- Reports on signature separability and on extensions of the classified pixels were also generated besides classification.
- For final display and presentation, software specific cartographic surroundings were used.

Phase VI : Representation and analysis

The final output of the exercise was displayed and printed using the image processing or any GIS software. a number of typical map features (called *surrounds*) like coordinates, borders, scale, legend and north line can be automatically generated and are customisable to a large extent.

Thematic maps, choropleth maps, maps with overlays cartograms is to be prepared depends on non spatial or tabular data in the study area. Characteristics are as follows:

- Tentative title and application of the final map
- Location and size of the study area
- Legend of the Final map
- Map scale and level of map accuracy
- Types of Image and reference data
- Pre-processing and classification approach 11

15.7.10.10 Non-Spatial or Tabular Data Processing:

This phase of work involved computation, tabulation, and analysis of primary data, which are collected through questionnaire survey. Initially a master table was prepared where all raw data were properly tabulated. For analyzing this arranged data, the study used various statistical and cartographic techniques Relationships between the social activity and environmental variables have been analysed using simple qualitative and statistical methods. The study also used Geographical Information System (GIS) to show the spatial distribution of the data.

The availability of open source software and free satellite data and related file format see Annexure-II & III.

15.7.11 Constraints of the Study :

The constraints of a project or a field study means the limitations while performing a project or study analysis. It creates some challenging difficulties in the study analysis, on the other hand it is a controlling phenomenon of a project study. In a project report preparation or implementation three main constraints are cost, time and scope.

15.7.12 CHAPTER-2

Geomorphic Setting of study area

- Climate
- Soil and groundwater
- Natural vegetation

- Animals
- Demographic and socio economic characteristics
- Conclusion

15.7.13 CHAPTER-3

Case Study

- Land Use Change in study area
- Impact of Land-use Changes and Management Possibilities
- Spread of infrasructure and administrative setup
- Impact of Unplanned Construction
- Development and growth of Transport System
- Spread of other economic Activities
- The Environmental Problems and their Management
- Physical Hazards
- The Problems and Management of Physical Hazards
- Urban Environmental Problems
- Opinion Surveys Related To Urban Environmental Problems
- Socio- Economic and Cultural Impact

15.7.14 CHAPTER-4

15.7.14.1 Conclusion :

A concluding remark is the last paragraph of the conclusion in a project report. It is called a concluding remark because it sums up the entire purpose of the project in a paragraph. As the name suggests, this remark wraps up the entire report with a period at the end.

15.7.14.2 Reference :

Reference is used to tell the reader where ideas from other sources like books, journals, articles, websites are used in a paper or report. It is used when writers have quoted word or sentence from any books, or published articles from any outside sources.

There are different types of reference style is available like APA style, MLA style, Oxford style, Harvard style and Chicago style.

15.7.14.3 Appendices :

Annexure- I

An appendix is supplementary material, usually attached at the end of a piece of writing, before your Works Cited. The appendices must be extracted from the Process Journal. All extracts should contain the date they were added to the journal. It may be material such as surveys, letters, graphs and charts.

Annexure- II

Open sources Software and availability

- The Sentinel Toolbox
- QGIS; Quantum GIS
- SAGA GIS: System for Automated Geoscientific Analyses
- ORFEO Toolbox (OTB)
- GRASS: Geographic Resources Analysis Support System
- PolSARPro
- ILWIS: Integrated Land and Water Information System
- OSSIM: Open Source Software Image Map
- ORFEO Toolbox (OTB): Optical and Radar Federated Earth Observation

Free Satellite data are available:

- Earth Explorer: https://earthexplorer.usgs.gov
- Glovis: glovis.usgs.gov/
- GLCF: http://www.landcover.org/
- Bhuvan: bhuvan.nrsc.gov.in
- Esa sentinel image: https://sentinel.esa.int/

Water related data are available:

- Wris: www.india-wris.nrsc.gov.in
  Open Government Data (OGD) Platform India
- https://data.gov.in/

Environmental Data are available:

- Geovanni :https://giovanni.gsfc.nasa.gov/
- www.diva-gis.org/
- http://www.naturalearthdata.com/
- https://urs.earthdata.nasa.gov/
- https://mapstory.org/
- https://www.nasa.gov/
- http://www.noaa.gov/

Annexure-III

File formats play an important role in image processing software packages

- For Scanning hardcopy Maps Raster output following file formats are required

  JPEG (Joint Photographic Experts Group) ...

  PNG (Portable Network Graphics) ...

  GIF (Graphics Interchange Format) ...

  PDF (Portable Document Format) ...

  SVG (Scalable Vector Graphics) ..

  TIFF (Tagged Image File)

  PSD (Photoshop Document)

  RAW (Raw Image Formats)
- **GeoTIFF** is a variant of TIFF that includes geolocation information in header (http://remotesensing.org/geotiff/geotiff.html)
- **HDF** or Hierarchical Data Format (http://hdf.ncsa.uiuc.edu/) is a selfdocumenting format
- **EOS-HDF is NASA version (http://hdf.ncsa.uiuc.edu/hdfeos.html)**
- **NITF** National Imagery Transmission Format (http://remotesensing.org/gdal/frmt_nitf.html) Department of Defense
- IMG (ERDAS IMAGINE Image)

- PIX Geomatica
- SHP Shapefiles (.shp) (Arc GIS) ESRI's shapefile format
- TAB (Tablefiles) MapInfo's file format
- KML/.KMZ: Keyhole Markup Language, an XML language used in Google Earth and Google Maps
- CSV (comma separated values) files.

15.8 Summary and Conclusion

This unit helps the learners to understand the practical application of remote sensing. It also helps to prepare a project or field work based report. The geospatial data collection, survey, information collection and their implication in the preparation of project report are discussed and analysed thoroughly. The structare of the project report is also elaborated in a suitable format. Therefore, it revelas that the learners can apply their knowledge gained from the earlier units fruitfully and able to prepare the project report of their own.

15.9 Keywords

Application of RS, Preparation of field project report, structure of the project report.

15.10 Model Questions

1. Prepare a survey schedule to collect data.
2. Discuss the implication of survey in project report preparation.
3. State the pattern of geospatial data collection.
4. What are the open sources of maps and data.
5. How satellite sensors are useful in field study?
6. Why 4Ps survey is important in field study?

7. State about the satellite data procurement system.
8. What is the application of visual image processing?
9. Discuss the structure of a project report.
10. Discuss the chapters of an ideal project report.
11. Give an account on the practical application of Digital Image processing (DIP)
12. What are the softwares available for processing RS data in the preparation of a field report?

15.11 References and Further Readings

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- Remote Sensing and GIS (English) 2 Rev ed Edition, Basudeb Bhatta, Oxford University Press, USA
- Remote Sensing Handbook - Three Volume Set Edited by Prasad S. Thenkabail, Ph.D. CRC Press – 2015
- Remote Sensing in Geology Siegal, B.S. and AR Gillespie, Wiley, New York
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