APPENDIX - III

Principles of remote sensing

Remote Sensing: Remote Sensing has been defined as the Science and art of obtaining information about an object, area, or phenomenon through the analysis of data acquired by the device that is not in physical contact with the object, area or phenomenon under investigation. Mostly the object is located on or near the earths' surface and the device (sensor) is more or less above the object and is at a substantial distance from it. The information is carried by electro magnetic radiation, some property of which is affected by the remotely sensed object. Remote sensing usually includes the study of earth's atmosphere as well as the surface. The main advantage of remote sensing are (1) Speed at which data can be acquired from large areas of earth's surface and (2) inaccessible areas can be investigated.

Classification of remote sensing systems : Remote Sensing Systems can be classified on the basis of many different criteria (1) **Active** and **passive** systems. An active system is a remote sensing system that transmits its own electric magnetic emanations at an object and then records the energy reflected or refracted back to the sensor. A passive system is a sensing system that detects or measures radiations emitted or reflected by the target.

(2) **Photographic or scanning systems :** In photographic systems, a photograph formed by the action of light on a base material coated with a sensitised solution that is chemically treated to fix the image points at the desired density, is used for further analysis. Photographic systems however operate over a narrow wave length band from 0.3 to 0.9 μm. They nevertheless produce relatively cheaply an image which is of high geometric fidelity and resolution. Scanning systems use scanners to make use of infrared radiation (wave band 3 to 14 μm) and micro wave radiation (wave band 5 to 500 mm).

(3) **Aircraft or satellite based** : In a remote system if the sensor platform is an aircraft it is called aircraft based and if it is a satellite it is termed as a satellite based.

Photography for air and space : Aerial photography from air craft was the first method of remote sensing. World wars I and II gave impetus to the aerial photography from aircraft, when it was used to identify and plot enemy positions. Topographic mapping from stereoscopic aerial photographs, improvement in the resolution of lenses and ability of platforms were further developments and 1945 onwards its use spread from topographic mapping to applications in geology, agriculture, forestry and archaelogy.

Even today in the age of satellite and electronic scanner systems aerial photograph still remains the most widely used type of remotely sensed data. The six characteristics of aerial photography that make it so popular are its (1) availibility, (2) economy, (3) synoptic view point, (4) time freezing ability, (5) spectral and spatial resolution, and (6) three dimensional perspective.

Availibility : Photographs are readily available for parts of the world, where aerial surveying has been carried out.

Economy : Aerial photographs give information more cheaply than that obtained from field surveys.

Synoptic view point : Aerial photographs enable detection of small scale features and spatial relationships that would not be evident on the ground.

Time freezing ability : An aerial photograph is a record of earth's surface at one point of time and can therefore be used as a historical record.

Spectral and spatial resolution : An aerial photograph is sensitive to radiation in wave lengths that are outside the spectral sensitivity range of the human eye. It can sense ultra violet (0.3 to 0.4 μm) and near infra red (0.7 to 0.9 μ m) rediation.

Three dimensional perspective : A stereoscopic view of the earth's surface can be created and measured both horizontally and vertically, a characteristic which is lacking in the majority of sensed images.

Photo interpretation : The study of an air photograph for the identification of ground features and acquision of information is termed as photo interpretation. It requires skill, experience and practice as the view presented by a photograph is quite unfamiliar to the eye. It becomes somewhat easier if stereo-pairs are studied under a pocket steroscope so that the ground relief shows up. As photographs are studied for a specific purpose such as urban development, suitability of site for engineering constructions, property valuation, obtaining information of rock formations or existance of minerals, agricultural developments etc., it is necessary that the interpreter has a knowledge of these fields of study. In attempting to indetify an object on the photograph, the following factors are considered by the interpreter. They are its (1) size, (2) shape, (3) shadow, (4) pattern (5) tone (6) texture, and (7) site of location.

Non photographic systems (Scanners): Major technological advances throughout 1970s and 1980s have been concerned with improving the capabilities of space bound sensing in terms of rates and quality of acquision, classification, storage of information etc. Photographic methods depend on the natural illumination and clear atmospheric conditions. The recent and future developments of active microwave and thermal infra-red sensor systems will help to modify this constraint, as both have an all weather day and night capability.

Images recorded in the scanning systems are discrete record as against aerial photographs which give continuous record. Scanning systems are automatic. Data is recorded as digital code and transmitted to the ground stations where it is stored in computer tapes. Satellite data of increasing quantity, variety and complexity can be processed by the present computer systems.

The various types of sensor systems that have been developed can be calssified as follows:

(1) Multispectral scanners recording visible and near infrared wave lengths from 0.3 to 1.4 μm.

(2) Thermal infrared scanners recording infrared wave lengths from 3 to 14 μm.

(3) Side ways looking radars recording microwave lengths from 5 to 500 mm.

(4) Passive micro wave scanners recording micro wave lengths from 5 to 500 mm.

Satellite Landsat (MSS) developed in 1972 records 4 images of a scene covering a ground area of 155 km x 185 km at a ground resolution of 80 m. These four images cover green (0.5 to 0.6 μm), red (0.6 to 0.7 μm), near infrared (0.7 to 0.8 μm) and near infra red (0.8 to 1 μm) wave bands.

Images are produced by reflecting the radiance, recorded from 79m wide scanlines on the earth's surface. A complete channel Lansat imagery comprises of 2340 scan lines and 3240 pixels (picture elements) per line, a total of 7.5 million pixels and 30 million pixels per scene of 4 channels.

Landsat 4 and 5 (1982-1984) incorporates important improvements and carry a seven band sensor known as the Thermatic Mapper (TM) which gives a spatial resolution of 30 m. The French Spot carries push broom scanners called High Resolution Visible (HRV) and gives a spatial resolution of 20 m.

Thermal infrared remote sensing system records temperature characteristic of objects and can be used to either estimate or detect temperature differences as the basis of discrimination between surface (indirectly subsurface) phenomena. HCMM Satellite contains radiometer recording in a visible and near infrared (0.55 to 1.1 μm) and a thermal infrared band (10.5 to 12.5 μm). Ground resolution varies from

0.6 km at the centre to 1 km at the edge. Data is used for geological mapping, vegetation mapping, soil moisture mapping, snow melt prediction and monitoring industrial thermal pollution. Microwave remote sensing especially the Synthetic Aperture Radar (SAR) carried by the satellite SEASAT has the greatest immediate potential for synoptic mapping of osceanic ice and water surfaces. Distinction between surface features on radar imagery is dependent upon the inter action of microwave energy and geometry of surfaces such as relief interval, angularity of form, particle size of sediments etc. Nominal resolution of SEASAT is 25 m.

Three resolutions-spectral, spatial emporal of the sensed images determine the discrimination betw nd analytical significance of units of data that compose the image. Spectral resolution involves degrees of contrast in radiance from different materials and objects in defined wave bands of electro magnetic spectrum. Spatial resolution is a function of the size of data collection units and ultimately determines the detail that can be extracted from the imagery. Temporal resolution is a function of environmental conditions such as hailstorm, duststorm, cloudy weather etc. Using digital processing techniques, it is possible to obtain better knowledge of imagery which could not be obtained by visual interpretation by tone, colour, size, shape, texture, and context as in the photographic image.

Satellite remote Sensing : The period 1960 onwards is marked by the birth of remote sensing satellites, development of high spatial resolution sensors for land application, operational data collection of atmospheric information and the experimentation with new sensors in a variety of new wave bands.

With a remote sensing satellite remote areas of land, oscean and ice can be covered. Data collected is spatially consistent and continuous and suitable for computer processing. Data collection is frequent and time required for collection is small. For example, Landsat Thermic Mapper, images a scene of 170 km X 155 km in 25.87 seconds.

Measurements from satellites are complementary to conventional observations. In situ observations are needed to calibrate satellite observations and satellite remote sensing allows a spatial extension of ground observations which under difficult conditions may be very costly. Satellite remote sensing provides a low cost system for environmental data collection. So far reception and analysis of data from civil satellite programmes was free of ownership restrictions and political control. However data obtained from air-craft is subject to copyright as ownership wrests with companies or their cliants carrying out the air survey.

Satellites are grouped in the following ways :

(1) From the function point of view : Earth resources satellites are used for applications in land use, vegetation, geology, geomorphology, hydrology etc. They carry sensors with a medium spatial resolution of 0.25 km and have a fast repeat cycles of less than a day. Satellite for military applications are for reconnaisance of military installations or meteorogy. This data is not publically available.

(2) From the orbit they follow The polar orbit is a low earth orbit where satellites fly at 200 to 1000 km altitude. The orbit takes the satellite over or near the north and south poles and the orbit is in the plane of the sun or sun synchronous that is the orbit remains in a constant plane in relation to the sun, while the earth spins below.

IRS-IB launched on 29th Aug. 91 was orbiting over the poles at a height of 904 km and took 113 minutes for each orbit and space craft revisited a specific region of the earth once every 22 days. IRS-IC and IRS-ID more advanced in resolution and revisit capability were launched in 1995 and 1997 respectively. IRS-IC and IRS-ID have an excellent resolution and can view objects as small as 5.6 m. The geostationary orbit is a high orbit where satellites are located above the equator at a distance of 35900 km which is the same as that used by the communication statellites. At this distance the orbital speed of the satellite is the same speed as the earth's rotation and so the satellite

appears to be fixed above the same point on the earth's surface. INSAT series of India are geostaionary satellites and have a repeat cycle of about 30 minutes.

(3) Classification can be done on the basis of the type of sensors they carry and the generation to which they belong (e.g. 1st generation, 2nd generation etc.)

(4) Satellites may be manned or unmanned. Mercury Gemini Appolo, Skylab of U. S. A. and Vostok, Soyuz of U. S. S. R. were manned. Most of the satellites now launched are unmanned.

Applications of remote sensing :

(1) Meteorology: Profiling of atmospheric temperature, pressure, water vapour content, and measurement of wind velocity.

(2) Oceanography : Measurement of sea surface temperature, mapping ocean currents and wave energy spetra.

(3) Glaciology : Mapping the distribution and motion of ice sheets, determining the navigability in sea.

(4) Geomorphology, Geology : Identification of rock types, location of geological faults and anomalies, measuring the figure of earth and observing tectonic movements.

(5) Topography and cartography : Obtaining accurate elevation data and referring them to given co-ordinate system, production and revision of maps.

(6) Agriculture, forestry, botany etc : monitoring the extent and type of vegetation cover, its state of health, mapping of soil types, their water content, forecasting crop yields, salinity and erosion of soils.

(7) Hydrology : assessing water resources, forecasting runoff from ice melt and snow.

(8) Disaster Control : Warning of sand and dust storms, avalanches, land slides, flooding, pollution etc.

(9) Planning application: Generation of inventories of land use and monitoring changes, assessing resources, performing traffic surveys.

(10) Military application : monitoring movement of vechicles and military formations, assessing terrain.

Remote Sensing in India : Indian Satellite system (Insat) is the largest domestic communication system in the world today. Commissioned with the launch of Insat-IB in 1983, the first generation satellites were multipurpose satellites providing long distance telecommunications, meterological earth observation and data relay, TV and radio broadcasting. The first generation includes Insat-1 A, 1 B, 1C and 1D. The second generation includes Insat-2A, 2B, 2C, 2D & 2E. The last 2E was launched on 3rd April 1999 and is to be used for weather forecast unlike other second generation satellites. The Satellite pictures obtained from IRS series revealed the shocking depletion of forest area from 23% (believed) to 14% (actual). NRSA's (National Remote Sensing Agency) prediction of reduced snow melt run off in one year enabled the Bhakra Beas Management Board to plan in advance the distribution of scarce summer flow from melting snow among power generation, irrigation and drinking water supply. The imageries collected from the remote sensing satellites have supplied very useful information to various agencies like Geological surveyt of India, Central Ground Water Board, Oil and Natural Gas Commission, Geodetic and Topographical Survey of India.

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