REMOTE SENSING APPLICATIONS: INDIAN EXPERIENCE

Shibendu Shankar Ray
Mahalanobis National Crop Forecast Centre,
Department of Agriculture & Cooperation, Krishi Vistar Sadan, Pusa Campus,
New Delhi – 110 012, INDIA

1. INTRODUCTION

Overexploitation of non-renewable natural resources to meet the basic amenities, like food, fuel and fibre to an ever-increasing population, has not only depleted the finite resources but also degraded their quality. Today, environmental considerations have become a major concern world over. The focus now is preserving the overall balance and value of the natural capital stock and a redefinition of short, medium and long-term considerations to reflect the real socio-economic costs and benefits of consumption and conservation. Accurate baseline information and methods to evaluate the quantity and the quality of each resource is the basic requirement for further planning. Remote sensing has been recognized now as a valuable tool for viewing, analyzing, characterizing, and making decisions about our environment.

2. REMOTE SENSING

Remote sensing (RS) is the science of making inferences about material objects from measurements, made at distance, without coming into physical contact with the objects under study. A remote sensing system consists of a sensor to collect the radiation and a platform – an aircraft, balloon, rocket, satellite or even a ground-based sensor-supporting stand - on which a sensor can be mounted. Currently a number of aircraft and spacecraft imaging systems are operating using remote sensing sensors. Some of the current image systems from spacecraft platform include Indian Remote Sensing Satellites (IRS), French National Earth Observation Satellite (SPOT), and Landsat 7 etc.

Remotely sensed data along with ground truth information and other collateral data has been extensively used to survey various natural resources like agriculture, forestry, minerals, water, marine etc., (Navalgund et al., 2007) and to study various physical phenomena. Since the same database is utilised by various disciplines, remotely sensed data is ideally suited to study inter-relationship of natural resources. Level at which information is available from RS data in a particular resource area is obviously quite different (Navalgund and Ray, 2000). Ground resolution requirements of different applications are different. Regional vegetation mapping may require only coarse spatial resolution data but applications in cadastral mapping require very high spatial resolution data. Spectral bands required for ensuring discriminability of objects for different applications can be quite different. For example, crop identification requires properly placed spectral bands in the red, near infrared and middle infrared wavelength regions. However, precise soil moisture determination demands use of microwave data L or C band. Crop physiological status determination or identification of mineral in the soil requires data in hyperspectral bands, i.e. large number of narrow spectral bands. Table 1 gives information about the spectral ranges required for different kind of applications.

Table 1. Applications related to natural resources management and spectral ranges required / employed

Theme	Application	Spectral ranges employed / required
Agriculture, Forestry and Land use / cover	Crop identification & acreage estimation	VIS,NIR,MIR,MW,
	Crop condition assessment and yield estimation	VIS,NIR,TIR
	Soil moisture	TIR and Microwave (L & C bands)
	Drought monitoring	VIS,NIR,MIR
	Land use/cover mapping	VIS,NIR,
	Forest fire detection	3-4 Micrometer, TIR
Water resources	Mapping surface water bodies	VIS,NIR
	Water quality monitoring	Narrow spectral bands in VIS,NIR Thermal
	Snow mapping	
	-aerial extent	VIS, NIR, MIR
	-depth (water equivalent)	Microwave
	Flood mapping	VIS, NIR
Marine resources and coastal studies	Phytoplankton estimation	Narrow spectral bands ~10nm in the VIS, NIR
	Fluorescence studies for Chlorophyll-A estimation	at 685 nm with 5 nm resolution +NIR
	Sea surface temperature	TIR, Microwaves
	Wetland mapping	TIR, NIR, MIR and
	Oil slicks	Microwaves (19.1 and 31 GHz)
Geology/Mineral resources	Structural geology	VIS, NIR and Microwaves
	Rock type identification	Narrow spectral bands in VIS NIR MIR & TIR

VIS:- 0.4 to 0.9 micrometer, **NIR**: 0.7 to 1.1 micrometer, **MIR:** 1.55 to 1.75 micrometer and 2.08 to 2.3 micrometer, **TIR:** 8-14 micrometer and Microwaves: L, C and X bands.

(Source: Joseph and Navalgund, 1999)

3. REMOTE SENSING APPLICATIONS

The major goal of Indian Remote Sensing pargramme is natural resources management for societal development. A large number of applications at national and regional level have been formulated and carried out meeting the specific needs of users in the country. Major areas of applications include agriculture, forestry, water resources, snow and glaciers, geology, cartography, coastal zone, marine fisheries, weather forecasting, ocean state forecasting, besides disaster monitoring and mitigation (Navalgund et al., 2007). Work carried out in a few of these is described in the following sections.

4. AGRICULTURE

Agriculture provides livelihood to about 60 per cent of the labour force and contributes nearly 18.6 per cent of the Gross Domestic Product (in 2005) and accounts for a sizeable share of the total value of the country's exports. Hence, there is strong need to improve the agricultural management system. Remote sensing data has been useful for large number activities having significance for the food security of the country. These include wasteland mapping and monitoring, soil resources mapping, crop production forecasting, horticultural development, cropping system analysis, precision farming etc. Some of these activities are described briefly here.

4.1.1 Crop production forecasting

Advance forecasting about crop condition and crop production has a strong bearing on national economy as well as day-to-day life of the. At global level, there have been three large experiments related to agricultural assessment. Those were the 1971 Corn Blight Watch Experiment (CBWE), the 1973 Crop Identification Technology Assessment for Remote Sensing (CITARS) and the 1974-78 Large Area Crop Inventory Experiment (LACIE). Among these LACIE, which was a joint effort NASA (National Aeronautics and Space Administration), USDA (United States Department of Agriculture) and NOAA (National Oceanic and Atmospheric Administration), was the first worldwide experiment to demonstrate the operational capability of RS technology for crop production forecasting.

In India, the first systematic attempt towards crop inventorying through remote sensing technique was carried out under a joint Indian Space Research Organisation (ISRO) and Indian Council of Agricultural Research (ICAR) - Agricultural Resources Inventory and Survey Experiment (ARISE), in which aerial colour infrared (CIR) photographs were used to estimate crop acreage in Anantpur district of Andhra Pradesh and in Patiala district of Punjab. Under IRS utilisation programme (IRSUP) of Dept. of Space, in 1984, three projects, namely i) Crop Production Forecasting, ii) Crop Yield Modelling, and iii) Crop Stress Detection were initiated to study different aspects of crop inventory using RS data. Later on, Crop Acreage and Production Estimation (CAPE) project was formulated under the Remote Sensing Applications Mission in 1986.

CAPE project, provided district level crop production forecast for all major crops (Wheat, rice, *rabi* sorghum, groundnut, cotton, rapeseed and mustard) for all major crop growing districts of the country (Navalgund et al., 1991). Crop acreage is estimated using the remote sensing data following stratified sample segment method. The district level RS based yield models have been developed using the empirical relationships between yield and single or multi-date (spectral profile) RS parameters. In some of the yield models RS parameters have been used along with other agrometeorological variables and/or a time trend variable.

CAPE project developed into a programme called, FASAL (Forecasting Agricultural output using Space, Agrometeorology and Land based observations), whose objective is to integrate various approaches and organisations for creating a hierarchical information system, which will help in providing information, related to crop condition and crop production any time of the season from sowing to harvest. Under FASAL, national/state level multiple production forecasts are issued for crops like Kharif Rice & Rabi Rice, Jute (using microwave data), wheat, winter potato and Rapeseed & Mustard (Parihar & Oza, 2006). The yield is estimated either using weather based models or by integrating remote sensing data into crop simulation models such as WOFOST. The successful operationalisation of FASAL project has resulted in creating a new institute (in 2012), called Mahalanobis National Crop Forecast Centre, under Ministry of Agriculture for implementation of FASAL programme.

4.1.2 Horticultural Development

Post-harvest losses for horticultural crops are estimated to be in the range of 60-80 per cent. Hence emphasis is given to develop post harvest infrastructure like cold storage, food processing, packaging, market outlets, etc. during current plan period. Most of the cold storage is concentrated in and around the consuming markets. Thus, very little facility exists to cater to the marginal farmers' requirement during the harvesting season. Remote sensing based crop map can be combined with other socio-economic facilities (like settlements, roads, current cold storage locations) to design a plan for optimal location of cold storage which will reduce the travel distance of the farmer. Ray et al. (2000) have tried this method to design plan for potato cold storage locations in Bardhaman district of West Bengal. Another important activity under horticultural development is the finding out suitable sites in the North Eastern states of India for horticulture, especially in the area which has been degraded due to shift cultivation, commonly known as Jhumming.

4.1.3 Cropping system Analysis

Differentiated landscapes and the associated biodiversity shaped by farming over the centuries may be seriously affected by the abandonment of land-use. The cropping pattern (mono crop, mixed crop), crop diversity in time and space, crop rotation are under going rapid change due to commercialization and globalization of agriculture. In order to make the land sustainable, the agricultural activity today is looked as a system rather than a single crop-producing unit. An essential component of this approach is the aim to adopt agricultural practices necessary to safeguard the environment and preserve the countryside. This calls for creating baseline information on the cropping system components. RS technology is the only tool that can derive timely information of the highly dynamic nature of agricultural activities of the vast country like India. For the first time crop rotation maps are prepared using remote sensing data. The crop rotation, along with many other cropping system characteristics (duration, diversity, intensity) derived from remote sensing data have been useful for crop diversification (Ray et al., 2005) and crop intensification programme (Panigrahy et al., 2005).

4.1.4 Precision Agriculture

The area available for agriculture is getting reduced day-by-day because of rapid industrialisation and urbanisation. The problem in front of the modern day farmer is to produce more from less area. Hence, the grower has to treat different grids of its large field differently for input application. In recent years the expanded use of Global Positioning System (GPS) and GIS, has given rise to agricultural advances in spatial data management that have revolutionised the way many growers mange their fields. In near future, a farmer will go to the field with a spreader or combine equipped with a GPS that records positional information related to variable rate of fertiliser application or yield at harvest for his farm. This ability to monitor the variability in the field and then to pinpoint areas for input application using variable rate method is known as 'precision farming'. Many growers, in developed countries, use this information for time and site specific field analyses with the assistance of 'farm management systems'. Farm management systems are essentially GIS with functions tailored to the activities of farming.

Satellite based RS data has a great role to play in precision farming, in the way of mapping the variability. Space Applications Centre has shown the utility of high spatial and hyperspectral remote sensing data for precision farming in different agricultural situations of India (Ray et al., 2007). However the requirement of a marketable RS technology for precision agriculture is the delivery of information with the following characteristics:

- Low Turn around time(acquired, corrected and processed) ~ 24-48 hrs
- Low data Cost (~ 100 Rs./acre/season)
- High Spatial Resolution (at least 2m multi-spectral for 5-10 ha synthetic field size)
- High Spectral Resolution (<25 nm for retrieving biophysical parameters)
- High Temporal Resolution (at least 5-6 data per season)
- Delivery of Analytical Products in Simpler Format

4.2 Water resources

Water is a primary source of life and sustains all human actives such as agriculture, industries and energy etc. The allocation and management of water resources is becoming a difficult task due to increasing demands, decreasing supplies and diminishing quality. Hence there is a urgent need to have accurate, reliable and timely data on various aspects of water resources and to update the technology of database creation and effective means of data integration to aid decision making.

4.2.1 Watershed development

Watershed is a geo-hydrological unit or a piece of land that drains at a common point and is considered to be synonymous with the catchment and drainage basin. This natural unit is evolved through the interaction of rainwater with landmass. For scientific utilization of natural resource base of land and water the ideal geographical unit would be the watershed. Watershed development is a comprehensive term meaning the rational utilisation of land and water resources of a watershed for optimum production with minimum hazard to natural resources. It essentially relates to the soil conversation in the watershed and means proper landuse, protecting land against all forms of deterioration, building and maintaining soil fertility, conserving water for farm use, proper management of local water, for drainage, flood protection and sediment reduction and increasing productivity from landuse.

The various stages of development of watersheds include characterization, prioritization, selection, action plan generation, formation of watershed association, implementation and monitoring the impact.

Characterization of watersheds needs defining the important watershed parameters like size, shape, relief, drainage, geology, soils, runoff, sedimentation etc. To get information about these is difficult and time-consuming through conventional means. Remote sensing is a valuable tool for determining some of these parameters either directly or through modeling. The amount of sediment load from a watershed is important for determining the storage capacity of reservoir. Life of a reservoir gets reduced due to sedimentation. Using RS data, it is possible to identity focal areas of erosion, monitor surface water spread, estimate volume of the reservoir and update the area-capacity curves. Modeling for estimation of soil loss using RS inputs besides conventional data has been done. This information is used for identifying erosion prone areas leading to watershed prioritization.

Developmental plans for optimal management of natural resources of a watershed on sustainable basis require reliable, up-to-date spatial information on various natural resources, physical terrain parameters, climate and socio-economic profile of the area. Integrated approach using remote sensing and spatial information systems provide cost-effective support in resources inventory including landuse mapping, comprehensive database for resources assessment, analytical tools for decision making and impact analysis for plan evaluation.

This integrated approach comprising preparation of thematic maps, generating composite land development units (CLDU) in GIS, suggesting suitable prescriptions for each land parcel based on its attribute including socio-economic data has been adopted successfully in a large number of districts in the whole country. Detailed action plans related to land and water resources development have been prepared on 1:50,000 scale for identified watershed in these districts (NRSA, 2002). Around 84 Mha area from 175 districts are covered under watershed development program of Integrated Mission for Sustainable Development (IMSD). The impact assessment of the implementation of the watershed development plans has shown remarkable improvement in crop area and productivity. For example, in Shehra and Lunawada taluka of Panchmahals district (Gujarat) action plans were implemented by the concerned Project Implementing Agencies (PIA). Check dams as suggested in the action plans have been constructed during 1998. As a result the cropped area in *Rab*i season, *kharif* crop productivity and financial return increased (Table 2). In the first year itself about 96 per cent of the invest cost of the check dam has been recovered (Patel et al., 1999).

Table 2. Impact of check dam creation as per the action plan (Source: Patel et al. 1999)

Parameters	**Before Check Dam**	**After Check Dam**
Kharif Productivity * (qtls/ha)	52	63
Rabi Crop area (ha)	33	42
Financial Return (lakh Rs.)	6.8	12.5

*Kharif cropped area remains unchanged

4.2.2 Irrigation management:

In spite of large investment made in the irrigation sector and the phenomenal growth of irrigation sector, return from the irrigated system in terms of crop yields, farm incomes and cost recovery are disappointing. Apart form that, there are additional problems of increase in soil salinity water logging etc. The reasons for poor performance of the canal projects are due to the fact that the emphasis on irrigation has been the construction of new projects, rather than proper management of the existing systems (Palaniswami, 1984).

Remote sensing data of irrigation management has following scopes:

- Water Distribution: Crop water requirement, Irrigation scheduling
- Crops: Irrigation crop area, Monitoring crop condition
- Soil: Monitoring water logging, salinity
- Finance: Actually irrigated land vs. Applications received for irrigation
- System Management: Performance evaluation

Various studies have been carried out in the country for crop monitoring, waterlogged area and saline area mapping and monitoring in various canal command areas using satellite based remote sensing data (Chari et al., 1994; Sahai et al., 1983). Space Applications Center has used satellite remote sensing data and GIS tools for monitoring system performance at distributory level for Mahi Right Bank Canal (MRBC) Command of Gujarat (Dadhwal et al., 1999). The study highlighted the areas with increasing waterlogging, salinity and urbanization, and hereby losing valuable culturable command area (CCA). The performance evaluation showed the disparity between the water released and the crop water required and also the unequitable water distribution between head and tail ends. This kind of analysis of command area performance using RS & GIS techniques will help in proper allocation of irrigation water and thereby decreasing chances of soil degradation (Ray et al., 2002).

4.2.3 Groundwater targeting

Easy availability of potable water is still a myth in many parts of the country, even after 60 years' of Independence. To construct wells or tubewells, there is a need to know the availability of ground water. Groundwater is basically controlled by the rock types, structures, geomorphology, soils etc. The usefulness of remote sensing data in identifying linear features such as fractures/ faults and geomorphic features such as buried channels etc. has been established**.** A countrywide hydrogeomorphic mapping showing ground water prospect areas was done on 1:250,000 scale using IRS 1A LISS I sensor data under National Technology Mission for drinking water (Sahai et al., 1991). Following this, more detailed maps for ten priority states on 1:50,000 scale have been generated in GIS environment under Rajeev Gandhi National Drinking Water Mission. The feedback has shown more than 90% success rate when wells were drilled based on ground water prospect maps generated using RS data (NRSA, 2003).

4.3 Forest and Ecosystem

Forest is one of the most important naturally renewable resources, which plays a significant role in maintaining ecological balance. The gradual reduction in the extent of the forest cover is a matter of great concern, since it not only maintains ecological balance but also supplies many of the basic needs of the human being. Hence there is a great need to take stock of the current forest and environment status and identify the areas which need priority attention. One of the important missions has been the first national level remote sensing based mapping of forest cover of the country in 1983. Since then, Forest Survey of India is carrying out biennial forest cover mapping.

4.3.1 Vegetation Dynamics

Regular monitoring of vegetation cover change will identify the forest areas under threat. Reserved forests are always prone to encroachment by the locals. To monitor the extent of forest loss, satellite imageries are useful by providing regular and repetitive information. Thus sometimes it acts as a legal tool for control of encroachment. Space Applications Centre proved this for the encroachment of Sanjay Gandhi National Park in Mumbai. . Apart from forest lands there is need to monitor the changes in grasslands since in an agriculture based economy, like that of India, a judicious ratio has to be maintained amongst grasslands, croplands and forestlands, in order to obtain optimum results in socio-economic and ecological terms. Jadhav et al. (1993) monitored and mapped the grassland of Banni, Kachchh (Gujarat) using multi-temporal satellite-based remote sensing data. They also studied the impact of invasion of the weed Prosopis juliflora and salinity ingress on the grassland.

4.3.2 Forest fire

Forest fire is one the major causes of deforestation and if fire occurs repeatedly it may cause permanent damage to carrying capacity of forestland. Repeated annual fires may decrease the growth of the grasses, herbs and shrubs that may result in increased soil erosion. There is wide scope of use of satellite data for forest fire detection and monitoring is wide. Jadhav et al. (1999) tried to integrate various fire causing parameters, like vegetation (mapped from satellite data), temperature, humidity, settlement etc. in GIS to identify the fire risk zones in Gir protected area of Gujarat. This kind of zonification will help the forest department to take necessary remedial measures in the high-risk zones.

4.3.3 Biodiversity characterization

Biodiversity is the best measure of influence of human being on nature. It is important as it provides stability to ecosystem and supplies vital requirements of human being, i.e. water and oxygen. There are threats to biodiversity through resource over-exploitation, pollution, climate change etc. Department of Space, at the request of Department of Biotechnology, took up a study for biodiversity characterization at landscape level using remote sensing and GIS (IIRS, 1998). The study has focused on identification of disturbance areas and biological richness areas for conservation and bioprospecting over North East region, Western Ghats, Andaman and Nicobar islands, Central India, Eastern Ghats and the East coast (Roy and Behera, 2002).

4.3.4 Coastal Zone Management

Coastal zones are of high ecological significance and economical interest, because costal waters have much higher content and variety of water constituents than open ocean, and thereby having a remarkable higher bioproductivity (Zimmermann, 1999). Remote sensing data is useful in studying following aspects of coastal zone (Nayak, 2000):

- Coastal ecosystems and marine living resources: This includes inventory of coastal habitats such as mangroves, coral reefs etc, reclamation of wetland and sustainable use of marine living resources, like fishes,
- Shoreline protection: This is done by shoreline-change mapping, studying suspended sediment dynamics etc.
- Coastal water quality: Study of pollution and phytoplankton blooms
- Coastal hazards and climate change: The study of effect of cyclones, storm surges, sea-level rise etc.
- Coastal Development: This includes site selection for industry, aquaculture etc.

Most of these works have been carried out in India, the description of which has been presented by Nayak (2002).

4.3.5 Wetland Study

Wetlands are valuable natural resources of considerable scientific interest, especially in environment point of view, because they are associated with biological diversity, important ecosystem functions and processes, and useful economically viable products (Rundquist, 2001). Wetlands provide for wildlife habitat, groundwater recharge, flood control, sediment filtration, nutrient retention, pollutant removal and wetland products such as decomposed plant matter and peat, fish, rice and some forest resources (Dugan, 1993). Remote sensing has been a powerful tool for wetland identification, classification, mapping, biomass, measurement and change detection (Rundquist, 2001). Realising the importance of wetlands in India, at the request of Ministry of Environment and Forests a national-level inventory and assessment of wetlands carried out using RESOURCESAT-1 LISS-III data of 2006–07 at 1: 50,000 scale (Panigrahy et al., 2012). A hierarchical system comprising 19 classes based on Ramsar definition has been used to classify the wetlands of India. The extent of wetlands has been estimated to be 15.26 m ha. Inland wetlands account for 69.22% (10.564 m ha), whereas the coastal wetlands account for 27.13% (4.14 m ha). The high-altitude wetlands (situated > 3000 m asl) in the Himalayan states were also mapped, comprising 126,249 ha of areal extent.

4.4 Ocean Biology and Fishery Forecasting

The operational OCM sensor on board Ocaensat-1 and more recently, Oceansat 2, has provided excellent opportunity to monitor and study the biogeological character of ocean around India. Algorithms have been developed for the retrieval of chlorophyll pigment and total suspended matter, characterization of colored dissolved organic carbon, underwater diffuse attenuation coefficient and marine atmospheric aerosol optical depth (Chauhan et al. 2002).

Aggregation of fish in ocean is influenced by many variables pertaining to environmental and biological conditions such as sea surface temperature (SST), chlorophyll concentration, currents, mixed layer depth, internal waves, winds, oxygen, salinity, predator-prey relationship etc. The technique developed for the Potential Fishing Zone (PFZ) forecast (up to 2-3 days in advance) which combines chlorophyll information from OCM and sea surface temperature (SST) from NOAA-AVHRR has been validated with a number of ship campaigns in the Indian waters. Results have shown 70-90% success in PFZ identification (Dwivedi et al., 2005).

4.5 Disaster Monitoring and Mitigation

The disaster management support services of Indian Space Applications Programme, are mainly directed towards creation of digital database for facilitating hazard zonation, damage assessment, etc., monitoring of major natural disasters using satellite and aerial data and development of appropriate techniques/tools, acquisition of close contour data for hazard prone areas using air-borne Laser Terrain Mapper, strengthening the communication back-bone for timely dissemination of information and emergency support, development of air-borne Synthetic Aperture Radar (DMSAR) towards all-weather monitoring capability, establishment of a Decision Support Centre at NRSC as a single-window service provider and support the International Charter on Space and Major Disasters, as a signatory. The important components of the Decision Support Centre (DSC) established at NRSC include: satellite/aerial data acquisition strategy, turn-around-time for data analysis and output generation, user required information and formats, dissemination to users and networking and support facilities such as digital database creation, hazard zonation, modeling, query-shell etc.

Near-real time flood monitoring is being done, wherein, administrative (village) and current land use layers are being overlaid in GIS on top of satellite-based inundation layers to identify affected settlements, damage assessment and for relief purposes**.** Drought is another important weather-related natural disaster. Being a semi-arid tropical country, India faces severe agricultural drought periodically due to erratic rainfall. A National Agricultural Drought Monitoring Systems (NADAMS) project gives fortnightly information during monsoon season at district level using satellite-derived NDVI information as input (NRSA, 1990). EO data has also helped in the preparation of landslide hazard zonation maps using databases on lithology, geological structures, slope, vegetation and land use. For earthquakes, seismic hazard zonation is an important step. Space data provide critical spatial inputs like geological structure, lithology, geomorphology etc for integrating with other database for hazard zonation. The availability of high-resolution data provides the necessary inputs for micro-seismic hazard zonation.

4.6 Climate Change Studies

Climate change is one of the most important global environmental challenges, with implications for food production, water supply, health, energy, etc. The remote sensing applications for climate change studies can be broadly divided into three categories, i) mapping and monitoring of climate change indicators, ii) mapping of the global change forcing agents, and iii) long-term impact assessment (ISRO, . Indian Space Research Organization has initiated a programme called PRACRITI (PRogrAmme on Climate change Research In Terrestrial environment), which studies various aspects of climate change and its impact. Some of the studies under this include, methane inventories from rice paddies and Indian livestock, assessment of the impact climate change on agricultural productivity and modeling runoff of major river basins of the country under climate change scenarios, understanding the spatial and temporal distribution ofg greenhouse gases using satellite data, studying the impact of climate change on glacier retreat, etc.

5. CONCLUSION

The remote sensing applications in India are nearly four decades old, starting from the coconut root wilt disease detection of 1970. Large number of nationally important applications has been carried out in this long span. It is difficult to summarize all these activities in a short article like this. Some activities, which the author has not been able to discuss include, land use/land cover change studies and snow and glacier monitoring, etc. This article also does not deal with the large number of studies carried for understanding atmospheric and oceanic processes and weather forecasting.

Indian earth observation programme has developed manifold. At present we have one of the best constellations of land, ocean and atmospheric observation systems. Some of the new EO systems which were added in recent past include the microwave remote sensing system RISAT-1, the atmospheric observation system Megha-Tropiques and the continuation of land observation through Resourcesat-2. All these systems would enhance the ability of remote sensing for better natural resources management towards national development.

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