UNIT 11

VISUAL IMAGE INTERPRETATION: SELECTED EXAMPLES

Structure

11.1 INTRODUCTION

In the previous units, you have learnt about basics of aerial photo interpretation, elements of visual image interpretation, interpretation keys and other related concepts. The observation of the differences between objects involves comparing different objects based on the image interpretation elements such as tone, shape, size, pattern, texture, shadow and association. The nature of each

of these interpretation elements has been described in the previous unit. In this unit, we will try to interpret few selected images based on the principles of visual image interpretation.

Expected Learning Outcomes

After studying this unit, you should be able to:

- identify and differentiate features present in remote sensing images;
- explain the process of visual image interpretation; and
- develop skills in visual interpretation of remote sensing images

11.2 INTERPRETING IMAGES

The most intuitive way to extract information from satellite images is by visual image interpretation. It is based on our ability to relate patterns and colours in an image to real world features. Human vision goes a step beyond perception of colour as it deals with the ability of the person to draw conclusions from visual observations. In analysing a picture, we are somewhere between the following two situations: direct and spontaneous recognition or using several clues to draw conclusions by a reasoning process (i.e. logical inference).

Spontaneous recognition refers to your ability to identify objects or phenomena in first glance. For example, in case of the rectangular shape of an object, you will use your professional experience. You can do this by concluding that a rectangular shape is a swimming pool because of its location in a garden near to a resort or big hotel. A simple visual interpretation of remotely sensed imagery can often reveal considerable detail on the nature and distribution of habitats in an area of interest. You are now aware that characteristics of the image are defined using a set of terms *viz*., tone, shape, size texture, pattern, site and association, called as elements of visual image interpretation. The simultaneous and often implicit use of all these elements is the strength of visual image interpretation.

In practice, objects and the features on Earth's surface are described more as classes than as materials. For instance, consider the material 'concrete'. It is used in roadways, parking lots, swimming pools, buildings and other structural units, which might be treated as a separate class. Similarly, we can subdivide 'vegetation' in a variety of ways such as trees, crops, grasslands, lake bloom algae, etc. Finer subdivisions are permissible, by classifying trees as deciduous or evergreen, or deciduous trees into oak, poplar, etc.

Two additional properties help us in distinguishing these various classes, namely; shape (geometric patterns) and use or context (sometimes including geographical locations). Thus, we may assign a feature composed of concrete to the classes 'streets' and 'parking lots', depending on whether its shape is long and narrow or more square or rectangular. Features with similar spectral signatures for vegetation could be assigned to the classes 'forest' or 'crops'

depending on whether the area in the images has irregular or straight (often rectangular, as is the case for most farms) boundaries.

To visually interpret digital data such as satellite images, individual spectral bands must be displayed simultaneously in the form of a colour composite. For example, Indian Remote Sensing Satellite (Resourcesat) 1, 2 and 3 broadly represent the blue, green and red parts of the electromagnetic spectrum. When these bands are fed through the corresponding blue, green and red 'colour guns' of a computer monitor, the resulting image strongly resembles what our eyes would see from the sensor's vantage point. We, thus, have an intuitive understanding of the colours presented and can usually make a meaningful interpretation of the scene (e.g., dark blue mostly represents deep water).

Before starting with the exercises let us quickly understand the two terms 'true colour' and 'false colour' images which would be often used here. Fig. 11.1 shows two pictures of the same location. Picture on the left is a 'true colour' image (Fig. 11.1a). This means that the picture shows objects in the same colours that your eyes would normally see. Picture on the right is a 'false colour' image (Fig. 11.1b), this means that the colours have been assigned to three different image bands which have been acquired in the wavelengths that your eyes might not normally see.

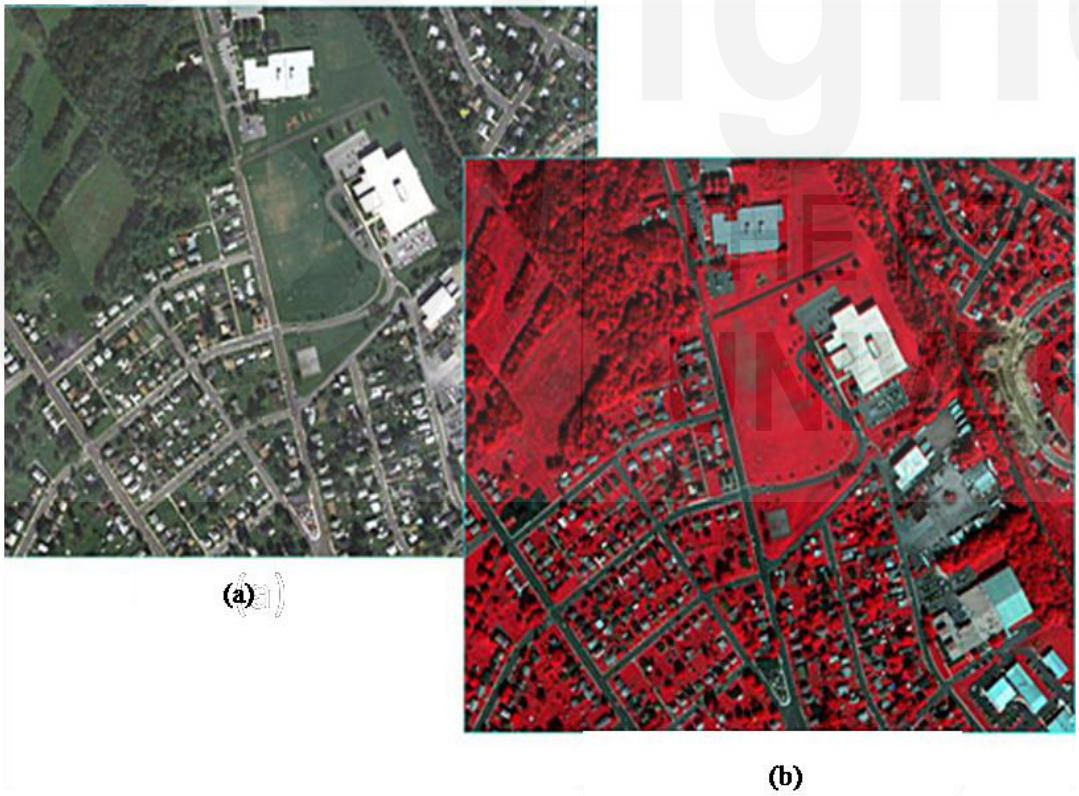


Fig. 11.1: Two satellite images of an area: a) True colour composite; and b) false colour composite.

Let us now move on to interpreting some of the satellite images using the concepts of visual image interpretation we have learnt. It is important to note that you should carefully observe the images given and try to answer the questions.

11.2.1 Exercise 1

Fig. 11.2 is a natural colour scene showing a region in the Jharkhand state of India. The data used to produce this scene were acquired by the LISS IV sensor with 5.8 m spatial resolution onboard IRS Resourcesat.

Fig. 11.2: Satellite image of an area of the Jharkhand state. (source: http://bhuvan.nrsc.gov.in)

Observe the image carefully and try to answer the following questions (use colour, shape, tone, texture and association to differentiate the features):

- What are the various features you can decipher from the image?
- Can you identify the coal mines? What elements did you use to interpret them?

11.2.2 Exercise 2

You can see the given below Fig. 11.3 is a true-colour image of the Thar Desert, Rajasthan, acquired by the LISS IV sensor onboard IRS Resourcesat.

Fig. 11.3: True colour image of the Thar Desert, Rajasthan acquired by the Resourcesat. (Source: http://bhuvan.nrsc.gov.in)

Observe the image carefully and answer the following questions:

- What landform does the image represent? Why?
- What are the other features that you can identify in the image?

Hint: While interpreting the image use the elements of visual interpretation (i.e. shape, size, shadow and association, etc.).

11.2.3 Exercise 3

Fig 11.4 shows an IRS Resourcesat-1 LISS IV image of Delhi in three bands of the reflected visible and infrared wavelength regions of electromagnetic spectrum.

Fig 11.4: IRS Resourcesat-1 image of a region of Delhi. (Source: http://bhuvan.nrsc.gov.in)

- Try to identify the famous building structures and other world famous man-made constructions in this image.
- What are the other features you can identify?

11.2.4 Exercise 4

You can see IRS Resourcesat-1 LISS IV image of Chandigarh is shown in Fig. 11.5.

- Even though the image has various shades and pattern of green, identify the various vegetation types in this image.
- Identify other features in this image which may have a role to play in establishing different vegetation types.

Fig. 11.5: IRS Resourcesat-1 image of Chandigarh. (Source: http://bhuvan.nrsc.gov.in)

11.2.5 Exercise 5

In Fig. 11.6, you can see a true colour image of IRS Resourcesat-1 AWiFS covering a portion of Arabian Sea, south of Gujarat coast in three bands of the reflected visible and infrared wavelength region.

Fig. 11.6: True colour image of a portion of Arabian Sea, south of Gujarat IRS Resourcesat-1 AWiFS. (Source: http://bhuvan.nrsc.gov.in)

- Can you identify different colours (brownish, greenish, dark blue and light blue) of water?
- Try guessing what these colours denote?

11.2.6 Exercise 6

You can see that given below is a true colour IRS Resourcesat-1 AWiFS image (Fig. 11.7) of the Himalayan Mountain Range that runs a curving path from west to east. In this image, the range separates southeastern China from India, and runs through (from left to right) northwestern India, Nepal, a small bit of northeastern India, and Bhutan.

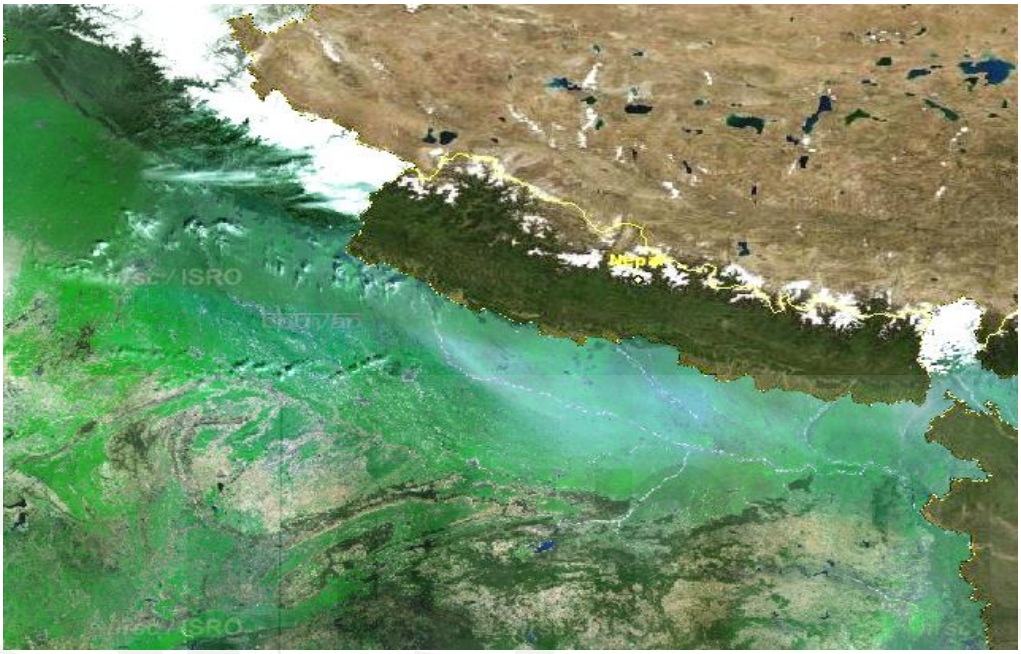


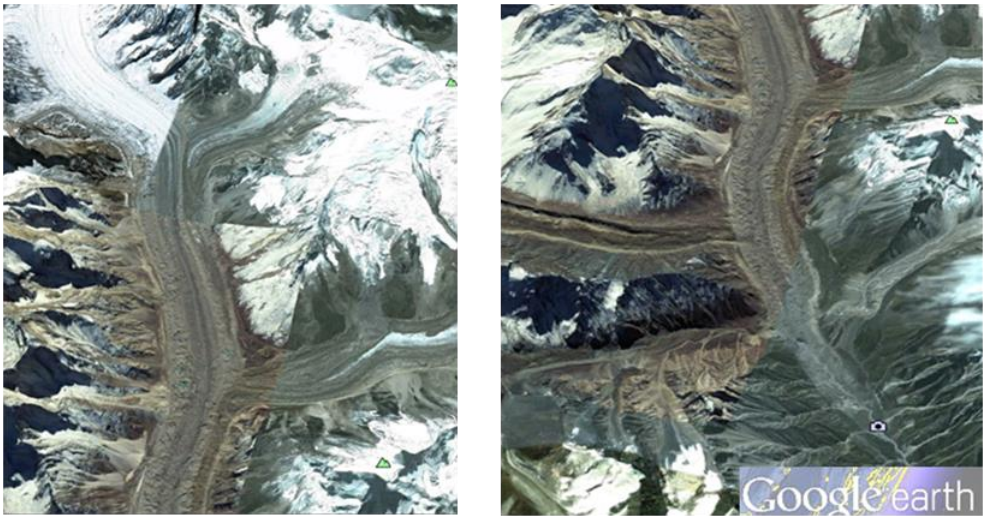
Fig. 11.7: True colour Resourcesat-1 image of the Himalayan Mountain Range
(Source: http://bhuvan.nrsc.gov.in)

- What are the various landforms that you can identify in this image? Justify your answer using the elements of visual interpretation that you have learnt.

11.2.7 Exercise 7

Fig. 11.8 shows the three images of Gaumukh glacier and its adjoining areas.

(a)



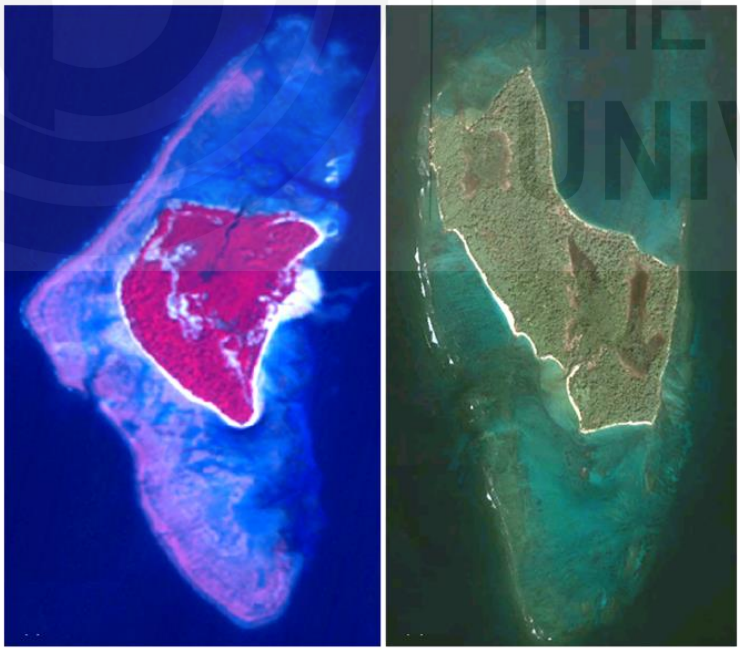
(b) (c)

Fig. 11.8: Satellite images of Gaumukh glacier: a) Gaumukh glacier and surroundings; b) southern part of the glacier; and c) northern part of the glacier. (Source: http://google.com/earth)

- What are the prominent features that you can identify in these images?
- What do the dark regions represent?

11.2.8 Exercise 8

Given below are the images from IRS Resourcesat-1 LISS III. You can see that Fig. 11.9a is a false colour image of Flat Island and Fig. 11.9b is a true colour image of Boat Island. Both the islands are in the Andaman Group of Islands and are surrounded by coral reefs.



(a) (b)

Fig. 11.9: Resourcesat-1 false colour composite (a) Flat Island; (b) True colour image of Boat Island, Andaman, India. (Source: http://www.google.com/earth)

- What features can you identify in this image?
- What visual elements have you used for your interpretation?

11.2.9 Exercise 9

Given below are the IRS-1D LISS III images of the islands in Kori creek located in the northwestern of Gulf of Kachchh in Gujarat (Fig. 11.10).

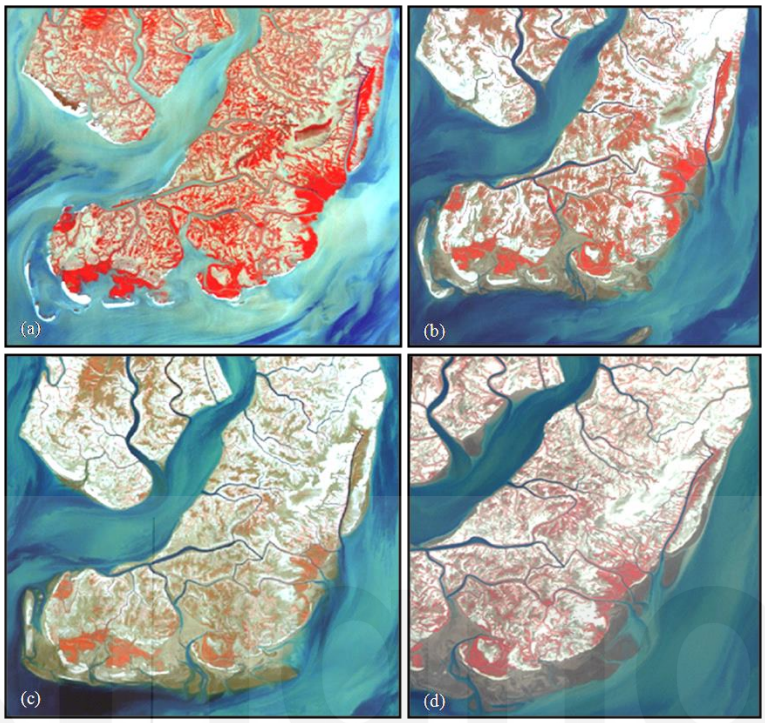


Fig. 11.10: IRS-1D LISS III images of islands in Kori creek, northwestern of Gulf of Kachchh, Gujarat obtained in: a) October, 1998; b) February, 1999; c) February, 2001; and d) March, 2007. (Source: http://bhuvan.nrsc.gov.in)

- What features can you identify from the image?
- What differences can you see in the images? What do you attribute these differences to?

11.2.10 Exercise 10

Fig. 11.11a is the true colour image of the Bhitarkanika delta in Orissa from IRS Resourcesat-1 AWiFS. Fig. 11.11b is a false colour composite generated using IRS-1D LISS III camera of the Gulf of Khambhat in Gujarat. Both images show estuaries and coastal habitats. Observe the images and try to answer the following questions:

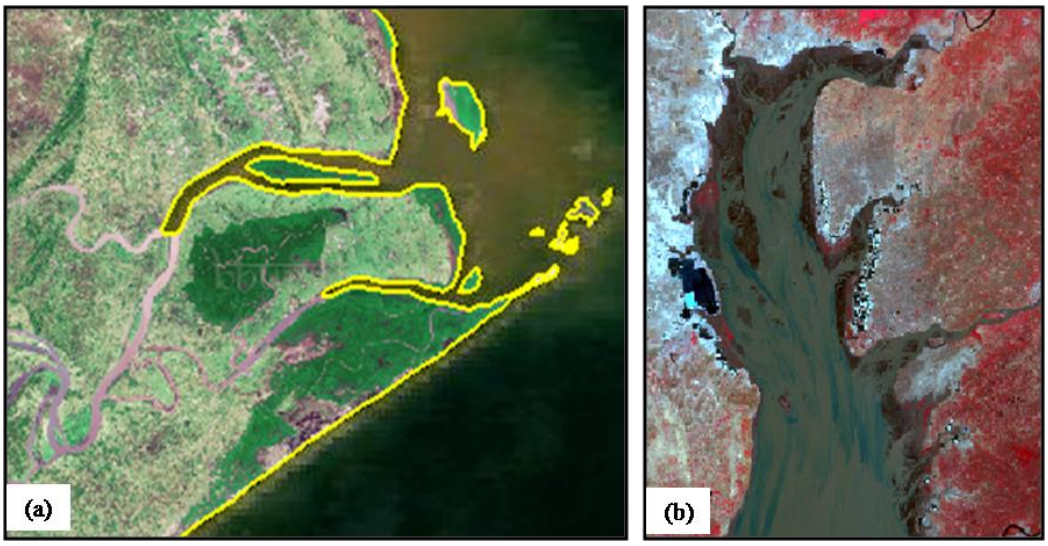


Fig. 11.11: IRS Resourcesat-1 images: a) True colour image of Bhitarkanika delta, Orissa; and b) False colour composite of the Gulf of Khambhat, Gujarat. (Source: http://bhuvan.nrsc.gov.in)

- What are the features that you can identify in these images?
- Can you differentiate the mangroves in both these images?

11.2.11 Answers to Exercises

Answer to Exercise 1

This image is of a region in the Jharkhand state of India. Jharkhand is known for its rich store of minerals; therefore, mining forms an integral part of the economy of Jharkhand. The districts of Bokaro, Ranchi, Jamshedpur, etc. are known for their rich mineral reserves. According to an estimate, Jharkhand possesses about 93% of medium coking coal, 30% of blendable coal and almost 100% of prime cooking coal. The open cast coal mines are clearly seen in the image.

The *open cast coal mines* are in *greyish white* tone and *irregular* shape (Fig. 11.2). The surrounding vegetation in *green hues* represents *thick forests* of Jharkhand. The various *blue-grey* clusters linked together by dark thin lines are *towns* and *villages* connected by roads. There are two major and three relatively minor *water bodies* which are showing *dark blue* tone.

Answer to Exercise 2

The Thar Desert or the Great Indian Desert in the northwestern part of the Indian subcontinent is spread over in area more than 200,000 sq. km. It is characterised by its massive rolling sand dunes, excessive heat (touching ~50ºC in May and June and sand temperatures rising to ~70ºC) dust storms and dust-raising winds often blowing with velocities of ~140-150 km/hr. It is a desolate region where sand is piled up into huge wind-blown dunes. The soils of the Desert are generally sandy to sandy-loam in texture. The low-lying loams have a hard pan of clay, calcium carbonate, silica and gypsum.

The image is of a part of Thar Desert in Rajasthan (Fig. 11.3). Settlements with *regular shaped and rough texture* are clearly seen in the image. In between the settlements lies the sandy desert which you would observe in *light tone,*

irregular shape and *smooth texture*. The wind-blown sand dunes are clearly seen.

Answer to Exercise 3

The famous *India Gate* is seen in the centre of the image. It is situated in the heart of New Delhi and is a prominent landmark in Delhi. In the extreme north-west corner of the image, there is *Connaught Place* (officially known as *Rajiv Chowk*) clearly seen in a *circular shape* (Fig. 11.4). It is one of the largest financial, commercial and business centers in Delhi. It is often abbreviated as CP and houses the headquarters of several Indian firms. Its surroundings occupy a place of pride amongst the heritage structures of the city, i.e. India Gate.

The ring road and Mathura road NH 2 is also seen traversing from the southeast to the northwest in the image. Below the India Gate a clear pattern of green criss-cross lines indicate the popular *Lodi Garden*. There are fallow lands on the right hand side of the river Yamuna.

Answer to Exercise 4

The image is of a part of Chandigarh, a union territory of India. There are three distinct land cover types (forest on plain land, mountainous forest, and a man-made vegetation cover) can be identified from the image texture. The *semi-rectangular* patch (Fig. 11.5) at the southwest corner is the *Golf course* (man-made vegetation cover). Grassland in between tree lines is clearly seen. The central portion of the image has a lake and Lake Reserved Forest (LRF) is to the north of the lake. The LRF has dense trees. The northern region to the LRF has residential area with planned tree cover. This area is probably inhabited and covered by shrubs or trees. The northeast corner of the image has vegetation cover on the foothills of the Siwalik range of the Himalayas (Nepali Reserved Forest). The different land cover types can primarily be differentiated based on texture and pattern.

Answer to Exercise 5

Gulf of Khambhat is an inlet of the Arabian Sea along the west coast of India. The waters of the Gulf of Khambhat and Arabian Sea below are startlingly different. Where the Arabian Sea, seen have *dark blue* and *blue* colours and clear deep water (Fig. 11.6) The Gulf waters are laden with sediments giving it a brown and brownish green tones. The Narmada and Tapti rivers empty into the Gulf, carrying sediments that give the brown color to the Gulf, is clearly visible in the image. The Gulf, which is actually quite shallow, is known for its extreme tides, vary greatly in height and run into it with amazing speed. At low tide, the bottom is left nearly dry for some distance below the town of Khambhat.

Answer to Exercise 6

In the top half of the image (Fig. 11.7), a number of blue coloured *irregular shaped water bodies* i.e. lakes, glow like jewels scattered throughout southeastern China's Plateau of Tibet. Many of the *lakes show tinges of blue-green that likely indicate microscopic plant life*. In the bottom half of the image, a number of major rivers flow (carefully note their shape, colour) to the

southeast, eventually join the Ganges and empty into the Bay of Bengal (not shown in the image). The Himalaya Mountains are covered with snow. And in northern India, a *gray haze of air pollution* (texture, colour) hangs over some of the most densely populated cities in the world.

Answer to Exercise 7

The Gangotri Glacier is located in Uttarkashi District, Uttarkhand state, India. This glacier is the source of the Ganges and is one of the largest in the Himalayas with an estimated volume of over 27 km^3. It is about 30 km long and 2 to 4 km wide. Around the glacier are the peaks of the Gangotri Group (top image). The two images below are of the Gaumukh glacier. Fig. 11.8a is the right image which shows the northern part of the glacier and Fig. 11.8b is the left image is of the southern end. Glaciated zone, rubble, moraine, etc. are seen in the image. The dark regions are the shadows of the mighty Himalayas. Snow (in bright white colour) is clearly seen covering the mountains.

Answer to Exercise 8

The coral reef of the Flat Island of the northern Andaman group has suffered extensive damage due to the tsunami and earthquake of 26 December, 2004. The coral reefs at the edges have got uplifted and thus remain exposed. This has resulted in the growth of *algae* showing *pink* tone (Fig. 11.9). A white edge is seen on the seaward side in the western part of the reef. This is the region where waves break and expend their energy along the fore reef and reef crest, and resulting bubbles show up as a white outline. The inner *blue hues* represent reef flat and shallow pools. Island has a sandy beach (linear and white) making up the coast.

Boat island reefs (located in the southwest Andaman region) have relatively remained unaffected by tsunami. The breaker zone, reef crest, reef flat and the pristine clear water on the reef is clearly visible. The inner reef flat portion has sandy bottom. You can see a linear sandy beach surrounding the island.

Answer to Exercise 9

These images show a part of the Kori Creek in the Kachchh region, Gujarat, western India. Kori Creek is a part of Indus delta system, which has been formed in humid climatic conditions. The present arid climatic conditions in the Indus delta have led to increase in salinity level.

The Kori Creek houses islands made up of clayey mud and dense mangrove cover. The image taken in 1998 shows that the islands are covered with *dense mangrove* cover (*bright red*). The *sparsely spaced mangroves are present inland* (*brownish red*) and salt affected mudflat further inland where tidal water does not reach daily (Fig. 11.10). On the southern edge of the islands are *crescent shaped* linear beaches. You can observe changes in mangrove cover as well as its habitat. A cyclone occurred in June 1999 that mostly impacted the Kori creek and the deltaic region going upto Pakistan. This impact is believed to have caused massive sand migration from the Indus River down to the delta. The deposition of sand (seen in *white* tone occupying most of the island) can be easily seen in subsequent images (February 1999, 2001 and March 2007). The

sand deposits were reported to have impacted the mangrove cover heavily leading to their mass destruction as observed here.

Answer to Exercise 10

Bhitarkanika is a unique habitat of mangrove forests located in Kendrapara district, Orissa. In 1975, Bhitarkanika was declared a Sanctuary under the Wildlife Protection Act, 1972, and comprises Bhitarkanika, Kalibhanjadian and Gahirmatha mangrove area. It is fed by the Dhamra, Maipura and Bhitarkanika rivers. Gahirmatha mangrove area is comprised Sunirupi Reserved Forest, Habilikuti Protected Forest and Gahirmatha Protected Forest. It is the second largest mangrove ecosystem after Sundarbans and is home to diverse flora and fauna intricately linked with each other. In the image, *dark green* tone with network of creeks along the coast is the mangrove habitat (Fig. 11.11a). Mangroves can be identified from the adjoining terrestrial vegetation by factors like

- their evergreen nature
- moist habitat
- network of creeks
- in the intertidal zone
- in the brackish water zone (i.e. fed by sea as well as river)

The second image (Fig. 11.11b) is of the Gulf of Khambhat. The uppermost estuary is the Mahi estuary. Narmada estuary is seen in the lower right. *Small bright red* patches in the intertidal zone in the central left, upper left, central right and lower right are the mangroves. These mangroves occupy small areas and some are recent habitats. Regular shapes of dark blue and light blue along the coast but on landward side are the salt pans. As the estuary is shallow, silt laden water are clearly seen. In this first image (Fig. 11.11a) mangroves are identified of the basis of dark green tone while in other image (Fig. 11.11b) by their bright red colour.

SAQ 1

Spend 5 mins

a) Study Fig. 8.2 and identify following features: (a) coal mines, (b) forest and (c) water bodies.

b) Examine Fig. 11.7 and answer the following question. What do white and blue colours represent in the image?

11.3 CLASSIFICATION SYSTEM

Let us recall definition of the terms like land cover and land use prior to studying the classification system, since both are often used in the context of image interpretation.

Land cover refers to the type of features present on the surface of the land. It refers to a physical property or resources e.g., water, snow, grassland, deciduous forest, sand, sugarcane crop, etc. The term ***Land use*** relates to the human activity or economic function for a specific area e.g., urban use, industrial use, recreation area or protected area.

Our ultimate aim of interpretation is to produce a land use/land cover map. It is of prime importance in overcoming problems such as unplanned development, deteriorating environmental quality, loss of agricultural lands, destruction of wetlands and loss of fish and wildlife habitat. Land use data are required in the understanding environmental processes and problems. Land use changes through time can also be interpreted from land cover change maps. These maps are an important tool in the planning process. Today in India, the variety of land use and land cover data requirement has increased extensively. Such data is increasingly used in tax assessments, natural resource inventories, water-resource inventory, flood control, water-supply planning and waste-water treatment. This data is also required for assessment of environmental impact resulting from development and management of energy and natural resources. This data is also helpful to make national summaries of land use patterns and changes for national policy formulation.

Land cover mapping in general, requires an abstraction of many aspects. The simplest way to do this is by introducing classes or categories. It is important that each class on the map be clearly defined and distinct from other classes.

11.3.1 Steps in Producing a Land Cover/Land Use Map

Before beginning to prepare a land use/land cover map, it is essential to identify the purpose for which the map is required and its user. This is followed by delineating the study area and identifying the classification system to be used.

A classification scheme defines the legend that will be used for the final map. For example, will the map show forest and non-forest or will it have several or even dozens of different categories? Should the final map categories represent land cover or something else such as land use, habitat, or conservation importance? The way in which the map will be used will dictate the content of the classification scheme. There are a large number of classification schemes used for land use and land cover maps throughout the world. Some of the more common schemes are given in Table 11.1.

Table 11.1: Common land use/land cover classification schemes.

Scheme	URL
Anderson and others, 1976	http://landcover,usgs.gov/pdf/anderson.pdf
National Land Cover Data	http://landcover.usgs.gov/classes.asp
FAO Land Cover Classification System	www.africover.org/LCCS.htm
Indian (NRSA) Land Cover Classification System	http://applications.nrsc.gov.in/pub.asp

You should remember that no matter what classification scheme is selected each class must be well defined and documented. For example, if a class is called '*forest*' one needs to specify what *constitutes a forest*. How dense do the trees have to be? How much area should the canopy occupy? Without this sort of information it is not possible for the user of the final map to know what the different classes represented.

When choosing an appropriate classification scheme you should decide whether its compatibility with existing schemes is necessary or desirable. Some advantages of using an existing system is that the classes are already defined and the map you produce can be easily compared with other maps using the same system. A balance must be struck between the classes that are desired and the classes that can be accurately and economically delimited, based on the map's purpose. In general, greater detail requires greater cost and time. A rule of thumb is to select the minimum number of classes that are practical. When you decide upon a classification system it is important that you document the details for each class and apply these class definitions in an objective manner.

When selecting classes, a hierarchical or non-hierarchical approach can be used. In a hierarchical approach, classes are nested such that major classes are broken into sub-classes and these sub-classes can further be divided if required. The advantage of such a system is that it can be easily generalised and it is easy to adapt to various scales. Hierarchical systems are often used when there is a need to maintain conformity with a national level classification system. A non-hierarchical approach however is designed for a specific purpose with a specific scale in mind. The advantage of a non-hierarchical system is that it can be modified to suit a specific application because it is not restricted by the constraints imposed by a hierarchical system. In other words, it can be easier to customise for specific project goals since it can include a mix of detailed and generalised land cover classes.

When defining classes you must decide how to classify mixed features such as transition and mosaic classes. One approach is to define explicitly these classes as mixed or transition and the other is to ignore the fact that classes are mixed and define classes. While deciding the approach to be used you must take into account the nature of the features being mapped and important mixed classes.

11.3.2 Example of a Land Use/Land Cover Classification System

There is no single ideal classification on land use/land cover. Anderson (1971) developed some criteria for classification systems. It has been designed to serve as a standard classification available for adoption by bodies involved in routine collection of land use and land cover data.

Anderson (1971) specified that a land use and land cover classification system based on remote sensor data should meet the following criteria:

- minimum level of interpretation accuracy in the identification of land use and land cover categories from remote sensor data should be at least 85%
- accuracy of interpretation for the several categories should be nearly equal
- repeatable or repetitive results should be obtainable from one interpreter to another and from one time of sensing to another
- classification system should be applicable over extensive areas
- categorisation should permit vegetation and other types of land cover to be used as surrogates for activity

- classification system should be suitable for use with remote sensing data obtained during different times of the year
- effective use of subcategories that can be obtained from ground surveys or from the use of larger scale or enhanced remote sensor data should be possible
- aggregation of categories must be possible
- comparison with future land use data should be possible
- multiple uses of land should be mapped when possible

U.S. Geological Survey has identified four levels of ***land use/land cover classification system*** for the use with remote sensor data and the type of remotely sensed data typically used to provide the information (Table 11.2).

Table 11.2: Four levels of land use/land cover classification system of the U.S. Geological Survey and corresponding typical data requirement.

Classification level	Typical data characteristics
I	Satellite imagery such as NOAA AVHRR (1.1 x 1.1 km), MODIS (250 x 250 m; 500 x 500 m), Landsat MSS (79 x 79 m), Landsat TM (30 x 30 m) and SPOT XS (20 x 20 m)
II	Satellite imagery such as SPOT HRV multispectral (10 x 10 m) and IRS-1C panchromatic (5 x 5 m). High-altitude aerial photography acquired at scales less than 1:80,000
III	Satellite imagery with 1 x 1m to 2.5 x 2.5 m nominal spatial resolution. Medium-altitude aerial photography at scales from 1:20,000 to 1: 80,000
IV	Satellite imagery with ≤ 1 x 1 m nominal spatial resolution (e.g., QuickBird, IKONOS). Low-altitude aerial photography at scales from 1:4,000 to 1:20,000

Information at levels I and II would generally be of interest to users who desire to generate data on a nationwide, interstate, or statewide basis. More detailed land use and land cover data such as those categorised at levels III and IV usually will be used more frequently by those who need and generate local information at the intrastate, district or municipal level.

Table 11.3 gives the level I and level II classes of classification system developed by Anderson (1971).

Table 11.3: Level I and level II classes of classification system given by Anderson (1971).

Classification level	
Level I	**Level II**
1 Urban or built-up land	11 Residential 12 Commercial and services 13 Industrial

	14 Transportation, Communications, and utilities 15 Industrial and commercial complexes 16 Mixed urban or built-up 16 Other urban or built-up land
2 Agricultural land	21 Cropland and pasture 22 Orchards, groves, vineyards, nurseries and ornamental horticultural areas 23 Confined feeding operations 24 Other agricultural land
3 Rangeland	31 Herbaceous rangeland 32 Shrub-brushland rangeland 33 Mixed rangeland
4 Forest land	41 Deciduous forest land 42 Evergreen forest land 43 Mixed forest land
5 Water	51 Streams and canals 52 Lakes 53 Reservoirs 54 Bays and estuaries
6 Wetland	61 Forest wetland 62 Non-forest wetland
7 Barren land	71 Dry salt flats 72 Beaches 73 Sandy areas other than beaches 74 Bare exposed rock 75 Strip mines, quarries and gravel pits 76 Transitional areas 77 Mixed barren land
8 Tundra	81 Shrub and brush tundra 82 Herbaceous tundra 83 Bare ground tundra 84 Wet tundra 85 Mixed tundra
	91 Perennial snowfields 92 Glaciers

This system satisfied three major attributes of the classification system:

- it gave names to categories by using accepted terminology
- it allowed inductive generalisations to be made and it met the principal objective of providing a land use and land cover classification system for use in land use planning and management activities

- it was amenable to further refinement on the basis of more extended and varied use

Since then there have been several other classification systems developed across the globe. It is beyond the scope of this chapter to discuss these various systems. The key ones, however, have been mentioned in Fig. 11.12.

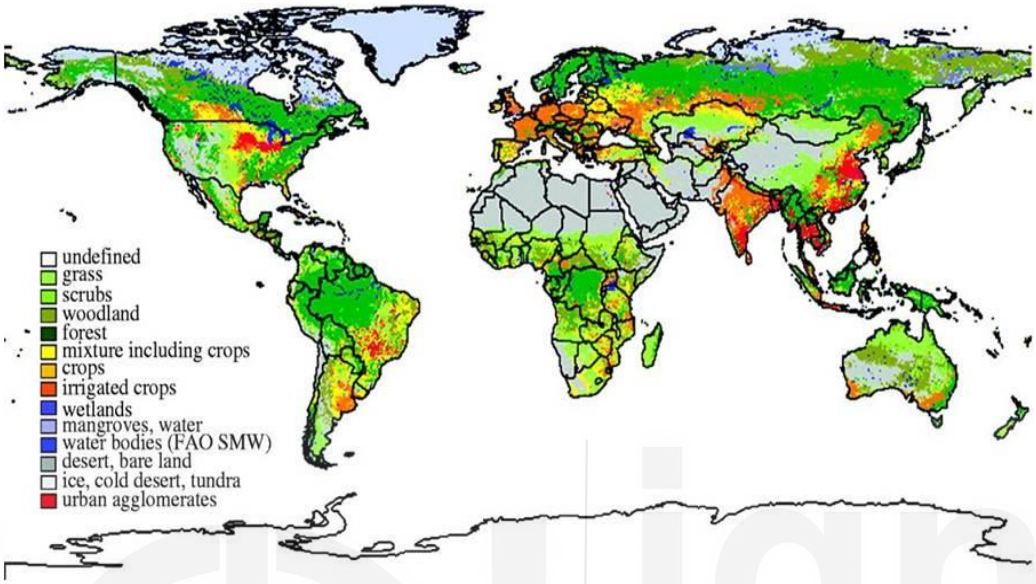


Fig. 11.12: FAO Agro-ecological zones (AEZ) database; example of data held showing predominant land cover in each grid cell mapped onto the globe. (Source: Smith et al., 2008)

11.3.3 Indian Scenario

Based on the need for current nationwide land use/land cover (LULC) maps by several agencies across the country, a LULC classification system with 24 categories upto Level II suitable for mapping on a 1:250,000 scale was developed by the National Remote Sensing Centre, Hyderabad, by taking into consideration the existing land use classification adopted by National Atlas and Thematic Mapping Organisation, Kolkata; Central Arid Zone Research Institute, Jodhpur and the details obtainable from satellite imagery. After discussions with nearly 40 user departments/institutions in the country, a 22 fold classification system was finalised and adopted for nationwide LULC analysis (Roy and Giriraj, 2008). You can find forest cover map of India 2007 on the site http://www.fsi.nic.in/sfr_2009/chapter2.pdf on page no. 15 as an example of a land cover map.

11.3.4 Ancillary Data in Image Interpretation

In addition to satellite or aerial imagery, other data can be used to increase the accuracy of the classification. Some possible ancillary data are digital elevation models (DEMs) and their derived datasets (slope and aspect), climate data such as rainfall and temperature, and vector overlays such as roads, rivers, and populated places. If there is an attribute that effects the distribution of land cover that exists in a mapped form it should be incorporated into the classification process. For example, DEMs often supplement satellite data when mapping land cover since vegetation classes are often limited to specific elevations or aspects. Incorporating these ancillary data into the classification process is not always easy.

11.3.5 Role of Field Observations in Image Interpretation

All image based mapping processes require field observations. Field observations can be used:

- to gather local knowledge beforehand to guide the interpretation. When dealing with a new area, some of the features observed on the images will not be understood and field observations will help in interpreting these features
- to validate the interpretation made
- to gather data about areas or features that cannot be studied from the image data

Data collected in the field must be georeferenced so that the point of data collection can be located on the imagery. GPS receivers are commonly used to record location information. The type of information collected can range from detailed notes describing a site to a photograph of the site. Some of the detailed information that can be recorded includes: type of vegetation, crown closure slope, aspect, soil type, and other bio-physical characteristics that are important to identify the land cover type. If photographs are taken it is a good idea to record the camera direction and make notes about the area to supplement the content in the photograph. For example, information about species composition, tree height, and possibly land use could be added.

11.3.6 Quality of Image Interpretation

The quality of the result of an image interpretation depends on a number of factors such as the interpreter, image data used and the guidelines provided.

Professional experience determines the skills of a photo-interpreter. A sound professional background is required, for instance, a geological interpretation can only be made by a geologist since s/he is able to relate image features to geological phenomena. Ground truthing is required to help the interpretation.

Image data applied also limit the phenomena that can be studied, both in thematic and geometric sense. One cannot, for example, generate a reliable database on the tertiary road system using multispectral satellite data. Likewise, black and white aerial photos contain limited information about agricultural crops.

Finally, quality of the interpretation guidelines largely influences interpretation. Consider, for example, a project in which a group of persons carry out a mapping project. Ambiguous guidelines will prevent a consistent mapping in which individual results form a seamless database of consistent quality.

Large projects and monitoring programmes and quality of interpretation guideline play an important role in ensuring the replicability of the work. Replicability or repeatability refers to the degree of correspondence obtained by different persons for the same area or by the same person for the same area at different time.

SAQ II

a) Identify land cover features from the following:

residential, industrial, transportation, communications, forest, rangeland and wetland.

11.4 SUMMARY

In this unit, you have studied about:

- Visual image interpretation is one of the methods to extract information from remote sensing image data.
- Interpretation keys or guidelines are required to instruct the image-interpreter. In such guidelines, the (seven) interpretation elements can be used to describe in order to recognise certain objects. Guidelines also provide a classification scheme, defining the thematic classes of interest and their (hierarchical) relationships.
- In all the interpretation and mapping processes, the use of ground observations is essential in acquiring knowledge of local situation; in gathering data for areas that cannot be mapped from the images and to check the result of the interpretation.
- Quality of the visual image interpretation results depends on the experience and skills of the interpreter, the appropriateness of the image data applied and the quality of the guidelines being used.

11.5 TERMINAL QUESTIONS

1. What is the role of visual image interpretation in the study of an area?
2. Give definitions of land cover and land use. Give an example of each of them.

11.6 REFERENCES

- Anderson, J. R. (1971), Land use classification schemes used in selected recent geographic applications of remote sensing. *Photogrammetric Engineering and Remote Sensing*, vol 37, no 4, pp. 379-387.
- Roy, P.S. and Giriraj, A. (2008), Land use and land cover analysis in Indian context. *Journal of Applied Sciences*, vol 8, no 8, pp.1346-1353.
- Smith, P. and others (2008), Greenhouse gas mitigation in agriculture. *Philosophical Transactions of Royal Society B: Biological Sciences, London*, vol 363, pp. 789-813.
- http://bhuvan.nrsc.gov.in, Bhuvan Beta – Indian Earth Observation Visualisation
- http://www.google.com/earth

Information from above mentioned websites was retrieved on February 2012.

11.7 FURTHER/SUGGESTED READINGS

- Anderson, J. R., Hardy, E. E., Roach, J. T., and Witmer, R. E. (1976), A land use and land cover classification system for use with remote sensor data, U.S. Geol. Survey Professional Paper, Vol 964, pp 1-28.
- Lillesand, T. M., Kiefer, R.W. and Chipman, J. W. (2004), *Remote Sensing and Image Interpretation*, Indian Edition, John Wiley and Sons, New Delhi.

11.8 ANSWERS

SAQ I

a) In Fig. 11.2, coal mines show greyish white tone and irregular shapes, forest cover is recognised by green hues and water bodies by dark blue tone.

b) In Fig 11.7, white patches of the image show area covered by snow and ice and blue colour represents the presence of large number of water bodies.

SAQ II

1. Forest, rangeland and wetland are the land cover features.

Terminal Questions

1. Refer to section 8.2.
2. Refer to section 8.3.