GEOGRAPHY

A Supplementary Text for Class XI

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FOREWORD

Our education system is making all efforts in fulfilling the directives issued by the Royal Government of Bhutan to make education meaningful and relevant to our children besides outlining the roles they are expected to play as the future citizens of the country.

Following the decision of the Ministry of Education to localize the Class XI and XII courses, with the BBE conducting the Bhutan Higher Secondary Certificate Examinations with effect from 2006, new topics of global importance have been added. Therefore, Bhutan Geography supplementary text for Class XI has been developed incorporating information on Global Warming, Green House Effect, Climate Change and Remote Sensing. These topics would be indispensable for our children to cope with the world of work as well as to understand the current issues of global importance. The course would impart the values of not only appreciating nature but also sustaining it. It would also emphasise the necessity of using nature prudently and not exploiting it till it collapses with no hope of revival. The awareness created through this supplementary text would also make the children preserve our pristine environment and ecological system.

We wish our teachers and students to learn from this book and contribute individually and collectively towards fulfilling His Majesty's visions of a strong, prosperous and sovereign independent Bhutan for all times to come.

Trashi Delek.

Thinley Gyamtsho
MINISTER
Ministry of Education

INTRODUCTION

The topics in the Geography Supplementary Text cover those that are not treated in the main textbook. For instance, the topics treated in this text are the ones from Unit Two and Unit Four. The other topics are in the main textbook titled *ISC Geography for Class XI* by D.R. Khullar. Thus, it is important to refer to the syllabus time and again to ensure that no topic is left out. The objective of introducing the topics like Remote Sensing, Climatic Change and the Koeppen Classification of Climate is to familiarize the students with some important avenues of learning.

The areas covered in the Supplementary Text also help the students to understand and discuss prominent issues of global implications like global warming and climatic changes. These topics would definitely give opportunities to the students to study global warming and effects of climatic change in the Bhutanese context.

Trashi Delek.

Dr Jagar Dorji
Chairperson
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Unit Two: Atmosphere

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2.5.1 Climate Change

Climate change has been a critical environmental and developmental issue. Studies have proved that the mountain ecosystem is more prone to the effects of climate change. The negative effects would be glacier melting, decline in agricultural production, forest degradation, bio diversity losses and perturbation in the natural water resource.

For a country like Bhutan, these negative impacts would be even more severe as more than 80% of the population depends on agriculture and natural resources. Moreover, hydro-electricity is the main source of revenue.

Let us examine some of the causes of climate change:

- ***Carbon dioxide:*** Variation in CO_2 content in the atmosphere is one of the major factors contributing to climate change. This colourless gas tends to let in all the in-coming shortwave solar radiation but absorbs the outgoing longwave radiation. The radiation that is absorbed is later released into the atmosphere. This creates a situation which is termed as "green house effect", thereby raising the temperature.

  The source of CO_2 is the industries. Although the plants take some percentage of the gas, some percentage is still in the atmosphere.

  it is possible that the increased presence of CO_2 in the atmosphere may even lead to the lowering of the temperature. Higher temperature would mean high rate of evaporation and more condensation in the form of clouds would reduce the temperature as the clouds would not let all the heat of the sun to reach the earth's surface.

- ***Volcanic dust:*** The dust from the volcanoes tends to deflect the shortwave radiation of the sun but the longwave radiation can pass through easily. So, if the volcanic dust is on a large scale, the earth's temperature may be lowered.

  The Krakatoa volcanoes of 1883 released so much dust into the atmosphere that it is believed to have brought down the temperature significantly. Only when the dust particles settled then did the temperature become normal.

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We are aware that the atmosphere is heated more by terrestrial radiation than by incoming solar radiation. There is, however, a natural balance of input and output of this radiation and the earth's climate changes relatively less. This helps the earth to support life within a particular range described by the biosphere. Any imbalance in the input and the output of the solar and terrestrial radiation will upset life on earth. Of late, many human activities, in the form of industrialization and urbanization, have upset the input and the output of solar radiation.

The environmental problem that we have today is mainly the consequences of human activities that have disturbed the input and output balance of solar radiation. Four major effects of climate change are global warming, green house effects, biomes desertification and ozone layer depletion.

- ***Global Warming :*** It has been proved that the temperature of the earth would see a rise of 3 degrees centigrade from its present level. This will result in net increase in temperature, which will further result in a change in the living conditions and even the relief features of the earth.

  Why is the earth warming up when there is neither any change in the sun's energy nor any in the movement of air over different parts of the earth?

  The release of carbon dioxide into the atmosphere from the natural processes such as volcanic eruptions, the decomposition of organic matter, gas exchange in the ocean and respiration by animals and by the human activities of burning of fossil fuels, and forest fires have increased the global level of carbon dioxide by nearly 30 %, and they continue to increase by roughly 3 percent every year. The worst offenders are the industrialised countries as they, as a whole, emit several tonnes of carbon dioxide per person per year. Methane is believed to be 20 times more effective in absorbing heat, molecule for molecule than carbon dioxide. While the natural sources of methane are not entirely clear, methane level in the atmosphere has almost doubled in the last 150 years and is now increasing by just over 1% annually. The main artificial source is agriculture, which produces some 350 million tonnes of methane every year in the guts of cattle and water logged fields such as paddy fields. Unfortunately, more methane enters the atmosphere when more food is produced. Nitrous oxide, which is emitted by car exhausts, fossils combustion, nitrogenous fertilizers, ploughing field and the burning vegetation, account for 6 %.

If atmospheric concentration of the green house gases continue to rise, the average world temperature will rise as well. No one knows exactly how this will happen. The average temperature of the planet has risen by only 5 degrees centigrade since the peak of the last Ice Age. So the effect of any change will undoubtedly be quite dramatic. But, this time, the speed of change could be as damaging as change itself, particularly since the ability of the biosphere to adapt is rapidly declining as a result of environmental degradation. There is also concern that the temperature increase will be uneven, perhaps ranging from less than 1 degree centigrade at the equator to more than 5 degrees centigrade at the higher latitudes.

Student Activity

"A warm climate, with long summers and mild winters may seem a pleasant prospect but there could be some unpleasant surprises lurking ahead".

Discuss, in pairs, some of the unpleasant surprises lurking ahead.

- ***Green House Effect :*** *The earth's umbrella*: Just like other bodies, the earth and its atmosphere emit energy in the form of heat. Heat energy radiated by the earth into the atmosphere, instead of dispersing it into the atmosphere, becomes trapped in the atmosphere, thanks to the effect of certain atmospheric gases. This is the *green house effect*, in which the earth's surface and the lower regions of the atmosphere maintain sufficient levels of heat to sustain life.

  The atmosphere contains certain gases that retain the heat given off by the planet. Some of these gases are carbon dioxide, nitrogen oxides, water vapour and methane. They are all found in a natural state in the atmosphere. These are the gases that produce greenhouse effect.

  Retaining heat: The amount of these gases can be increased because of certain human activities, which can be very dangerous because if the atmosphere retains too much heat, the earth will become too hot. The gradual overheating of the earth is called *global warming.*

  Trees assimilate carbon dioxide the most, using it to create food and new plant tissues through photosynthesis. Trees act as "regulators" of this green house gas. Because of the gradual disappearance of forested areas that absorb carbon dioxide, the atmospheric quantity of this gas could be greatly increased in the future.

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We cannot ignore the effects of the combustion of oil, natural gas, and coal in industry. Twenty billion tones of carbon dioxide are released into the atmosphere every year, mostly as a result of industrial activity. Industrial processes increase the carbon dioxide content of the air and prevent the earth from discarding excess heat.

Gases called CFCs cause global warming. Ultraviolet light frees the chlorine that is found in these gases. The chlorine then decomposes the particles of the ozone layer, reducing its concentration in the stratosphere. The result is that the ultraviolet radiation can penetrate the atmosphere more easily.

Apart from dangerously increasing the temperature on earth, UV radiation can damage plant tissues. Seeds and plankton might stop producing food. Industrial emissions, human activities, ocean pollution that prevents the exchange of gases with the atmosphere, and the impoverishment of the soil due to modern agricultural techniques and intensive livestock rearing, are all factors that influence the changes that are taking place in the atmosphere, affecting earth's climate. Intense volcanic activity can also produce climate change.

- ***Desertification of the Biome****:* The term 'biome' refers to a community of life forms with its own characteristic vegetation and animals that survives in a cycle of a unit called the ecosystem. The percentage of carbon dioxide in the atmosphere would be minimum, if there were a balance in the ecosystem. As man tends to ruthlessly cut down the trees for selfish means, the amount of carbon dioxide in the atmosphere increases. With mountain ranges blocking the movement of moisture, the earth's great biomes (the rain-forest and grasslands) face the danger of turning into dry lands. It is believed that the Gobi and the Sahara deserts are already becoming bigger, not to forget the Thar Desert.

  Bare lands would reflect heat into the atmosphere more rapidly than the lands with vegetation cover. This would cause a drastic change in the proportion of sun radiation reflected back from the surface of the earth, which would eventually contribute to long-term changes in the climate globally.

- ***Ozone Layer Depletion :*** Ozone (O_3) is one of the important gases present in the atmosphere**,** which is a type of oxygen molecule formed of three atoms, rather than two. Ozone is practically present in all atmospheric regions., but the stratosphere is where ozone has its greatest effect on life on earth and on the atmosphere's dynamics. Ozone absorbs UV radiation from the sun. It performs a vital role in protecting life on our planet.

  In 1985, British scientists reported having found a hole in the Ozone layer over the Antarctic. Since then, it has grown steadily larger and now covers an area the size of the USA. It has been found that the holes appearing in the Ozone layer are human-made. The major culprit responsible is a group of chemicals known as chlorofluorocarbons, or CFCs, although halons (used in some fire extinguishers) are also to blame. When CFC molecules consisting of chlorine, fluorine and carbon atoms are exposed to strong ultraviolet radiation high above the earth surface, it is broken apart. This releases a chlorine atom, which attacks Ozone. Some 1.2 million tonnes of CFCs are produced every year. They have become essential ingredients in a myriad industrial and domestic products. CFCs were used as propellants in aerosol sprays, refrigerators, as coolants in air conditioning plants, in cleaning agents and in plastic foam packaging. Consequently, the number of chlorine atoms in the atmosphere has already increased by four to five times the normal level and continues to increase every year.

  Research in the US has shown that a depletion of just 1% of ozone layer causes a 2% increase in the incidence of skin cancer every year. More people will also suffer from cataracts and other eye diseases caused by radiation. At the same time, a higher dose of ultra violet may slow down plant photosynthesis. It reduces leaf size, stunts growth, impairs seed quality and also increases susceptibility to weeds and disease. The world oceans could be affected. Too much of ultra violet radiation tends to disorientate the tiny planktonic creatures in the sea, causing them to die. If this happens on a large scale, it would affect the entire ocean ecosystem.

Student Activity

Read the above information in the box and answer the following questions

1. Is urbanization portrayed in the box above? Give reasons to support your answer.

2. Now, vehicle emission test programme is taken very seriously. How will such a programme help in improving the climatic conditions?

3. What would happen if we do not check vehicular emission?

4. Explain how the increase in vehicular emission will lead to climate change?

5. Examine some of the consequences of climate change.

6. (a) Visit the nearest RSTA Office and find out the numbers of vehicles that have been added to the locality you live in from 2000 to 2004.

   (b) Arrange your findings into groups like two wheelers, light vehicles, and heavy vehicles.

   (c) Write a short report on your findings giving proper justifications on the increase or decrease of each type of vehicle.

Unit Two: Atmosphere

2.5 World Climate types

2.5.1 Classification of Climate

To cope with the diversity of information that the concept of climate encompasses, the most meaningful aspects must be selected and some systematic way found to classify the data. Classifiers generally have chosen temperature and precipitation as the most significant as well readily available features to serve as the framework of their classifications.

Classification of climate is an intellectual function based on human perception. It is not a natural occurrence; it is a product of the human mind. Its value depends on its use.

Suppose a beginning geography student in Georgia is asked to describe the climate of Southern China. The student is likely to be surprised. But a world map that shows a respectable climate classification, however, can tell the student that the climate of Southern China is similar to that of Georgia. One function of a climate classification is to facilitate the understanding of world climates by analogy (recognition of similarities between familiar and unfamiliar features).

Today, we recognize five main kinds of climate in the world. They are:

- Equatorial warm wet climate
- Tropical hot and dry climate
- Sub-tropical warm temperate climate
- Mid-latitude cool temperature climate
- High latitude cold climate

Many climatologists have tried to show the distinction between these five basic climatic zones and to sub-divide the zones into various ways. Most efforts have relied primarily on natural vegetation as an indicator of climate. Classifications with the greatest learning value have three important attributes:

- They are relatively simple to comprehend and to use
- They show some sort of orderly pattern over the earth
- They give some indication of genesis (reasons underlying development)

The common approach adopted for the climate classification of the world on the basis of natural vegetation is the **Koeppen Classification Approach.**

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Koeppen Classification: Wladimir Koeppen, the German botanist and climatologist, presented his descriptive scheme of classification of the world climates based on vegetation zones. He revised his scheme in the year 1918 where he concentrated on monthly and annual averages of temperature and precipitation and their seasonal distribution. It may be pointed out that the classification of Koeppen is more popular because it is quantitative in nature, as numerical values of temperature precipitation have been used in delineating boundaries of different climatic types. The climates have been named on the basis of alphabets.

Koeppen used five major vegetation zones of the world. Based on these five vegetation zones, he divided the world climates into five principal types and designated them by the capital letters, such as **A, B, C, D,** and **E**. Their explanations are presented below.

i. **A Climate**: Humid tropical climate characterized by the winterless season, warm and moist conditions throughout the year with mean temperature always above 18ºC. On account of these characteristics, A Climate is also known as Tropical Rainy Climate. This is further divided into four sub-types according to the periodicity and regime of precipitation. They are:
   - **Af** Climate (Equatorial Rainforest Climate),
   - **Aw** Climate (Savannah Climate),
   - **Am** Climate (Monsoon Climate), and
   - **As** Climate (Dry Summers).

ii. **B Climate**: Dry climate where evaporation exceeds precipitation and there is constant water deficit throughout the year. Considering the annual temperature and the rainiest month of the year, B climate is again divided into two types, such as **BW** (Dry Climate) and **BS** (Semi Arid or Steppe Climate). **BW** and **BS** Climates further branched out into four categories. These are:
   - **BWh** (Tropical Desert Climate with average annual temperature above 18ºC).
   - **BSh** (Tropical Steppe Climate with average annual temperature above 18ºC).
   - **BWk** (Middle Latitude Cold Desert Climate with mean annual temperature below 18ºC).
   - **BSk** (Middle Latitude Cold Steppe Climate with mean annual temperature below 18ºC).

iii. **C Climate**: Humid mid-latitude warm temperature climates with mild winters. The average temperature of the coldest and the warmest months ranges between 8ºC and 18ºC. C Climate is called Humid Mesothermal or Warm Temperature Rainy Climate.

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Depending on seasonal distribution of precipitation of **B Climate,** this climate type is classified into the following three subtypes.

- **Cf** Climate (Western Europe Type with precipitation throughout the year).
- **Cw** Climate (China Type with precipitation more in the wettest month of summer season than the driest month of winter season).
- **Cs** Climate (Mediterranean Type with precipitation more in the wettest month of winter season than the driest winter season).

iv. **D Climate**: A humid or cold forest climate with severe winters and average temperature of the coldest and the warmest months is below 3ºC and above 10ºC respectively. The ground remains snow covered for several months of the year. This climate is also termed as Humid Microthermal or Cold Snow Forest Climate. D climate is sub-divided into two categories. They are:

- **Df** Climate (Humid cold climate, no dry season).
- **Dw** Climate (Humid cold climate, dry winters).

v. **E Climate**: Polar climate with no summer season, but characterized by average temperature of the warmest month below 10ºC. ET and EF Climates are the two main categories.

- **ET** Climate (Tundra Climate with temperature of the warmest month below 10ºC, but above 0ºC).
- **EF** Climate (Perpetual snow covered climate with temperature below 0ºC all the year).

Advantages of Koeppen Classification: Koeppen Classification of Climate has gained importance in the recent studies of temperature and precipitation, distribution of vegetation, and its comprehensiveness.

i. Koeppen used temperature and precipitation statistics in his classification of climate. The two weather elements, particularly temperature and precipitation are most widely and frequently adopted. Since the classification is based on statistical parameters, each region can be precisely defined.

ii. Temperature and precipitation are the two most reliable weather elements that show the effects of climatic control more clearly than any other weather elements. These elements affect other aspects of our physical environment more directly than any other element. Koeppen's classification is based on the relationship between the types of plants at a particular place and climatic characteristics of the place. Thus, his scheme of classification is not a mere abstraction.

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iii. Further, Koeppen introduced the concept of effective precipitation which depends on the rate of potential evapotranspiration. Potential evapotranspiration is largely controlled by temperature. Thus, in Koeppen's classification, the relation between heat and moisture factor gets due recognition. The moisture requirement of the plant varies with the rate of evapotranspiration. For example, the amount of precipitation sufficient to support coniferous forest in the cool temperate zone may support little plant life in the low latitude desert.

iv. The classification is appealing to geographers because of the visible association of vegetation with climate types. Since, climatic boundaries in the classification were designed to delimit the vegetation regions, they may be taken to be "vegetation lines".

v. The system of classification is so simple, comprehensive, and detailed that it can be easily used at different educational levels.

Limitations of the Koeppen Classification: The Koeppen Classification suffers from the following disadvantages. They are:

i. His classification is based on the mean monthly values of temperature and precipitation. With this statistic only, the most potent factor for precipitation can be estimated, rather than obtaining an accurate measure. This makes the comparison from one locality to another rather difficult.

ii. Further, Koeppen did not take into account such weather elements as wind, precipitation intensity, amount of cloudiness, and daily temperature extremes in order to make his classification general and simple.

iii. Another major defect is that it is empirical and, therefore, based on facts and observation. The causative factors of climate have been totally ignored. Thus, the air masses, which form the very bases of modern climatology, do not find any place in his classification.

In conclusion, we can say that the letter symbols used by Koeppen in his classification provide an international shorthand describing climatic regions that are difficult to characterize in words. At first, the scheme may look a bit difficult, but a close examination reveals that it is based on certain critical values with which all geography students soon become familiar.

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Student Activity

1. Koeppen classified the world climate into five principal types based on vegetation. Write down the main characteristics of each type of climate.

2. Discuss the advantages of the Koppen's classification of climate.

3. Mention some of the limitation of the Koppen's classification of climate.

Unit Four: Remote Sensing

4.1 Remote Sensing

Remote Sensing can be defined as gaining knowledge about objects or phenomena, which are not in direct contact with the sensor. Images acquired by remote sensing satellites offer a unique perspective of the earth, its resources, and the human impact upon it. In a little more than a commercial industry, satellite remote sensing has proven itself as a cost-effective source of valuable information for numerous applications, including urban planning, environmental monitoring, agricultural management, oil exploration, market development and many others.

In many ways, the value of satellite images and the information derived from them is obvious. They give us an overhead look at objects and features on the earth's surface and help us understand the relationship among these features that might not be as apparent when viewed from the ground level. The 'remote' aspect of remote sensing also enhances its value by enabling us to see things halfway around the globe without ever having to leave our place.

In addition to these apparent benefits, satellite images literally show more than what meets the eye, b y revealing hidden details otherwise concealed from human view. Some images expose disease in vegetation, mineral in rock outcrop, or pollution in rivers. And some satellites see through clouds and fog veiling parts of the earth's surface.

This topic is designed to introduce you to the vocabulary and basic concepts of remote sensing technology and to familiarize you with the current and possible future satellite system.

Definitions of Remote Sensing

- Remote Sensing is inferring something about the nature and properties of an object, surface/area, or phenomenon through the analysis of data/information collected by a sensor that is not in physical contact with the object, surface/area, or phenomenon under investigation.

- Remote Sensing is the science and art of acquiring information about material objects, areas, or phenomena through the analysis of data acquired by a device from measurements made at a distance, without coming into physical contact with the objects, area, or phenomena under investigation.

The main components of Remote Sensing

The remote sensing systems consist of the following three important components:

- Energy Source (**Passive System**: sun, irradiance from earth's materials; **Active System**: irradiance from artificially generated energy sources, such as radar).

- Platforms (vehicle to carry the sensor) (truck, aircraft, space shuttle satellite, radio controlled aeroplanes, balloons).

- Sensors (devices or instruments to detect and record the electromagnetic radiation from the surface of the earth, such as radiometer, audiometer, magnetometer, and gravimeter) (camera, scanners).

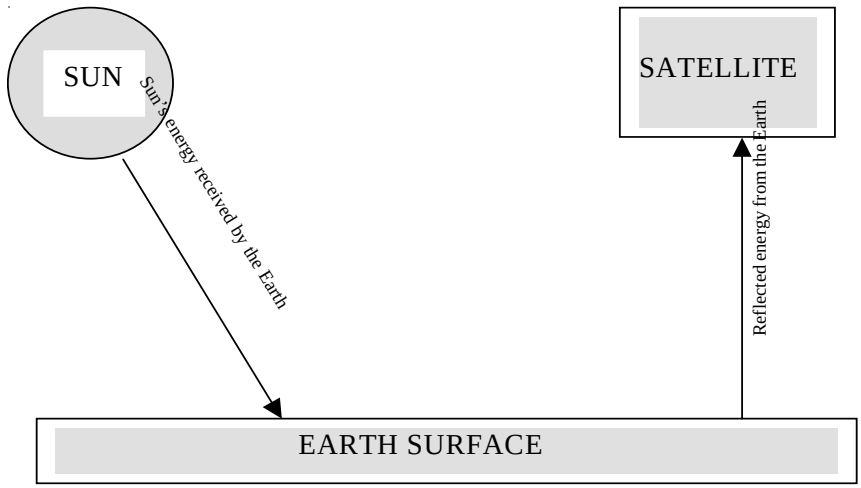

Figure 1. The Components of Remote Sensing System.

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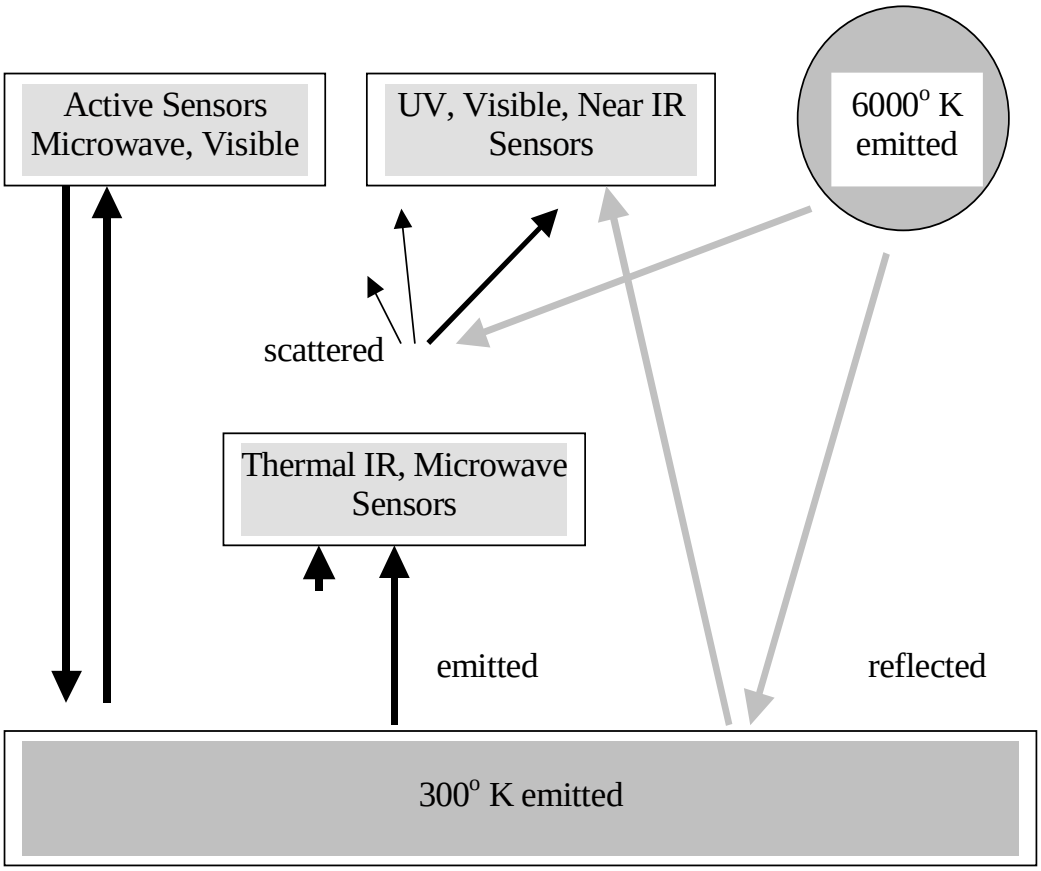

Figure 2. Types of Sensor used in the Electromagnetic Spectrum
(Jensen, J.R., 2000: 544)

Types of Remote Sensing

Remote Sensing is classified into two types. They are:

i. Passive Remote Sensing.

Passive Remote Sensing makes use of sensors that detect the reflected or emitted electromagnetic radiation from the natural source (sun). In other words, the sensors mounted in the satellites detect the solar energy reflected or emitted from the earth surface.

ii. Active Remote Sensing.

Active Remote Sensing deals with the application of sensors that can detect reflected energy from objects that are irradiated from an artificially generated source of energy. In other words, the satellites generate their own source of energy, unlike the sun in passive remote sensing, and the sensors detect the reflected or emitted energy. The Radar is an example of active remote sensing.

The Principles of Electromagnetic (EM) Spectrum

The Electromagnetic spectrum plays an important role in remote sensing. Understanding the basic principles of electromagnetic spectrum is necessary because remote sensing makes extensive use of ultraviolet, visible, infrared, microwave, and radar portions of the spectrum. Electromagnetic Radiation regions used in Remote Sensing are presented below.

- The ultraviolet region (0.3 μm to 0.4μm).
- The visible region (0.4μm to 0.7μm).
- The near infrared region (0.7μm to 1.3μm).
- The middle infrared (1.3μm to 3.0μm).
- The thermal region (3.0μm to 14μm).
- The Microwave region (1mm to 1m).

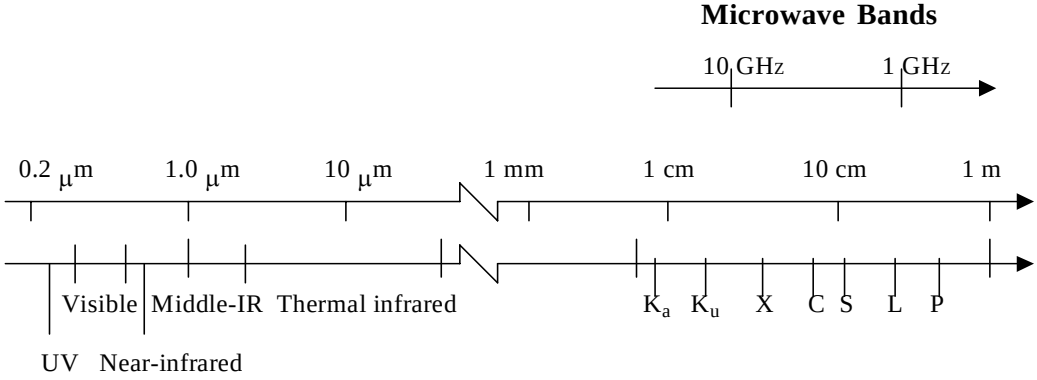

Figure 3. The Regions of EM Spectrum used in Remote Sensing (Figure 4.2 from Jensen)

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Advantages of Remote Sensing

Remote Sensing technique has the following advantages:

i. Less Time-consuming

The process of mapping from satellite imagery involves a lot of processing, field verification and ground truthing. However, a remote sensing satellite can map a vast forest or an entire city in less time than is the case in conventional surveying method.

ii. Global Coverage

Satellites are not limited by political or geographic boundaries. Commercial remote sensing satellites are in polar orbits that take them over every location on the earth. Regardless of whether your project area is on top of mountain or in the middle of the ocean, a remote sensing satellite can collect an entire image of it.

iii. Uptodate Information

In today's rapidly changing world, we need current information to make critical decisions. Maps are months or years old by the time they are printed. But we can have a satellite image in our hands a couple of days after it is acquired. An image is the most uptodate map available. However, an image has to be process and various types of corrections made and more information added before it can be called "image map."

iv. Synoptic View

Remote sensing satellites can capture the details of land cover, transportation routes, and major infrastructure spread over hundreds or even thousands of square kilometers in a single image.

v. Accuracy

The camera does not lie and neither does a satellite sensor. Since there is no human involvement in the creation of a raw satellite image, the information it contains is an accurate, objective and unbiased representation of objects and features on the Earth's surface.

Disadvantages of Remote Sensing

However, Remote Sensing has the following problems. They are:

i. Today, there are remote sensing sensors which can penetrate cloud cover like a radar. However, in general, data acquisition during the cloud-cover is a difficult task because the energy system in the visible ranges from the sun cannot penetrate the clouds.

ii. Remote sensing satellite images are expensive in nature. A raw satellite image can cost around $ 50.00 per square kilometer.

iii. Ground resolution is generally inadequate for detailed studies at micro level, particularly, in mountainous terrain.

iv. Stereo viewing or three-dimensional viewing is not possible.

Overview of Remote Sensing Applications

Some areas of application on resource related studies are given below:

Natural Resources Development and Management	**Type of Information Collected from RS Data**	**Potential Decis ions Based on RS Information**
Water resources for hydro power irrigation	Mapping and monitoring of rivers, lakes, reservoirs and their catchments. Mapping and monitoring of snow cover, seasonal runoff forecasts	Investment decisions, like funding agencies M anagement of reservoirs
Forest resources	Mapping and monitoring of existing forest	Zoning of protected forest; definition of policies on forestry, forestry management
Mineral resources	Geological mapping, prospecting of minerals, oil, gas, etc.	Investmen t decisions
Agriculture land use planning	Current land use Historical land use and land use changes	Areas requiring intervention Definition of meaningful land use plans
Soil Conservation	Vegetation cover maps Mapping of land cover changes (deforestati on) leading to watershed degradation Mapping of areas affected by salination	Land use planning and zoning to improve Management Improved irrigation management Land use planning
Food security	Regular status maps of important crops (crop monitoring)	Ea rly purchases on the world markets

Image Interpretation

Image or photo interpretation refers to the examination and analysis of images or photos to identify objects and features that are available in the images or photos. The goal of image interpretation is to generate information products that are based on the objective set of criteria defined by the users and information products are acceptable to the user's level of uncertainty or error. Image interpretation considers the following requirements. They are:

- Image interpretation can be conducted on any type of image.
- The source of the data is important in terms of interpretation of the image to define the information content of the image.
- The scale of the imagery is very important.
- Image interpretation should be based on a carefully defined set of goals and objectives, e.g., what information is desired from the image interpretation.
- The goals and objectives of image interpretation should strongly influence the way in which the data are collected.

Reasons for Using Image Interpretation

Image interpretation is an important tool in remote sensing because it:

- Represents the fundamental process for human (visual) analysis of remote sensing imagery.
- Provides a unique spatial observation study.
- Provides information that cannot easily be obtained in any other way.
- Gives accurate mapping, including 3-dimensional information.
- Generates information beyond our visual perception range.
- Allows performing change detection studies.

Methods of Image Interpretation

The two principal methods of image interpretation are:
i. Visual Image Interpretation, and
ii. Digital Classification**.**

i. Visual Image Interpretation.

In visual interpretation, a trained operator manually delineates homogenous areas and features on the image. The image can be processed on a computer and printed as hardcopy or displayed as softcopy on the monitor. The decision rules will be established in the form of an interpretation key, showing typical colours, tones, and textures of the features.

The advantage of visual interpretation is that a human operator is capable of using contextual information (e.g. a bright patch in the middle of a river is likely to be a sand bank, and not a built up land, although it may look so spectrally), as well as completing interrupted linear features (e.g. roads which are not entirely visible due to trees). This method of interpretation is a time-consuming process.

ii. Digital Classification

In this method, pixels (picture elements) are assigned to one class on an individual basis. The decision rules are implemented as mathematical discriminant functions. The advantage is rapidity and operator interdependence of the process; the disadvantage is the loss of contextual information.

Key Elements of Image Interpretation

The examination of image characteristics deals with various elements involved in image interpretation. The following are the key elements used in the image interpretation.

i. *Colour:* Colour display or remote sensing data is of importance for effective visual interpretation. Colour is more convenient for the identification of object details. For example, vegetation types and species can be more easily interpreted by less experienced interpreters using colour information. Sometimes colour infrared photographs or false colour images will give more specific information, depending upon the emulsion of the film or the filter used and the object being imaged. To understand the colour of features on an image, one should keep in mind what colour combination was used to make that colour composite image and the spectral reflectance curves for those features.

ii. *Tone:* Tone refers to the colour of the object that varies in gray. These coloured objects depend upon the reflectance capacity. When it varies, we can express it in terms of light, intermediate and dark. Example, if there were water body in that area, it would appear dark because water does not reflect but absorbs. Cement would be seen as light coloured. If the area were marshy with grasses or mingled with other objects, it would have an intermediate colour.

iii. *Shape:* Shape refers to general form or the outline of an object. It gives important clues to identify the object. Each landform will have a unique shape. For example, a highway will be curved in shape; a railway will be more or less straight with gentle curves.

iv. Shadow: The outline shadow provides a profile view of an object. It can also give information on the height of a tower, tall building, mountain ranges, and others, as well as shape information from the non-vertical perspective, such as the shape of a bridge.

v. Pattern: Pattern is a regular, usually repeated shape, in respect to an object. For example, rows of houses or apartments, regularly spaced ricefields, interchanges of highways, orchards, and so on, can provide information from their unique patterns.

vi. Site: Site refers to the location of the objects in relation to other features or objects. For example, sudden appearance or disappearance of vegetation is a good clue to the underlying soil types or drainage conditions, or the way the trees are planted can also indicate a stream joints.

vii. Size: Size refers to the form of an object that is very important in identifying the object. It gives clues to other associated features. Size (length, width, perimeter, area) of the object varies according to scale.

viii. Texture: Texture is a group of repeated small patterns. It is related to the appearance of objects, rough or smooth (based on tone). For example, if there is an oak tree, the surface will be smooth; or if there is grass, some roughness will be shown. Homogenous grasslands exhibit a smooth texture, coniferous forests usually show a coarse texture. However, this depends upon the scale of photograph of image.

ix. Association: The relation of a particular feature to its surrounding is an important key to interpretation. Sometimes a single feature by itself may not be distinctive enough to permit its identification. Example: sinkholes appear as dark spots on imagery where the surface or immediate surface soil consists of limestone. Thus, the appearance of sinkhole is always associated with surface limestone formation. Another example is that of dark-toned features associated with flood plain of a river that can be interpreted as in filled Ox-bow lake.

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Student Activity

1. What is Remote Sensing?
2. What are the main components of a remote sensing system?
3. Explain Passive and Active Remote Sensing? Give examples.
4. With the help of diagram, describe Electromagnetic Radiation?
5. Explain Image Interpretation and mention the uses of image interpretation.
6. Define Visual Image Interpretation and Digital Image Interpretation.
7. With help of your teacher, get the aerial photograph and write a simple image interpretation applying all the key elements used in image interpretation and analysis.
8. List down the advantages and disadvantages of Remote Sensing.
9. Remote sensing technology has been applied in various fields of research in the modern age. Discuss this point with the help of examples.

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