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Acquisition, Processing and Management of Remote Sensing Data

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Abstract : *Remote Sensing techniques have shown great potential in acquiring reliable data concerning the distribution and use of known sources, and in identifying further resources. Landsat, SPOT and IRS satellites provide data in various parts of the electromagnetic spectrum with varying spatial resolutions from 10 to 80 meters.*

The advantages of satellite based remote sensing are large area coverage, synoptic view and capability to provide information over all accessible and inaccessible regions. Hydrologic mapping, soil moisture estimation, Snowmelt run off forecast, coastal monitoring are some of the proven areas of remote sensing application with very high cost benefit returns. Management of data involves several need based tools like image availability, procurement querry, theme oriented image analysis querry and integrated survey and evaluation.

1. Introduction

Space technology has taken very rapid strides since the launch of the first artificial satellite sputnik in 1957. The first proposals for civilian satellite remote sensing system were announced in 1960 after the analysis of hand held camera images from the Gemini and Appollo missions.

So far considering utilisation potential and feasibility it can be said that 5 satellites in Landsat series, Indian Remote Sensing Satellite, SPOT satellite of France and Marine observation satellite of Japan are the most significant remote sensing satellites going round the earth in a polar orbit synchronous with the Sun, which are presented in Table 1. In addition, there were several one-time remote sensing missions like PAVANTERRA, SIR A, B and C, MAGSAT and SASAT which collected remote sensing data in a limited form but they are not discussed in the present article. At present only Landsat 5, IRS and spot satellites have become inactive.

It is well-known that essentially remote sensing is carried out from space. The spatial segment comprises a platform which is a satellite with onboard multispectral scanners, and down link transmission configuration. The scanners are either of optomechanical type of push broom type. The ground segment consists of receiving station and data processing facility. A typical earth station coverage extends around a radius of about 3000 kms.

The remote sensing data is available in the form of imagery in black and white. From the Earth, features are identified with specific reflectance capabilities referred to as signature. There are mainly three such signatures in

Table 1 : Details of Remote Sensing Satellites

Satellite	Sensor	Wavelength (Microns)	Resolution (Meters)	Area of Coverage and Availability of Data
I R S	LISS-I	0.45 — 0.52 0.52 — 0.59 0.62 — 0.68 0.77 — 0.86	73	Woldwide— Data collected archived and distributed by Dept. of Space - Government of India,
Landsat-5	MSS	0.5 — 0.6 0.6 — 0.7 0 7 — 0 8 0.8 — 1.1	80	(a) Indian - subcontinent - Data collected and distributed by Department of Space - Government of India.
	TM	0.45 — 0.52 0.52 — 0.60 0.63 — 0.69 0.76 — 0.90 1,55 — 1.75 10 40 — 12.50 2.08 — 2.35	36	(b) Europe - Data distributed by EARTHNET - FRG (c) Worldwide-Data distributed by EROS - Data Centre USA.
Spot	MLA	0 50 — 0.59 0.61 — 0.68 0 79 — 0.89	20	French space Agency, Toulouse, France.
	PLA	0.45 — 0.80	10	
NOAA	AVHRR	0.58 — 0.68 0.72 — 1.12 3.52 — 3.90 10 30 —11.30 11.50 —12.50	1000	NOAA Environmental and information service. Washington D.C.-U.S.A.

Remote Sensing which are presented in Table 2, Each spectral signature is identified with specific colours of which the interpretation varies from satellite to satellite. However, to extract the signature very clearly additional colours have to be imposed and such an imposition requires minimum three bands with the primary colours of red, blue and green, which will yield 6 different colours. The colour composite by masking one feature and boosting other features thus generated, provide the false colour photographs. They are called false colour photographs because the colours are not natural colours representing nature. For example the forest which is green in nature becomes red in the imagery. The imagery is available at various scales ranging from 1 : Million to 1 to 50,000 depending

Table 2 : Component of Remote Sensing

Spectral Signature	Identification	(Satellite)	Interpretation
1. Reflectance characteristics	(a) Black & White colour and IR Photography	IRS SPOT LANDSAT-5 MOS	(a) Visual Interpretation aids like additive colour viewer, large format optical enlarger.
2. Emissive characteristics	(a) Thermal Infrared sensors (TIR)		
	(b) Passive microwave sensors (Radio) meters)		(b) Interactive image processing system
3. Scattering characteristics	(a) Active micro-wave sensors (Radars)	ERS - 1 RADARSAT (to be launched during 1991-92)	(c) Numerical analysis of Remote Sensing data

upon the sensor and the spatial resolution for analysis on an interactive image processing system. The data is available in the form of a 1600 bpi track 1/2 inch magnetic tape or cartridriage tape or a floppy. The floppy will consist of about 512/512 size data of all the bands. The earth station gets the data transmitted from the satellite platform.

Satellite transmission data is classified into bands depending upon the ranges of frequencies. There are several bands such as L, S, C, Ka, X, L, C, and S, whose frequencies are presented in Table 3. The receiving station consists of data receiving antenna terminals and a data recording facility. A block diagram showing overall conceptual frame work of data collection transmission processing, interpretation and output products and resources management is shown in Fig. 1.

It can be seen from Fig. 1 that two basic methods of data processing are existing,

Table 3 : Transmission Bands with Corresponding Frequencies

Band	Frequences Range G Hz
L	1 — 2
S	2 — 4
C	4 — 8
X	8 — 12
Ku	12 — 18
K	18 — 21
Ka	27 — 40

namely, Image or Visual oriented and Numerical or computer aided analysis. The photographic film, which measures the variations of the electromagnetic fields, is interpreted visually by the photo interpreter by means of various dividing elements, such as, size, shape shadow, texture, etc. into various informational classes. The interpreter uses conjunctive evidence to confirm his conclusions.

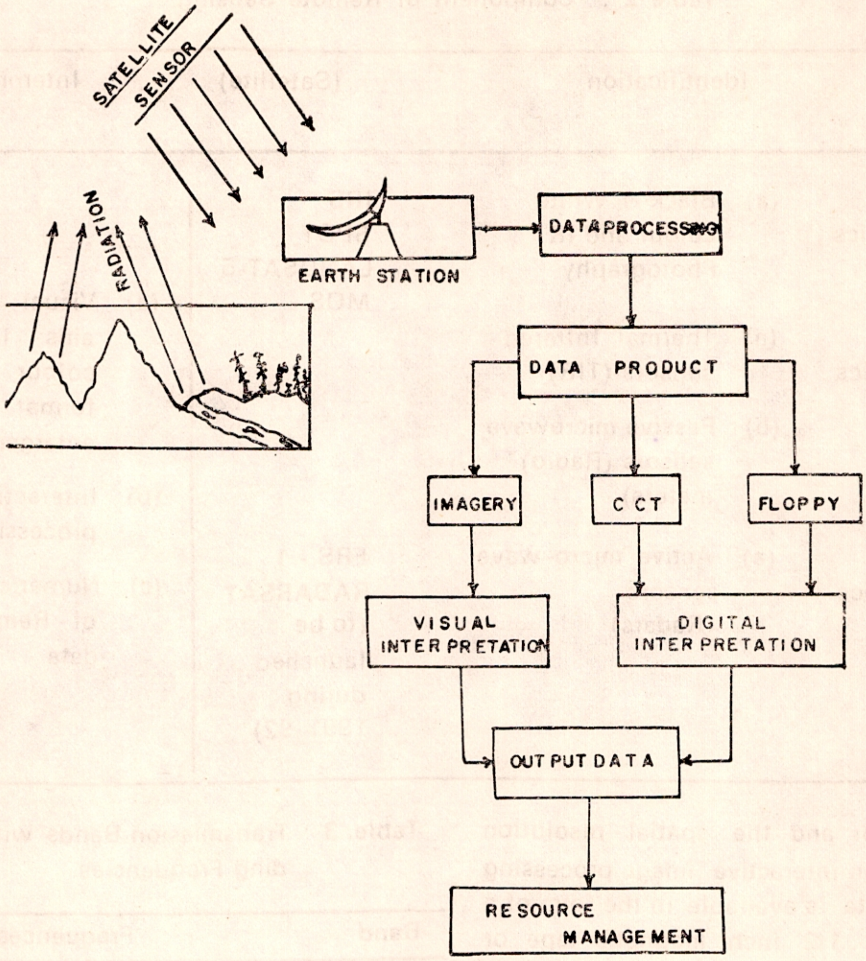

Fig. 1 : Data Flow of Remote Sensing

2. Indian Remote Sensing Satellite and Data Collection

The experience gained through the conduct of multi-spectral aerial surveys and most importantly the vast experience gained by various agencies in the use of remote sensing data, led to the approval of the Indian Remote Sensing Satellite (IRS-1) launched in March, 1988. The Indian earth station receives data from IRS, Landsat and also from French Satellite SPOT. NOAA series of satellite with a coverage of nearly 3800 km radius from its location are used for meteorological studies. The specifications of IRS and its application scope are given in Table 4. The primary focus of the utilisation efforts are in the areas of agriculture, forestry, hydrology, geology, and coastal oceanography. This is being achieved through the National Natural Resources Management Systems (NNRMS), Government of India.

Generally the data is transmitted in X, S and L bands of electromagnetic spectrum. There are several terminals at earth station complex at Hyderabad. One terminal operates in S-L band for receiving Multispectral scanner (MSS) data from LANDSAT-5 and Advanced very High Resolution Radiometer (AVHRR) data from NOAA satellite. This terminal is modified for X-S Band for receiving MSS and

Table 4 : Spectral Range of I.R.S—1A Along with their Applications

Band	Spectral Range (Microns)	Application Areas
1.	0.45—0.52	* Coastal environment studies (Coastal morphology and sedimentation studies) * Soil/Vegetation differentation * Coniferous / Seciduous vegetation discrimination
2.	0.52—0.59	* Vegetation vigour * Rock/Soil discrimination * Turbidity and bathymetry in shallow waters
3.	0.62—0 68	* Strong Chlorophylabsorption leading to discrimination of plant species.
4.	0.77—0.86	* Delineation of water features * Land form / geomorphic studies

Thermatic Mapper (TM) data from Landsat - 5. Both these terminals are upgraded for receiving data from the Indian Remote Sensing Satellite (IRS) which is being used for receiving data from the French remote sensing satellite, SPOT.

3. Applications - Remote Sensing

The immense potential of Remote Sensing for applications concerning natural resource targetting, inventory and mapping and environmental monitoring, has been demonstrated worldwide through a variety of studies covering many aspects of the hydrosphere, geosphere and biosphere. An overview of the potential of the Remote Sensing for various applications is illustrated in Fig. 2 This illustration primarily summarises the applications based on three modes of interpretation, viz, visual interpretation insitu interpretation called Ground truth and digital data interpretation. These three models lead to themes concerning geosciences, agriculture, soils, forestry, land use, water resources and oceanography. Apart from qualitative studies, quantitative methods employing various numerical analysis and emperical models are useful for hydrological and oceanographic applications. Few application areas are highlighted in the next section.

3.1 Snow Mapping

Remote Sensing has been looked upon by many as a promising means of attacking the problems of snow extent, distribution, water equivalent, water content, age, thickness and

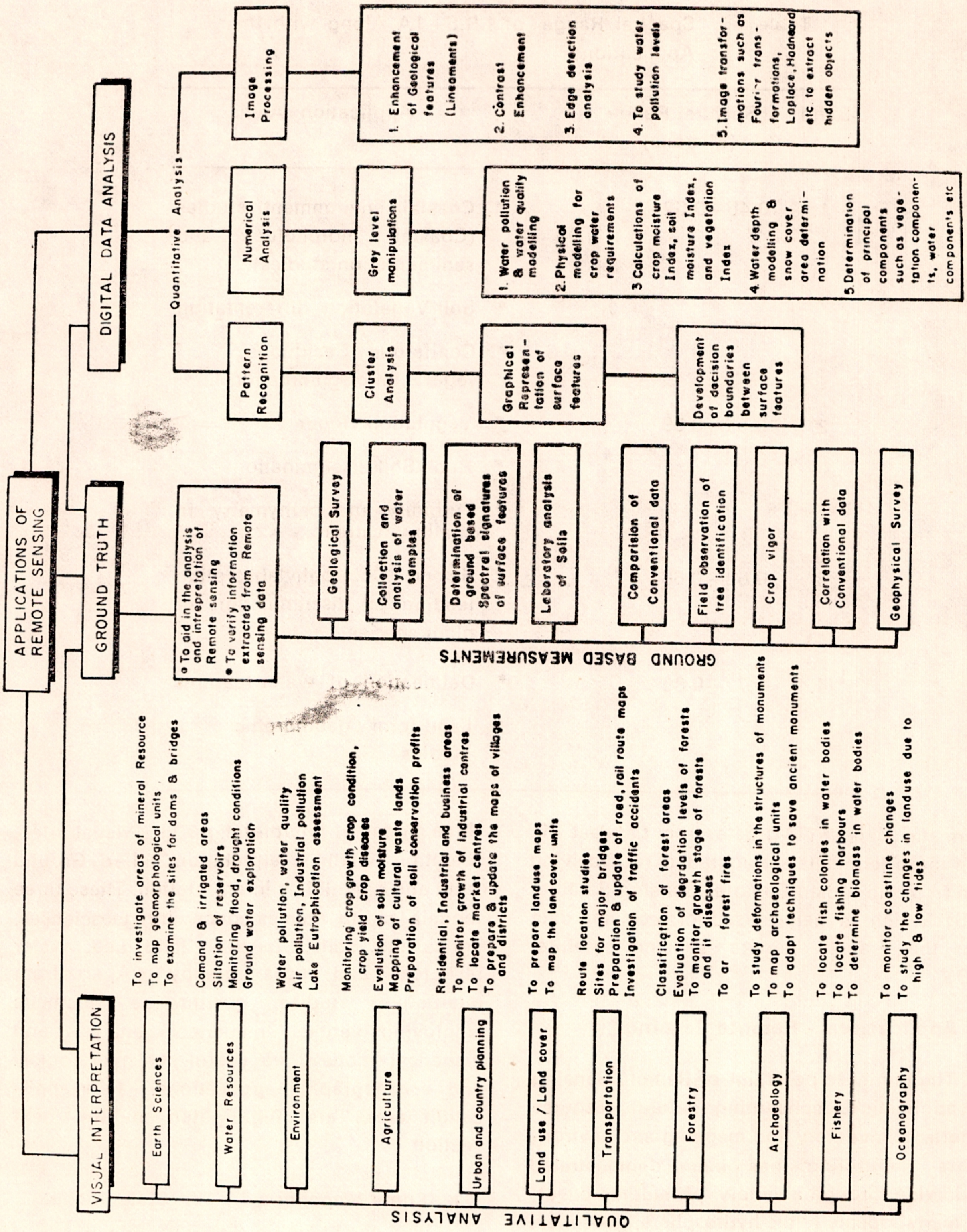

Fig. 2 : Applications of Remote Sensing

density which play a large part in the aseessment of the snow pack's contribution to run off. This is very useful to hydrologist in his specific drainage basins because it can be applied to immediate forecasting problem through the appropriate model or prediction device. The basic pioneering work in satellite snow-extent mapping was carried out by Barnes and Bowley (1968). Wiesnet (1974) provided percentage of snow-cover data to the appropriate river forecast centres within 36 hours of the NOAA-2 satellite transit across the basin.

Drought Monitoring

Though substantial work on drought monitoring is carried-out (**Briz-Kishore,** 1986a) by conventional methods, the most significant development is the use of the visible and near Infrared bands for monitoring the health and vigour of vegetation and crops. NOAA weather satellites have provided unique capabilities to monitor vegetation dynamics as at regional to global scale (Tucker et. al., 1984). The impact of the 1982-1983 El Nino Southern Oscillation related drought was detected in the Global Vegetation index anomalies over Asia (Malingreau, 1986).

An independent objective and near-real time system of drought monitoring was attempted by Indian Space Research Organisation during 1982 drought for entire Southern Peninsular India. This first experiment revealed that a combination of NOAA/AVHRR and Landsat data can provide a better monitoring system for drought. The use of meteorological satellite data to assess the spatial and temporal inadequacies of rainfall at critical crop stages, and subsequent assessment of crop status/ condition based on vegetation index on a long-term basis. This helps in assessing the performance of suggested measures of land water conservation and related impacts. The satellite remote sensing also helped drinking technology mission in identifying the groundwater potential zones and mapping on 15:0,000 scale for 51 districts covering primarily drought prone areas in the country.

3.2 Hydrogeological Applications :

Earlier researches discussed several hydrological problems including drainage and well-logging (Briz-Kishore, 1988) for which Remote Sensing techniques have been successfully used outlining the extent of surface water; tracing geologic structures and lithological and geomorphic features that would indicate possible sources of ground-water; and measuring the temperature of surface water. Through the use of such methods, large areas can be examined in a short period of time. Remote sensing, in recent years has been accepted as the first technique to be used in the investigation process, although it can also be applied later in combination with other methods.

While the use of satellite images of medium and high re-solution permits the analysis of broadscale regional data, very high resolution data of SPOT and aerial photographs are very useful to map local structures in greater detail. Analysis of geological units and tectonic structures, revealing morphology, climatic conditions, vegetation, and other factors, also discloses such hydrogeologic factors as the recharge zones of water-bearing horizons and the direction of ground water flow. Other geologic and geomorphologic features such as systems of fractures and faults, variations in slope, and hydrographic patterns related to groundwater occurrence are being detected.

In arid areas, which are mostly without vegetation cover, remote sensing imagery show almost all the data relevant for detection of underground aquifers. In humid areas which are mostly covered by vegetation, there is surplus of water in the soil and it can be identified by using microwave remote sensing techniques and also by infrared aerial photographs.

Infrared thermal images are particularly suitable for hydrogeological investigations in coastal regions where ground water flows discharge into the sea. Because of the temperature differences between the cold ground water and the warm sea water, freshwater coastal springs can be identified by the sharp contrast between the colour of the sea water and that of the flow of the submarine springs discharging into it. The use of remote sensing techniques in groundwater surveys have proved beneficial in reducing the time and the cost involved in surveys and in collecting accurate and reliable data.

3.4 Flood Mapping

Using sensing and storing information outside the wave-lengths of light provides special advantages for flood plain mapping by making possible the delineation of the inundated areas via infrared bands, even for a considerable period of time after the passage of the flood upto 20 to 25 days, particularly in arid and semi-arid regions. Best results may usually be obtained by using and composing two or more images containing information at various wavelengths, particularly if the inundated area includes different types of ground surface (bare soil, cropland, forest, snow cover, etc.),

Beyond the identification of areas inundated by a selected particular flood, remote sensing data can provide useful information for purposes of flood loss prevention and management in several other respects, particularly in the downstream reaches of large river systems where the process of the formation and recess of a flood takes several weeks or months. The delineation of areas exposed to flooding is only the first part of the assessment of flood hazards. An equally important and usually even more difficult second part is the assessment of losses and damages that represent and quantify the consequences of potential floods in a socio-economic context.

3.5 Soil Moisture Monitoring

Passive and active microwave and thermal infrared sensors have potential for soil moisture assessment. The temperature and soil moisture are clearly related to thermal IR emission and the thermal variation mapping is useful, provided the vegetation cover is not dense. The scattering effect of vegetation and of the irregular surface is a formidable problem to overcome in the use of passive and active microwave sensors. It might be pertinent to note that while the ground resolution of the passive microwave sensor is altitude-dependent, synthetic aperture radar (SAR) is not nearly so dependent on altitude; hence the active microwave remote sensing techniques using SAR are more useful provide finer resolution.

4. Natural Resources Management

For assessing the needs of decision-makers the field of natural resources has been classified into broad Resource Management areas. This will have certain resource management activities which have been identified as inventory allocation, monitoring, warning, damage assessment, legal actions, etc. In each resource management area specific resource management activity can be defined and these are called the resource management functions. The resource management functions as a data set. The data set is contained in data base which in turn is contained in data bank. (BRIZ-KISHORE, 1986-1988). The data collected and stored for the entire management area covering all functions in a data base; the external informations, technology, socio-economic conditions from the data bank. The natural resources information system (NRIS) is a vital component. The data base particularly in respect of land use and land cover has the largest impact on any planning decisions for a specific area of a region. There is an imperative need as a reliability index to the data for common temporality index to the data, common temporality, and classification, under National Natural Resources Management System (NNRMS) and aimed at scientifically gathering the information about various resources.

Advantages and Limitations

Since the launch of first remote sensing satellite Landsat I in 1972, remote sensing techniques have undergone improved spectral and spatial resolutions. The Landsat - 5, IRS, and SPOT satellites currently in orbit in space are providing data continuously.

The advantages of satellite based remote sensing are large area coverage and synoptic view, and capability to provide information over all accessible and inaccessible regions.

Conclusion

Remote sensing techniques have been found to be very useful in providing information on natural resource and environment. The unique capability to cover vast areas affected by droughts, floods, cyclones, landslides and earthquakes is being fully utilised. Hydrologic mapping, soil moisture estimation, snowmelt runoff forecast, and coastal monitoring are some of the proven areas of remote sensing application with very high cost benefit returns.

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