UNIT 11  NATURAL RESOURCES STUDIES AND MANAGEMENT

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11.1 INTRODUCTION

In the first three blocks, you have studied about geoinformatics, the concept of geospatial data analysis tools and the basics of mapping. The applications of geoinformatics have great potential as the technology can be utilised for resource inventory, baseline data creation, planning and management purposes.

This unit, which has two major parts, comprises of introduction about the application aspects of geoinformatics with special reference to studies of natural resources and their management. The first and second parts discuss a broad spectrum of conceptual ideas pertaining to the capability of geoinformatics for different kinds of ecosystems, and natural resources management, respectively with some case studies and examples.

Objectives

After reading this unit, you should be able to:

- discuss the scope of geoinformatics for terrestrial ecosystem studies and management;
- explain applications of geoinformatics for aquatic ecosystem studies and management;
- describe the role of geoinformatics in land and water resources studies, mapping and management; and
- elucidate the role of geoinformatics in minerals and soil resources studies.
Before studying the role of geoinformatics in ecosystem management, let us have a brief overview of ecology, ecosystem and environment.

Ecology is concerned with the study of the structure and function of organisms and their environment. It is also described as the science of living things in relation to their environment that provides linkages to problems related to environmental planning. It helps to understand the importance and its contribution to the environmental management. It includes relationships between organisms and their physical environments (physiological ecology); between organisms of the same species (population ecology); between organisms of different species (community ecology); and between organisms and the fluxes of matter and energy through biological systems (ecosystem ecology). Possibly, the most important role of ecology is the concept of an ecosystem.

Ecosystem is the basic functional unit that incorporates organisms, populations and communities together with the causal mechanisms that define the relationships, interdependencies and pathways that direct energy flow and control the properties of the system (Balasubramanian, 1995). Ecosystem is a complex network of both biotic and abiotic components dependent either directly or indirectly upon the input of solar energy as shown in Fig. 11.1. Flow of energy and matter in a typical ecosystem is shown in Fig. 11.2. The flow establishes critical cycles of matter and energy that sustain ecosystem structure, function and complexity in a dynamic balance over time and space.

Environment is the combination of various Terrestrial and Aquatic ecosystems that includes Hill ecosystem, fluvial ecosystem, Coastal ecosystem, Desert ecosystem and many more.

Fig. 11.1: Components of an Ecosystem (source: www.physicalgeography.net)

Fig. 11.2: Flow of energy and matter in a typical Ecosystem (source: www.physicalgeography.net)
11.2.1 Advantages and Role of Geoinformatics in Ecosystem Studies

You should note that the condition of terrain/landscape, in which all the types of ecosystem are present is not uniform throughout the world. Some of them are situated in the rugged mountain while others in deep valley. Further, some of the ecosystems are not completely accessible by people due to their large aerial extents. In addition to this, there are number of different kinds of features and organisms bearing unique and varied characteristics in an environment.

Geoinformatics has the following advantages for ecosystem related studies:

- it is possible to map all types of terrains ranging from rugged mountains to deeper valleys due to capture of satellite images from higher altitude
- by virtue of use of high-resolution sensor and high-end computer technology, it is possible to discriminate more features, which are not distinguishable by our naked eye
- due to temporal resolution, it is possible to visualise the past and present changes that have taken place in an ecosystem, especially for forest cover changes, land degradation and so on
- handling of voluminous data, both raster and vector, is possible under an umbrella of geoinformatics
- it is time and cost-effective, particularly for large areas.

Following kinds of studies are possible using geoinformatics technology for terrestrial and aquatic ecosystems:

- estimation of terrestrial and aquatic vegetation cover and historical changes
- shoreline mapping
- identification of different kinds of plant communities
- biodiversity estimation, species richness and distribution
- migration of wildlife
- desertification
- identification and mapping of habitats and habitat suitability, etc.
- identification and mapping of water bodies
- monitoring water quality
- mapping bathymetry
- primary productivity
- identification of potential fishing zones
- mapping and monitoring of water surface temperature, etc.

Let us now discuss about the applications of geoinformatics in mapping, monitoring and managing the ecosystem and natural resources with some examples and case studies. You should note that the application of geoinformatics is vast hence we would be briefly discussing selected applications.
For our convenience, let us categorise ecosystems into two categories i.e., Terrestrial and Aquatic ecosystems and discuss them one by one.

### 11.2.2 Terrestrial Ecosystems

Geosciences have a profound impact on ecosystems because global circulation patterns and climate zones set basic physical conditions for the organisms that inhabit a given area. The most important factors are:

- temperature ranges
- moisture availability
- light, and
- nutrient availability

These factors together determine what types of life forms are most likely to flourish in specific regions and what environmental challenges they will face. Earth is divided into distinct climate zones that are created by global circulation patterns. The tropics are the warmest and wettest regions of the globe while subtropical high-pressure zones create dry zones at about 30° latitude north and south. Temperatures and precipitation are lowest at the poles. These conditions create different types of biomes as shown in Fig. 11.3.

**Biomes** are defined as broad geographic zones whose plants and animals are adapted to different climate patterns. Since temperature and precipitation vary by latitude, Earth’s major terrestrial biomes are broad zones that stretch around the globe. Land biomes are typically named for their characteristic types of vegetation, which in turn influence what kinds of animals will live there. Soil characteristics also vary from one biome to another, depending on local climate and geology. It includes forest ecosystem, grassland ecosystem, desert ecosystem, manmade or artificial ecosystem (such as crop fields and gardens).

![Fig. 11.3: The main biomes in the world (source: http://en.wikipedia.org)](image)

In the following paragraphs, we will discuss about some of the examples of applications of geoinformatics.

In a recent study by Padalia and Roy, (2010), tropical forests (spread over 1,294 km² area) of South Andaman Islands were mapped using remote sensing data. They mapped vegetation types, structure and composition of the 17
vegetation classes spreading over 89.92% forested area of the islands as shown in the Fig. 11.4. They reported that evergreen, semi-evergreen and mangrove forests were reasonably well distributed forests, while moist deciduous and littoral evergreen were narrowly restricted. They also studied the forest cover density with the help of remote sensing data and field sample plots (Fig. 11.5), and reported that the stocking was quite variable across the forest types. About 60% of forested area is under medium to high canopy density. Information on floristic composition, structure and diversity of various forest types were obtained from field sample plots. Evergreen forests were found to have highest diversity followed almost equally by semi-evergreen and moist deciduous forests.

Fig. 11.4: Vegetation type map of South Andaman Islands prepared using Landsat TM remote sensing data. (source: www.springerlink.com/content/cg23876q1024p85p/fulltext.pdf)

Geoinformatics also helps in biodiversity characterisation. In a study, vegetation diversity of the Western Ghats was assessed to find biodiversity hot-spots using principles of landscape ecology and geoinformatics techniques (http://pune.cdac.in/html/geomat/projcomp.aspx). Biodiversity maps were generated and areas for conservation were prioritised using information on
biodiversity, disturbance and ecosystem uniqueness. Spatial and non-spatial databases were modelled using GIS to prepare various spatial indices, such as interspersion, juxtaposition, porosity, patchiness, disturbance index. Finally, outputs were integrated to prepare biodiversity map of the area as shown in Fig. 11.6.

Fig. 11.5: Forest canopy density map of South Andaman Islands derived using IRS 1D LISSII and Pan merged data. (source: www.springerlink.com/content/cg23876q1024p85p/fulltext.pdf)

Fig. 11.6: Biodiversity characterisation at Landscape Level using Satellite Remote Sensing in the Western Ghats of Maharashtra (source: http://pune.cdac.in/html/geomat/projcomp.aspx)
Let us now understand the potential of geoinformatics for terrestrial ecosystem through a case study in which forest cover was monitored through remote sensing data for a period of about 70 years.

**Case Study: Geoinformatics in Forest Cover Change Detection in a part of Eastern Ghat.**

One of the main advantages of remote sensing technique is temporal resolution that helps in generating data sets. The case study focuses on the role of remote sensing and GIS in assessment of changes in forest cover, between 1931 and 2001, in the Kalrayan hills, Tamil Nadu (Fig. 11.7). The trend of forest cover changes over the time span of 70 years was precisely analysed using high resolution Satellite data. In this case study, the Indian Remote Sensing Satellites (IRS) LISS III geocoded False Colour Composite (FCC) of year 2001 at 1:50,000 scale was used for assessing the temporal changes in the forest cover (Fig. 11.7).

Map of the study area, the Kalrayan hills, was prepared from SOI topographical maps at 1:50,000 scale. The forest cover in the study area was derived from the SOI topographical maps of 1931 and 1971 at 1:50,000 (after georegistration), respectively. The classes were then visually interpreted from the 2001 IRS 1C LISS III geocoded satellite data by using the elements of image interpretation. The forest areas were delineated from their red tone and contiguous pattern. The scrubs were identified from their brownish yellow tone, coarse texture and scattered pattern. The agriculture and human habitations were identified from the light reddish-brown tone and regular pattern. The rocky outcrops were identified from their brighter tone, absence of vegetation cover and their association to the steeper slopes. Necessary ground truthing were carried out and corrections were made at required places and the various classes viz. forests, scrubs, agriculture and human habitation, and rocky outcrops were identified. Thus, a thematic layer depicting various forests and other land use classes was generated. The primary forest type and landuse maps were prepared based on field observation and image interpretation.

The ArcGIS software was used to prepare the classified (final) forest cover and land use maps. Finally, the status of changes (either increase or decrease) during 1931-1971, 1931-2001 and 1971-2001 and land covers were assessed by overlaying of various period (1931, 1971 and 2001) maps (Fig. 11.8). The final maps which represent the forest cover and its changes during 1931, 1971 & 2001 (both in area and percentage) were also generated. The changes observed are given in Table 11.1. It was noticed that forest cover has increased between 1931 and 1971 because of the implementation of various afforestation schemes by the forest department and sacred grooves. It also revealed that the forest cover loss between 1971 and 2001 could be due to shifting cultivation and illegal encroachments by villagers; and the forest cover drastically decreased on plateau areas due to human population pressure (Sakthivel et al, 2010). The study analysed forest cover change in the tropical deciduous forest region of the Eastern Ghats of India. This study shows the utility of geoinformatics in forest cover change detection and restoration planning.
Table 11.1: Forest cover and its changes during the period 1931-2001

<table>
<thead>
<tr>
<th>Year</th>
<th>Forest Cover (in km²)</th>
<th>Changes observed in Forest Cover (in km²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1931</td>
<td>275.6</td>
<td>-</td>
</tr>
<tr>
<td>1971</td>
<td>481.7</td>
<td>206.1 (1971-1931)</td>
</tr>
<tr>
<td>2001</td>
<td>266.5</td>
<td>9.1 (2001-1931)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>215.2 (2001-1971)</td>
</tr>
</tbody>
</table>

Fig. 11.7: a) A panoramic view of the Kalrayan Hills, a part of Eastern Ghats; b) IRS-1C LISS-III satellite image of a part of Kalrayan hills, Eastern Ghats (source: Sakthivel et al, 2010)

Fig. 11.8: Forest cover (a) in 1971, (b) in 2001 and (c) forest cover changes observed (1971-2001), Kalrayan hills, Eastern Ghats (source: Sakthivel et al, 2010)
11.2.3 Aquatic Ecosystems

Aquatic biomes (marine and freshwater) cover three-quarters of the Earth’s surface, and include rivers, lakes, coral reefs, estuaries, and open ocean. Of these, the oceans account for the maximum area. Large bodies of water (oceans and lakes) are stratified into different layers based on temperature. Surface waters are warmest and contain most of the available light but depend on mixing to bring up nutrients from deeper levels. The distribution of temperature, light, and nutrients set broad conditions for life in aquatic biomes in much the same way that climate and soils do for land biomes. Daily or seasonal changes occur in marine and freshwater biomes. For example, in the intertidal zone where the oceans and land meet, areas are submerged and exposed as the tide moves in and out. During the winter months, lakes and ponds can freeze over, and wetlands that are covered with water in late winter and spring can dry out during the summer months.

Saltwater and freshwater ecosystems contain several types of organisms. One type of aquatic life is weakly swimming, free-floating plankton (consisting mostly of phyto plankton and zoo plankton), and another type is nekton (strongly swimming consumers), such as fish, turtles and whales. A third type, bottom dwellers (benthos), include barnacles and oysters that anchor themselves at one spot, worms that burrow into the sand or mud, and lobsters and crabs that walk about on the bottom. Finally, decomposers break down the organic compounds in the dead bodies and wastes of aquatic organisms into simple nutrient compound for use by producers.

Aquatic ecosystems are further classified into the following two types on the basis of salt content in water.

- **Fresh Water Ecosystem (Pond, Lake, River and Spring Ecosystem)**
  Fresh water life zones occur where water with a dissolved salt concentration of less than 1% by volume accumulates on or flows through the surfaces of
terrestrial biomes. Examples are standing (also called as \textit{lentic}) bodies of water, such as lakes, pond and inland wetlands and flowing (known as \textit{lotic}) systems, such as streams and rivers (Fig. 11.9). Although, freshwater systems cover less than 1% of Earth’s surface, they contain a variety of species and provide a number of ecological and economic services.

![Fig. 11.9: An example of a (a) lentic and (b) lotic ecosystem (source: http://en.wikipedia.org/wiki/Lentic_ecosystem)](image)

Small streams, which originate from high altitude areas, join to form rivers which flow downhill and ultimately to the ocean as part of the hydrologic cycle. As streams flow downhill, they become powerful shapers of land. Over millions of years, the friction of moving water levels the mountains and cuts deep canyons. The rock and soil, transported by water are deposited as sediment in low-lying areas. Streams are fairly open ecosystems that receive many of their nutrients from bordering land ecosystems. Such nutrient inputs come from falling leaves, animal faeces, insects, and other forms of biomass washed into streams during heavy rainstorms or by melting snow. To protect a stream or river ecosystem from excessive inputs of nutrients and pollutants, we must protect its watershed and the land around it. As discussed above, a river starts its journey from mountains or hill and it creates different kinds of landforms during its three stages (i.e. youth, mature and old). Rivers can easily be mapped through remote sensing. Following kinds of study are commonly carried out using geoinformatics:

- identification of paleochannels as shown in Fig. 11.10
- mapping of water bodies and their monitoring as shown in Fig. 11.11
- river migration
- identification of flood prone areas and flood inundated areas, etc.

Water quality can also be accessed through remote sensing. Lakes are the large natural bodies of standing fresh water formed when precipitation, runoff or groundwater seepages fills depressions in the Earth’s surface.

Biomass is biological material from living or recently living organisms such as wood, waste gas and alcohol fuels.
Fig. 11.10: IRS P3 WiFS image showing palaeo drainage in Sarasvati River Basin. Thick channels represent the course of river Sarasvati. The synoptic coverage of remote sensing data and indirect evidence such as presence of vegetation in a linear fashion helps in identifying a palaeo channel (source: www.springerlink.com/content/6816423032wt48k8/fulltext.pdf)

Fig. 11.11: Mapping and monitoring of Lake Chhad in Africa. The lake falls in the territory of four countries namely Chad, Cameroon, Nigeria and Niger. The images of different time period show how the lake has almost disappeared with time. The first image of 1973 shows large extent of the lake which has gradually reduced. The 2001 image shows that the lake has almost disappeared and is occupied by vegetation (source: http://en.wikipedia.org/wiki/Lake_Chad)
• **Marine or Oceanic Ecosystem (Estuaries and Ocean Ecosystem)**

Oceans have two major categories: the coastal zones and open sea. The coastal zone is warm, nutrient-rich, shallow water that extends from the high-tide mark on land to the gently sloping, shallow edge of the continental shelf. This zone has numerous interactions with the land, and thus easily affected by human activities. The coastal zone contains 90% of all marine species and most ecosystems found in the coastal zone have a high net primary productivity per unit area because of the ample supplies of sunlight and nutrients.

One highly productive area in the coastal zone is the estuary. Estuary is a partially enclosed area of coastal water where sea mixes with fresh water nutrients coming from rivers, streams and run off from land. Estuaries (Fig. 11.12) and their associated coastal wetlands (i.e. land areas covered with water throughout the year) include river mouths, inlets, bays, mangrove forest swamps in tropical waters and salt marshes in temperate zones. In the context of marine or oceanic ecosystems, geoinformatics is generally used for the following:

• shoreline mapping and change detection
• coastal habitat mapping and monitoring
• mapping bathymetry
• monitoring water quality
• sediment discharge
• marine pollution
• oil spill
• potential fishing zone demarcation, etc.

![Fig. 11.12: An estuary mouth and coastal waters, part of an aquatic ecosystem. (source: http://en.wikipedia.org/wiki/Lentic_ecosystemand www.isro.org/scripts/rsa_czs.aspx)](image)

Mapping of shorelines (i.e. the boundary between land and sea) is one of the most common applications of remote sensing data in coastal applications. It is easy to demarcate the shoreline from remote sensing images, and with the comparison of historical shorelines one can estimate the erosion and accretion and also understand the nature of shoreline as shown in Fig. 11.13.

About 7500 km long coastal zone of India has been mapped using remote sensing data at different scales. It also included mapping and monitoring of
vital/critical coastal habitats, such as coral reefs and mangroves, marine protected areas, shore line changes, coastal landforms, land use/land cover, impact of sea level rise to be used for the integrated coastal zone management (Nayak, 2002 & 2004; Nayak and Bahuguna, 2001). Coastal Zone Information System (CZIS) have also been developed for different parts of the Indian coast (Dwarakish et. al., 2006). Further, models have been developed for preparing integrated coastal zone management plans and identifying suitable sites for mangrove plantation.

Fig. 11.13: Shoreline changes in Mahanadi deltaic coast as observed from field survey and remote sensing data. (A) Comparison of field survey data of 1929-30 with IRS 1D LISS-III image of 2001. (B) Comparison of field survey data of 1972-74 with the LISS-III image of 2001. Note the different zones of accretion and erosion (source: ISRO Scientific Report, 2003)

In one of the studies, mangroves of the Marine National Park of the Gulf of Kachchh, which constitute the second largest patch of mangroves in Gujarat was mapped using remote sensing data with the help of ground data (Fig. 11.14a). The mangroves, comprising of six species, cover about 11,000 ha. The study identified distribution of different mangrove communities with respect to shoreline (Fig. 11.14b). The zoning of the mangroves also helped in assessing the diversity of the region. Based on the richness of species, some areas were identified as highly diverse and most suitable area for preservation.

Fig. 11.14: a) Mangrove habitat map and b) Mangrove zonation map of Jindra and surroundings in the southern part of the Gulf of Kachchh prepared using IRS LISS III data of 1998 (source: www.springerlink.com/content/36507w5142116056/fulltext.pdf)
It is difficult to physically survey large areas of waterbody and sea. Capability of remote sensing data to provide synoptic view and repeatability at definite time interval helps in water quality mapping and monitoring over a large area. Fig. 11.15 shows a river bringing pollutants in a bay in Andhra Pradesh.

Fig. 11.15: Discharge of pollutants from a river in the bay and breach of Kakinada spit in Andhra Pradesh as observed in IRS-1C LISS-III image (source: ISRO Scientific Report, 2003)

Similarly, the total suspended matter in water can also be estimated and movements of sediment plumes can be monitored as shown in the Fig. 11.16.

Fig. 11.16: Suspended sediment concentration as derived from IRS-P4 Ocean Colour Monitor (OCM) data showing sediment dispersal pattern in the Gulf of Kachchh and Arabian Sea. Colour bar indicates concentration levels. (source: www.mapindia.org/2005/papers/pdf/310.pdf)
Geoinformatics is being actively used by Fisheries Survey of India (FSI) for fishery forecast by synergistic application of chlorophyll and SST data derived. The technique developed for the potential fishing zone (PFZ) forecast (up to 2-3 days in advance), which combines chlorophyll information from OCM and SST from NOAA-AVHRR has been validated with a number of ship campaigns in the Indian water (Fig. 11.17). Results have shown 70-90% success in PFZ identification.

Check Your Progress II

1) List out the aquatic ecosystems related studies which can be carried out using geoinformatics.

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11.3 GEOINFORMATICS IN NATURAL RESOURCES MANAGEMENT

In this section, we will discuss about the applications of geoinformatics in natural resources management. Literal meaning for resource is wealth. Conservation and proper management of natural resources is essential for the betterment of future generation. Because of greater areal extent, voluminous data and uneven topography under changing climatic condition, monitoring and managing the available resources by people is not an easy task.

Let us see, how geoinformatics is being used for natural resources management. As you know satellite sensors collects data from space without
having any physical contact with the feature. The data are available both in the form of hard copy print and digital format. By using various interpretation keys and elements and applying proper interpretations techniques, such as visual interpretation (for hard copy/printed data) and digital image processing (for digital data) techniques, the data can be converted into an information or a map to represent a theme, which is called as **thematic map**. A thematic map may have only point/line/polygon features or combination of these features. The various thematic maps can be viewed/over-laid in a GIS environment to visualise any on-going natural process, which determines the existence or extinction of natural resources in an area.

Following kinds of information and studies are possible using geoinformatics technology in natural resources management.

- identification of degraded land
- identification of mineral resources
- identification of potential mineral zones
- mapping of different rock types
- water resources mapping
- water quality mapping and monitoring
- identification of potential groundwater zones
- soil resources mapping, etc.

In the following subsections, we will discuss some of the case studies for different kinds of natural resources from which you can better understand the use of geoinformatics with special reference to natural resources management.

### 11.3.1 Land Resources

Land is an important resource which man puts in to diverse uses. Land is used for construction of buildings, roads, railways, etc. It is also used for cultivation, grazing of animals, mining, industries, etc. The type of land use varies from one region to another. The proportions of land put to different major uses, such as cultivation, forests, grazing and human settlements in any region change in course of time. The land use pattern shows variation not only from one region to another but also from time to time in same region. These valuable land resources are subjected to various kinds of degradation. When degradation level continues to rise, it directly affects the living resources of an area. Already considerable areas of the world are highly degraded due to natural as well as anthropogenic activities. Some of the important natural causes that result in land degradation are soil erosion, landslides, volcanoes, earthquakes, floods, droughts and desertification. Anthropogenic causes include deforestation, construction of large dams, mining, over-irrigation, persistent usage of fertilisers and pesticides, etc.

Some of the commonly observed applications of geoinformatics for land resources are following:

- land use/land cover mapping
- geomorphology
- land degradation, etc.
Utility of remote sensing data has long been established for geomorphological applications because of its capability of providing synoptic view and repetitive coverage. Studies related to movements of sand dunes, shifting of rivers, beach migration and changes are the most common examples. The geomorphological maps are useful in monitoring, planning and management of several other resources aspects.

11.3.2 Mineral Resources

Let us first see, what is meant by a mineral. Mineral is a naturally occurring inorganic substance having definite chemical composition and atomic structure. Minerals are compounds of their constituent elements, whereas rocks are mixtures of their component minerals. Thus, the mineral quartz, (SiO$_2$) is a compound of the elements silicon (Si) and oxygen (O), whereas the rock granite is a mixture of several minerals, and one of them is the quartz.

Mineral resource is a mineral deposit that is of great economic value and which can be mined profitably. Demarcation of mineral resource is carried out by using some clues, such as soil tonal variations, dense or stunted vegetation growth and different anomalies.

Geoinformatics has several applications in mineral resources and geomorphology related studies. Some of the application areas are given below:

- preparing reconnaissance maps of inaccessible areas
- updating existing geological maps
- identifying potential mineral zones

![Fig. 11.18: Illustrating the concept of mineral potential zone mapping. (a) favourable parameter x (such as geochemical anomalies); (b) favourable parameter y (such as faults); (c) mineral potential zone map prepared based on the occurrence of the favourable parameters x and y showing the prospective areas where the mineral of our interest may be found](image)

As listed above and shown in Fig. 11.18, geoinformatics is useful for identifying potential zones for a specific mineral. The potential zones are identified based on the analysis and mapping of different parameters which are favourable for occurrence of a particular mineral as shown in the figure.

11.3.3 Water Resources Management

Water is an elixir of life and is available as an extremely finite but replenishable natural resource. Water is the most widely occurring substance...
on this planet. Globally distributed by the hydrological cycle and driven by the energy cycle, the circulation of water powers most of the other natural cycles and conditions the weather and climate. Water has shaped the Earth’s evolution and continues to fashion its progress. Some proportion of the water resurface later to aid/sustain river flow.

The definition of water resource is the total range of natural waters present on the Earth and that are of potential use to human beings. These water resources may occur in form of liquid, vapour or solid. These resources include rivers, lakes, ground water, oceans, snow fields, glaciers, etc. Water covers about 71% of Earth’s surface and is vital for all forms of life on it. About 1.6% of water is below the ground in aquifer and about 0.001% is present in air as vapour, perspiration and clouds. About 0.6% of water is present on land’s surface in form of rivers, lakes and ponds. Glaciers and polar ice caps cover about 2.4%. The largest part of surface water is in form of oceans as approximately 97% (Fig. 11.19).

The strength of remote sensing techniques lies in their ability to provide both spatial and temporal views of surface water quality parameters that are typically not possible from in situ measurements. Remote sensing makes it possible to monitor the landscape effectively and efficiently, identifying water bodies with significant water quality problems. Water quality parameters can often be quantified using remote sensing techniques, which allow management plans to be formulated to reduce movement of substances from watersheds to water bodies, thus reducing the effects of the pollutant on water quality.

The various pollutants of water bodies are sedimentation, industrial effluents, municipal sewage, agricultural runoff and air pollution. Remote sensing for determining water quality of larger water bodies makes use of the properties of light and its interaction with water, its constituents and the adjacent terrain.

To demarcate the groundwater potential zones, different thematic maps, such as geology, geological structure, hydrogeomorphology, landuse, drainage and topography, etc., are prepared and analysed along with the ground survey data.

To demarcate the different groundwater potential zones, all the thematic layers are integrated together according to their importance through the GIS union concept (Fig. 11.20). Favourable conditions for the occurrence of ground water

**Energy Cycle**: Energy enters the ecosystem from the Sun and exits after the organisms have taken as much as they need. Organisms release energy back into the biosphere as heat. Energy also enters the ecosystem from the interior of the Earth and is usually in the form of heat, not the electromagnetic radiation from the Sun.
are studied and the areas where the favourable conditions (based on the above mentioned parameters) occur are identified. The ground water potential zones can be classified into (i) very good, (ii) good, (iii) moderate and (iv) poor, based on these parameters and the favourable conditions.

With increasing awareness towards climate change and global warming, a number of studies have been taken up for inventory, monitoring and retreat of Himalayan glaciers. Majority of the studies are concentrating on glacier inventory of Himalayas (Indus, Ganga and Brahmaputra basins), snow cover monitoring and estimation of retreat of Himalayan glaciers. Glacial inventory has already been carried out for many parts of the glacial regions of Indus, Ganga and Brahmaputra basins at 1:50,000 scale. Fig. 11.21 shows an example of snow cover and glacier monitoring.

Fig. 11.20: Satellite image and the various maps derived from the image and used as input in generation of ground water prospect map (source: [www.ias.ac.in/currsci/dec252007/1747.pdf](http://www.ias.ac.in/currsci/dec252007/1747.pdf))

Fig. 11.21: a) Monitoring of snow using AWiFS data for the period 2004-2008, b) Retreat of Himalayan glaciers showing about 16% loss in glacial area during 1962-2004 (source: [www.isro.org/scripts/rsa_sgs.aspx](http://www.isro.org/scripts/rsa_sgs.aspx))

### 11.3.4 Soil Resources

The soil is at the interface between the atmosphere and lithosphere. It also has an interface with the biosphere and hydrosphere, i.e. the sphere describing surface water, ground water and oceans. A combination of physical, chemical...
and biotic forces acts on organic and weathered rock fragments to produce soils with a porous fabric that contain water and air. The unconsolidated mineral or organic material on the immediate surface of the Earth serves as a natural medium for the growth of land plants.

Because soil is important for cultivation and agricultural production, soil fertility and productivity are important issues to address. Detailed pedological knowledge is useful for land evaluation purposes. Soils are an integral part of landscapes and the knowledge of the distribution of different soils helps to preserve a high standard in environmental quality. For example, site specific management cannot be developed without detailed knowledge of soils. Remote sensing is useful for identification and mapping of different kinds of soil. You should note that remote sensing is particularly useful for soil mapping when surface soils are not covered with dense vegetation. Another important parameter where remote sensing is useful is the soil moisture content. Optical remote sensing techniques are useful for soil type mapping and delineation of their boundaries whereas microwave remote sensing is useful for soil moisture content mapping.

### 11.4 ACTIVITY

1) See your surroundings and find out where you can use geoinformatics.
2) Prepare a list of the areas where you think you can apply geoinformatics.

### 11.5 SUMMARY

In this unit, we have discussed about applications and scope of geoinformatics for studying terrestrial and aquatic ecosystem and natural resources. Let us now summarise what we have studied in this unit.

- Geoinformatics is useful for identifying suitable habitats for different kinds of animals and plants, different land and aquatic plant communities and their cover, biodiversity estimation, species richness and historical changes.
- Geoinformatics is also useful for identification of degraded land, potential mineral resources and zones, mapping of different rock types and soil resources.
- The technology is also used for identification of potential groundwater zones, mapping and monitoring of water resource and water quality.

### 11.6 UNIT END QUESTIONS

1) What is meant by ecosystem and how do you classify it?
2) How do you use geoinformatics for forest cover change detection studies?
3) How will you apply remote sensing tool to demarcate ground water potential zones?
4) Describe how geoinformatics is useful in natural resources management?
11.7 REFERENCES

- www.ias.ac.in/currscci/dec252007/1747.pdf.
- www.ias.ac.in/currscci/dec252007/1747.pdf.
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- www.springerlink.com/content/36507w5142116056/fulltext.pdf.
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- www.springerlink.com/content/cg23876q1024p85p/fulltext.pdf.
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All websites were retrieved between 10 June 2011 and 03 August 2011.

11.8 FURTHER/SUGGESTED READING


11.9 ANSWERS

Check Your Progress I

1) Abiotic and biotic components.

2) The major findings in the forest cover change detection case study:
   - Forest cover has increased between 1931-1971 because of the implementation of various afforestation schemes by the forest department and sacred grooves.
   - Forest cover has decreased between 1971-2001 due to shifting cultivation and illegal encroachments by villagers.

Check Your Progress II

The studies that can be carried out using geoinformatics for aquatic ecosystem are: identification of paleochannels, river migration, mapping and monitoring of water bodies and identification of flood prone areas and flood inundated areas, etc.

Unit End Questions

1) Ecosystem is the basic functional unit that incorporates organisms, populations and communities together with the causal mechanisms that define the relationships, interdependencies and pathways that direct energy flow and control the properties of the system. Ecosystem is categorised into terrestrial and aquatic ecosystems.

2) Forest cover change detection can be done using geoinformatics techniques by adopting systematic procedures such as preparation of forest cover maps of different seasons/years. The forest areas can be delineated from their red tone and contiguous pattern. The scrubs can be identified from their brownish yellow tone, coarse texture and scattered pattern. The agriculture and human habitations can be identified from the light reddish-brown tone and regular pattern. The rocky outcrops/slopes are identified from their brighter tone, absence of vegetal cover and their association to the steeper slopes.

3) For the purpose of ground water potential zone demarcation the following maps, such as area of interest, geology, drainage, drainage density,
lineament, lineament density, geomorphology, land use land cover, slope, rainfall, etc., are prepared with due care during interpretation. After preparing the above mentioned thematic maps, all the features are ranked as per their favourability towards the presence of ground water. Finally, all the thematic layers are integrated in GIS and a map showing distribution of ground water potential zones comes as an output of the integration depending upon the ranking of favourable conditions.

4. The various thematic maps can be viewed in a GIS environment to visualise any ongoing natural processes, which determine the existence or extinction of natural resources in an area. Apart from this various information and studies are possible such as identification of degraded land, potential mineral resources and zones, groundwater potential zones, mapping of different rock types, mapping and monitoring of water resources and quality, etc.