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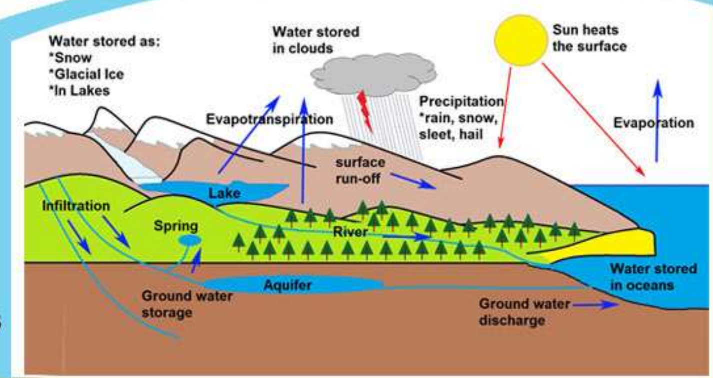


**Paper No: 6 Remote Sensing & GIS Applications in Environmental Sciences**

**Module : 29 Applications of Remote Sensing and GIS in Land Resource Management**

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| Description of Module | |
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| **Subject Name** | **Environmental Sciences** |
| **Paper Name** | Remote Sensing & GIS Applications in Environmental Sciences |
| **Module Name/Title** | Applications of Remote Sensing and GIS in Land Resource Management |
| **Module Id** | EVS/RSGIS-EVS/29 |
| **Pre-requisites** | Basic knowledge of school- level physics and fundamentals of remote sensing and GIS |
| **Objectives** | To understand the basic principle of remote sensing for mapping and monitoring of land resources for their conservation |
| **Keywords** | Remote sensing, GIS, Resources, Land, Conservation |

**Module 29: Applications of Remote Sensing and GIS in Land Resource Management**

**CONTENTS**



## 1. Aim of the Module

The objective of this module is as follows:

- It will encompass the requirements and problems associated with land resources.
- It will identify the different areas where geospatial technology can contribute.
- It will explore and discuss various applications of Remote Sensing and GIS in land management.

At the end of this module, the learner would know about the importance, methodology and how the management of the land resources can be made easy by RS/GIS technology.

## 2. Introduction

Land is a scarce resource due to immense agricultural and demographic pressure. Hence, information on land use, land cover and possibilities for their optimal use is essential for the selection, planning and implementation of land use schemes to meet the increasing demands for basic human needs and welfare. The information on land characteristics and distribution also assists in monitoring the dynamics of land use resulting out of changing demands of increasing population. Nations, village communities as well as individual land users need to make the best choices among options for the use of land in order to support the development without hazard of land degradation, which would endanger sustainable production of food and other rural products. Land Information Systems (LIS) have emerged as a powerful tools management and analysis of the large amount of in the basic data and information, statistical, spatial and temporal, needed to generate in a flexible, versatile, and integrated manner, information products in the form of maps as well as tabular and textual reports for land use decisions.

## 3. Importance of land resources

Land includes al1 the natural environmental resources contained on the earth's surface like soil, terrain, water, climate and weather. Human welfare and socioeconomic development depend on the capability of the land resources to provide food, fuel, timber, fiber and other raw materials, many other products of plants and animals as well as shelter and recreation. Pressures on land is everywhere and the need to achieve a balance between the exploitation and conservation of the land resources have made rational resources use and management at all levels (world, regional, sub-national and local**)** a vital issue. Global and regional institutions as well as individual countries also need to look at the present and future requirements for produce and goods from the available land resources and how to satisfy these requirements considering them against the possibilities and constraints of a sustainable production from these resources. Land resource management is linked to the sustainable development.

## 4. Historical perspective

The history of remote sensing, however, dates back to as early as 1827 when Nicephore Niepce took the first picture of nature. Since then, the advancement of technology continued with the use of a captive balloon in 1858, pigeons in 1903, low altitude aircraft during World War-1, and high altitude aircraft in the 1950s to take aerial photographs. The satellite remote sensing era began when Television Infrared Observation Satellites (TIROS-1), the first meteorological satellite, were launched in 1960. In India the trend in Geospatial Technology with reference to applications has received a tremendous boost over the last fifty years. The Remote Sensing and space technology in India has been realized effectively since 1960s. Application of this technology has travelled a long way since then. Further forward motion in the utilization of aerial photographs in India gathered momentum with the establishment of the Indian Photo Interpretation Institute (renamed as Indian Institute of Remote Sensing in 1983) under Survey of India in 1966 for imparting training in aerial Remote Sensing techniques. The first Indian Remote Sensing satellite (IRS-1A) was launched in 17th March, 1988. Now, the Indian Remote Sensing satellite system has the world's largest constellation of Remote Sensing satellites in operation, which provides leadership and continuity in earth observations through an operational earth observation infrastructure. There are 10 Remote Sensing satellites in operation viz. CARTOSAT (**Cartography and Satellite**) 1 & 2, CARTOSAT-2B, IRS-1C, IRS-1D, IRS-P3, Oceansat-1, Oceansat-2, Resourcesat-1 and Technology Experiment Satellite, (TES). The late 70s and early 80s was the period of emergence of Remote Sensing applications as a powerful tool for land resources survey and management. Currently, more than a dozen satellites are in orbit producing petabytes of data every day.

## 5. Definition and Scope

The term "remote sensing" first emerged in the 1950s and refers to "*the science and art of obtaining information about an object, area, or phenomenon through the analysis of data acquired by a device that is not in contact with the object, area, or phenomenon under investigation*". The era of satellite remote sensing began with the launching of Landsat-1 in July 1972 by the National Aeronautics and Space Administration (NASA), United States. It is based on the use of image data acquired by sensors of different types such as aerial camera, scanner or radar. The satellite remote sensing is used to interpret the images or numerical values obtained from a distance in order to acquire meaningful information of particular features on earth. The instruments used for this purpose may employ any of a variety of physical energy distributions. Sonars, for example, work on the principle of acoustic wave distribution, optical instruments such as the photographic camera and multi-spectral scanner use electromagnetic energy distribution. Remote sensing covers all techniques related to the analysis and use of data from satellites, such as Meteosat, *National Oceanic and Atmospheric* Administration (NOAA)-Advanced Very High Resolution Radiometer (AVHRR), Landsat, *(French: Satellite Pour l'Observation de la Terre)* SPOT, Earth Resources Satellite (ERS) - *Satellite Access Request* (SAR*)* and from aerial photographs. The main objective of remote sensing is to map and monitor the earth's resources.

The Geographical Information System (GIS) is computerized software that stores, retrieves, manipulates, analyzes and displays geographically referenced data sets, which can be used for different applications. Here the word '*Geographic*' deals with spatial objects or features which can be referenced or related to a specific location on the earth surface. The object may be physical/natural or may be cultural / man made. Likewise the word '*Information*' deals with the large quantity of data about a particular object on the earth surface. The data include a set of qualitative and quantitative aspects which the real world objects acquire. The term '*System*' is used to represent systems approach where the environment consists of a large number of objects / features on the earth's surface and their complex characteristics are broken down into their component parts for easy understanding and handling. GIS data are represented and stored in the form of vector or raster. In a vector data structure, geospatial data are represented as points, lines or polygons. For examples, fire rings or campsites would be stored as points, trails or streams as lines and forests or recreation opportunity classes as polygons. In contrast, a raster data structure represents geospatial data in a regular grid of cells and the attribute applies to the entire cell. Raster data provide continuous coverage of an area. For example, Digital Elevation Model showing slope, aspect and elevation in a grid for an area is a raster data structure. Attribute data can be handled in rational database software comprised of records and fields. GIS, therefore, can offer the unique ability to link such spatial and attribute data and tries to manipulate and analyze the relationships among them. In implementing georeferenced data using GIS, three important stages are involved. These are data preparation and entry, analysis and presentation. GIS can store the voluminous amount of spatial (maps) and non spatial (tabular data) information. It has potential uses in land resource management and inventory. The collection of remotely sensed data facilitates the synoptic analyses of Earth. Today, the data obtained is usually stored and manipulated using computers. The most common software used in remote sensing is *Earth Resource Data Analysis System (*ERDAS) Imagine, Environmental Systems Research Institute (ESRI), MapInfo, and ER Mapper.

## 6. Active and Passive Remote Sensing

Remote sensing uses devices known as sensors that can measure and record the electromagnetic energy. *Active sensors* such as radar and laser have their own source of energy and can emit a controlled beam of energy to the surface and can measure the amount of reflected energy. These sensors are used to measure the time delay between the emission and return and can determine the location, height, speed and direction of an object under investigation. As active sensors can emit their own controlled signals, they can be operated both day and night, regardless of the energy available from external sources. *Passive sensors*, on the contrary, can only work using the natural sources of energy. As a result, most passive sensors use the sun as a source of energy and can only work during daytime. However, passive sensors that measure the longer wavelengths related to the earth's temperature does not depend on the external source of illumination and can be operated at any time.

## 7. Methods in Remote Sensing

*i.* ***Remote sensing image data***: Data can be used from different satellites such as Land Remote-Sensing Satellite (LANDSAT) (spatial resolution 30m), LISS III (spatial resolution 23.5m) and Advanced Space borne Thermal Emission and Reflection Radiometer (ASTER) data (spatial resolution 15m). These images provided suitable cloud-free spatial coverage with relatively high spatial and spectral resolutions.

*ii.* ***Geometric correction***: Accurate registration of multispectral remote sensing data is essential for analyzing land use and land cover conditions of a particular geographic location. The geometric correction of remote sensing data is done for the distortions and degradations caused by the errors due to variation in altitude, velocity of the sensor platform, variations in scan speed and in the sweep of the sensor's field of view, earth curvature and relief displacement. The images are georeferenced using the polyconic projections with Root Mean Square Error (RMS) and LANDSAT-7 ETM+ data are reprojected to polyconic projections.

iii. ***Ground reference data***: In image analysis, ground reference data play important roles to determine information classes, interpret decisions, and assess the accuracies of the results. Substantial reference data and a thorough knowledge of the geographic area are required at this stage.

iv. ***Classification scheme***: Classification schemes provide frameworks for organizing and categorizing information that can be extracted from image data. A proper classification scheme includes classes that are both important to the study and discernible from the data on hand. Image enhancement, contrast stretching and false color composites are worked out and the interpretation of images are carried out using the various interpretation keys like the shape, size, pattern, tone, texture, shadows, location, association and resolution.

v. ***Image Classification Techniques:*** The overall objective of the image classification procedure is to automatically categorize all pixels in an image into land cover classes or themes. . Classes have to be distinguished in an image and classification needs to have different spectral characteristics. This can be analyzed by comparing spectral reflectance curves. Image classification gives results to a certain level of reliability. The principle of image classification is that a pixel is assigned to a class based on its feature vector by comparing it to predefined clusters in the feature space. Doing so for all image pixels result in a classified image.

**a.** ***Unsupervised Classification***: The unsupervised classification approach is an automated classification method that creates a thematic raster layer from a remotely sensed image by letting the software identifies statistical patterns in the data without using any ground truth data.

**b.** ***Supervised Classification***: Here the image analyst supervises the pixel categorization process by specifying, to the computer algorithm, numerical descriptions of various land cover types present in the image. Training samples that describe the typical spectral pattern of land cover classes are defined. Pixels in the image are compared numerically to the training samples and are labeled to land cover classes that have similar characteristics.

**c.** ***Fuzzy supervised classification approach***: This approach allows for multiple and partial class memberships at the level of individual pixels and accommodate fuzziness in all three stages of a supervised classification of remotely sensed imagery. This approach considers that each pixel might belong to several different classes without definite boundaries.

*vi.* ***Accuracy assessment*****:** In thematic mapping from remotely sensed data, the term accuracy is used typically to express the degree of 'correctness' of a map or classification. A thematic map derived with a classification may be considered accurate if it provides an unbiased representation of the land cover of the region it portrays. In essence, therefore, classification accuracy is typically taken to mean the degree to which the derived image classification agrees with reality or conforms to the 'truth'. A set of reference pixels representing geographic points on the classified image is required for the accuracy assessment. Randomly selected reference pixels lessen or eliminate the possibility of bias. A random stratified sampling method was used to prepare the ground reference data. This sampling method allocates the sample size for each land use based on its spatial extent.

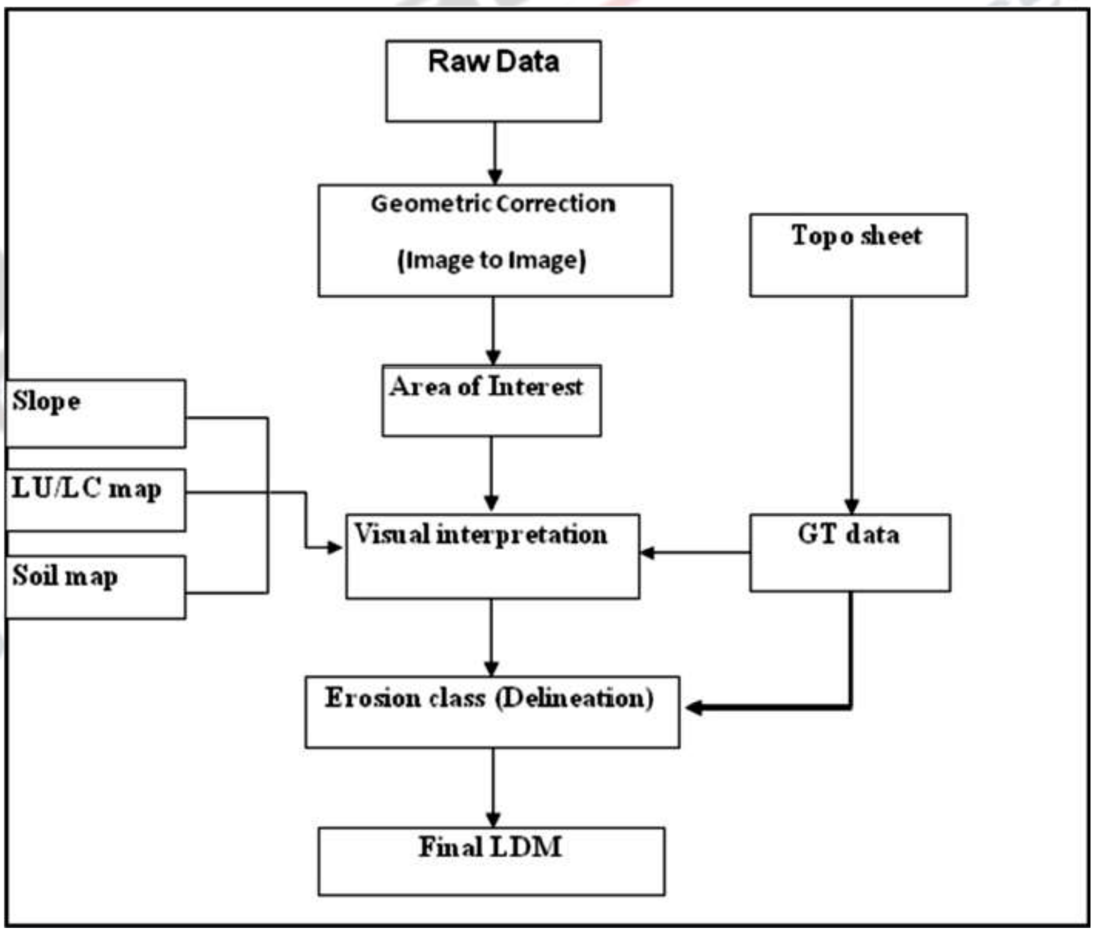


**Figure:** Flow diagram of generation of Land Resources Map (Adopted and modified from Tagore *et al.*, 2012).

*vii.* ***Land Use Classification System:*** Different classes of Land use- covers like Settlements, Forests, Agriculture, waste land etc. classified. By comparing the data of two different time interval the rate of increase, decrease and percent change can be estimated for each land use class. The map and data base generated from the technique itself has wide application like land use planning, flood management etc.

*viii.* ***Land Use Mapping and Distribution:*** A supervised maximum likelihood classification may be implemented for the two images and the final classification products provide an overview of the major land use / land cover features of lands for two time intervals and classifications like Water Body, Forest Reserve, Built up Area Vegetation and Farmland etc. can be done.

## 8. Advantages over conventional methods

The remote sensing techniques provide the synoptic view of large areas which is not possible by conventional ground survey methods. Satellite data are received periodically and the periodicity of data acquisition varies from one satellite to another. This capability of satellites helps in updating the information and monitoring the changes at short intervals. Remote sensing has a unique capability of recording data in visible as well as invisible (ultra-violet, infrared, thermal infrared, microwave etc.) parts of the electromagnetic spectrum. Therefore, certain phenomena which cannot be seen by the human eye can be observed through remote sensing techniques. Remote sensing concerns with electromagnetic energy from sun and its interaction with Earths features. But, quite often, similar spectral reflectance by different earth features and dissimilar spectral reflectance by similar earth features create spectral confusion leading to misclassification. These problems can be overcome by systematic ground truth information.

It is, therefore, evident that although the conventional methods of data collection are essential and should be continued in the efficiency of data collection both in terms of cost and time will decrease manifold if these are supplemented and/or complemented by remote sensing techniques. Nowadays one can easily survey, and do mapping of an area of interest such as village location map, plantation area, treatment area etc. within the shortest possible time. Administrative maps, soil maps, management maps etc. can also be prepared, stored and retrieved in digital form easily. Territorial units such as range, block, compartment, etc. can be easily mapped on the basis of visible/identifiable physical features such as streams, ridges, roads etc. by digitization.

## 9. Disadvantage of geospatial technology

Despite its invaluable applications in different areas of interest, the use of remote sensing technology in monitoring and managing habitats and ecosystems is likely to face some practical drawbacks. These include practical limitations, which are usually inherent in the technology itself, such as the limited ability of light to penetrate through water and atmosphere. The second limitation of remote sensing is the difficulties in assessing suitability in certain sensors. For example, remote sensing tends to provide geomorphological rather than ecological information on reef structures. This is because of the limited spectral and spatial resolution of the sensors caused by the presence of various external barriers like turbidity and water depth.

1. Data gaps – availability of the right data at the right time.
2. Cloud cover – particularly for biodiversity and land cover applications in the tropics.
3. Lack of systematic archiving of remote sensing images.
4. Regional disparities in data access and in the skills needed to interpret imagery.
5. Data costs, which are still significant, particularly for high-resolution imagery.
6. Costs of ground-truthing – remote sensing is seldom sufficient in its own right, but needs to be combined with selective ground-truthing.
7. Sovereignty concerns.
8. Most applications are still experimental, and costs of scaling up are significant.
9. Current lack of an international institution to coordinate among space agencies.
10. It requires skilled/committed manpower/labour.

## 10. Land Resource Management

Land resource consists of soil, forests, crops, livestock, etc., the land component of the earth's hydrologic cycle (snow cover, soil moisture and associated runoff, underground water) and mineral resources. Most of these land resources are used for production of food, fodder, fuel wood, fiber and for making improvements in productivity of land. Some of the basic land resources information needs are on soil characteristics; slope and degree of roughness; surface and groundwater availability; present land cover and use characteristics; biological conditions, such as disease and insect infestations of crops, grass land and forest land; urban development, etc. The geospatial technology like RS/GIS/ Global Positioning System(GPS) are having various applications in land suitability and productivity assessment; land use planning, land degradation assessment, quantification of land resources constraints; land management, agricultural technology transfer, agricultural inputs recommendations, farming systems analysis and development; environmental impact assessment; monitoring land resources development; agro-ecological characterization for research planning; agro-economic zoning for land development and nature conservation and ecosystem research and management etc. It also provides information about the land use/land cover classification, soil classification, land capability classification, soil slope and relief features, which are used for the resources management and regional planning.

**Integrated Mission for Sustainable Development (IMSD)**

Natural resources management for sustainable development is a major study undertaken by the Department of Space, to provide practical solutions to such problems through the technology of Satellite Remote Sensing. The study has been taken up in 174 districts all over the country, covering nearly 45 percent of the geographic area of the country. It aims to generate spatial databases on various natural resource themes, to integrate and analyze them for arriving at sustainable agro-based landuse alternatives. These maps serve as vital inputs for policy makers in the planning and implementation of developmental activities related to watershed management.

Background

During the drought of 1987 all over the country, a remote sensing approach was utilized to explore the possibility of obtaining solutions for drought mitigation. Due to the promise shown by the technology, the concept is tried in 21 drought prone districts of the country spread all over the country. The first cut results were presented by Chairman ISRO /Secretary DOS to Planning Commission. The methodology adopted was satisfactory leading to the expansion of the study to include about 153 districts under IMSD Phase-ll during the year 1992. At this stage, the scope of the work was enlarged not only to address drought but also land and water development through and integrated approach on watershed basis. While IMSD phase-ll was under Space has generated maps and plans for 92 selected DPAP blocks of the country. For this study identification of the blocks was done on the basis of having more than 20% wastelands in the study area.

Methodology

Three seasons satellite data was interpreted (1: 50,000 scale) and with the help of Survey of India toposheet of same scale to prepare thematic maps. The satellite data obtained from IRS series (IA-IC) were of excellent quality to prepare maps on 1: 50000 scale. Additionally, socio-economic and rainfall data are also gathered and depicted on 1:250,000 scale. Drainage, Watershed information is extracted from SOI toposheet with additional inputs from satellite data for upgradation.

Landuse / Landcover

These maps are prepared using two season data (Kharif & Rabi) for a crop calendar year. The main categories shown are single crop (Kharif/Rabi), Double Crops, Forests (Density and Vegetation), Different types of wastelands, degraded lands, water bodies etc.

Hydogeomorphology

These maps are prepared using Rabi/Summer data. They depict different rock types (Lithology), landforms indicating ground water prospects and potentials.

Soil

They indicate Soil series /Associations of series (sixth level of abstraction as per USDS soil classification system). Important informations on physical, chemical and morphological properties are interpreted for capability / Irrigability and Soil suitability.

Other thematic maps like Transport & settlement network, slope, drainage, watershed are prepared using toposheet updated with satellite imageries.

Watershed maps are prepared based upon the five-fold classification of AIS & LUS and further improvement. The resource regions are divided into basin, catchment, subcatchment, watershed, subwatershed, mini-watershed, micro- watershed etc. Eventually 500-1000 ha. watersheds are delineated to serve as spatial units for implementation of action plans.

Transport network, settlement location and village boundary maps depict various types of roads, location of villages with their boundaries are shown/Information of village boundaries is taken from revenue maps wherever required. Rainfall maps are based on information obtained from different meteorological observatories under IMD, State Govt. etc. Rainfall information is shown in the form of ISO HYETAL maps & bar charts indicating monthly average rainfall and number of rainy days, every month.

Slope maps are prepared using SOI toposheets with 20m contour interval. The map has a seven category legend being followed by All India soil and Land Use Survey Organisation.

Socio economic data is collected from census handbook, district gazetteer and other sources.

Data Integration

Once the data base is created, the resource potential is evaluated by integrating so that action items can be assigned to each parcel of land. This is done by overlaying different layers leading to the development of composite land development units (CLDUs). Sets of guidelines are also developed from field traverse/experience. These guidelines are unique combinations, in the form of a table represent the benchmark situations which can be extrapolated to similar terrain conditions. Different action items for land and water management are assigned based on social and economic viability. While this process can be done in a manual way, computer based geographic information systems (GIS) are suitable to interpret vast data in a speedier & logical way. It offers facility for periodical up-gradation also. The action plan items are site specific involving crops & cropping systems (Intensive Agriculture, Agroforestry, Silvipasture etc. and locating water harvesting structures (check dams, nala, bunds, percolation tank etc.) for judicious utilisation of surface and ground water (based on water budgeting, water balance studies etc.). The study also addressed measures to conserve soil (trenching, contour bunding etc.,) & water management (sprinkler and drip irrigation) & through land management (FYM and fertilizer application). Socio economic analysis plays a key role in suggesting the development of infrastructure facilities like establishment of milk collection centres (based on spatial distribution of cattle populations and road net-work), schools (literacy levels amongst children), fertilizer and seed depot establishment (economic profile of farmers and agricultural land holdings), schemes for weaker sections (Demographic profile especially of SC/ST Population) etc. Certain

suggestion are also given for crop/animal husbandry using information available from contemporary technology developed from different institutes like ICAR, DST, NIC, CGWB, AIS & LUS.NAEG etc.
Department of Space has taken number of measures for the smooth running of various steps involved in this processes to fulfil the local aspirations as well as involve the district machinery. Watershed identification is done by the District Collector / Project Director, DRDA based on overall backwardness of the study area/ watershed. At mapping level, quality Assurance and Standardization teams consisting of expert have been constituted to oversee/maintain uniformity of content and consistency in the level of information generated and presented in the maps. The suggested action plans are validated in the field and suitably modified by officials of different line departments of the districts based on their local experiences which enhances the acceptability of action items. Expert committees constituted for each state/district review action plans before implementation is taken up. Implementation of action plans is carried out by the district administration with the help of local population and NGO's through various centrally sponsored schemes like DPAP, DDP, IWPD, IRDP, MWS, EAS, JRY,NWDPRA etc.

Bottlenecks

IMSD approach is not institutionalised yet. Hence it is not a mandate for any planning or development process. Hence its utility is seeking wider acceptance. Secondly, the officials who are to use the maps are not trained for the same. Orientation courses are being held by DOS/State Remote Sensing Centres to bridge the gap in the area of map reading/orientation. There is practical problem of physically identifying the parcel of land going under a particular action item for treatment in the field. To overcome this, action plan maps are being over laid on satellite data/ cadastral maps bringing the reference level to 1:12,500 from 1:50,000 thereby making it easier to orient one self with ground situations for effective implementation. All these measures are contributing to the increased use of satellite technology in development. For the success of this programme and effective implementation, meetings are being held periodically with the local population to seek their views and suggestions. Monitoring for the evaluation of success of this approach is being done through adequate data to support. Remote Sensing provides a quick and efficient tool to monitor change/improvement in vegetation cover, water levels in tanks etc.

These change detection studied can provide information for periodical review of various implementation works.

Results of Implementation - Case Studies

The IMSD programme being carried out in India presently covers 175 districts (almost a third of the country), representing diverse terrain, agro-climatic zones, and social practices. With the involvement of
user agencies and departments, six selected watersheds in Bhiwani, Ahemadnagar, Kalahandi, Anantpur, Jhabua and Dharmapuri districts covering diverse situations, have been taken up for actual implementation of the IMSD strategy to demonstrate convincingly the efficacy of the methodology.

Detailed action plans for the above identified watershed in these districts have been prepared, which includes demarcation of sites for the following:

• construction of rain water harvesting structures

• implementation of soil conservation measures

• identification of areas suitable for afforestation, agro-forestry, agro-horticulture and fuel wood as well as fodder development

• evolution of appropriate methods for sand-dune stabilisation

• identification of appropriate locale-specific agricultural practices for maximising food grain output and protection of natural environment

The action plans have been critically evaluated by expert committees for taking up action plan implementation works. The result obtained clearly demonstrate the potential of IMSD strategy for benefiting the people at the grass roots level and improving food and economic security of these people at the grassroots level.

**Land Information System**

An increasingly useful application of GIS is the development of Land Information System, which provides upto date records of land tenure, land values, landuse, ownership details etc. in both textural and graphic formats. In such a system, the land parcel (survey boundary) is the principal unit around which the collection, storage and retrieval of information operate. The information contained in a cadastral system makes it possible to identify the extent and level of development and management of land (assuming the quality of information in the cadastres is adequate) to make effective plans for the future.

With the availability of high-resolution data from state - of - art satellite like IRS-1C and proposed satellites like Cartosat with 2m resolution, the satellite data with integration of cadastral boundaries help in generating information in greater details and facilitate updating of existing records. They also serve as useful inputs in prioritizing implementation of area development plans and effective monitoring.

Concern about the rapid degradation of many renewable natural resources have led to wide range of application of satellite remote sensing and GIS technology. It was realized that satellites, by their repetitive scanning can detect trend of resource status over a period and are particularly well suited to observe dynamic factors that change rapidly such as vegetation, moisture, water, etc. There are some diverse fields in which remote sensing and GIS technology are used for natural resource assessment:  In India, LANDSAT map at 1:1 million scale (MSS false color data) were replaced by IRS-1A data at a scale of 1:250000. Land use/cover Change detection is very essential for better understanding of landscape dynamic during a known period of time having sustainable management.  Soil resource mapping of India was initiated in 1986 using a 3-tier approach comprising image interpretation; field mapping and laboratory analysis and cartography and printing. One hundred seventy six false colour composites (FCC‟s) imagery of LANDSAT MSS and IRS 1B data on 1:250,000 scale were interpreted visually to prepare pre-field physiography cum photomorphic maps considering, geology, terrain, environmental conditions, landscape elements and image characteristics.  For the purpose of consistently and repeatedly monitor forests over larger areas, it is preferable to use remote sensing data and automated image analysis techniques. Several types of remote sensing data, including aerial photography, multi-spectral scanner (MSS), radar (Radio Detection and Ranging), Lidar (Light Detection and Ranging) laser and Videography data have been used by forest agencies to detect, identify, classify, evaluate and measure various forest cover types and their changes.  Earth Observation Satellite (EOS) data has been extensively used to map surface water bodies, monitor their spread and estimate the volume of water. The SWIR band of AWIFS sensor in IRS-P6 was found to be useful in better discrimination of snow and cloud, besides delineating the transition and patch in snow covered areas. Snow-melt runoff forecasts are being made using IRS WiFS/AWiFS and NOAA/AVHRR data. These forecasts enable better planning of water resources by the respective water management boards.  In India, satellite data is widely used to study many aspects of coastal zone. During last thirty years, availability of remote sensing data has ensured synoptic and repetitive coverage for the entire Earth. This information has been extremely useful in generation of spatial information on coastal environment at various scales and with reasonable classification and control accuracy. In India, coastal wetland, land use and landform and shoreline-change maps have been produced on 1:250,000, 1:50,000 and 1:25,000 scale using IRS LISS I, II and III, LANDSAT MSS/TM and SPOT data (Nayak, 2002). IV. REMOTE SENSING AND GISFOR NATURAL RESOURCE MANAGEMENT Natural Resources Management System (NNRMS) is a national level inter-agency system for integrated natural resources in country. NNRMS is established in 1983 and is supported by Planning Commission, Government of India. NNRMS supports the optimal utilization of country's natural resources by providing for a proper and systematic inventory of natural resources available using remote sensing data in conjunction with conventional data/techniques. In doing so, NNRMS adopts various advanced technologies of satellite and aerial remote 155 | P a g e sensing; Geographical Information Systems (GIS); precise Positioning Systems; database and networking infrastructure and advanced ground-based survey techniques. The NNRMS activities have been restructured in the recent times to reflect the changing technological and applications dimensions in the country and elsewhere. Accordingly, a 3-tier strategy is being considered with the following direction:  Organizing the spatial databases with GIS capabilities and working towards a Natural Resources Repository with front-end NNRMS portal for data and value added services  Taking cognizance of the convergent technologies, integrating satellite communications and remote sensing applications for disaster management and Village Resource Centers with the concept of working with the community  User funded projects meeting the objectives/goals of the user departments/agencies both at the national and regional/local scale. Figure: Elements of NNRMS Sour

Forecasting Agricultural output using Space, Agrometeorology and Land based observations (FASAL) FASAL is a countrywide project funded by the Ministry of Agriculture and Cooperation and executed by DOS along with various State Remote Sensing Applications Centres, State Departments of Agriculture and Agricultural

Universities. Crop production forecasting of major crops (kharif rice, rabi rice, wheat, jute, potato, mustard) and at district level (wheat, cotton, mustard, sorghum, sugarcane), in the country has been done for 2009-10. Kharif rice production forecasting for 2009-10 using three-date Synthetic Aperture Radar (SAR) data for state and national level shows that around 14% reduction in acreage and 19% reduction in production, as compared to 2008-09. The reduction is mainly due to lower acreage in the States of Bihar, Jharkhand, Madhya Pradesh, Uttar Pradesh and West Bengal due to insufficient rainfall. 156 | P a g e 4.2 National Agricultural Drought Assessment and Monitoring System Near real time assessment of agricultural drought at district level for 9 states and sub district level for 4 states, in terms of prevalence, severity and persistence, during kharif season (June-Nov) and submission of monthly drought reports to the Ministry of Agriculture and State Departments of Agriculture and Relief of different states has been the main focus of this project. The methodology essentially reflects the integration of satellite derived crop condition/surface wetness with ground collected rainfall and crop area progression to evolve decision rules on the prevalence, intensity and persistence of agricultural drought situation. The drought information is effectively used for contingency planning and for drought declaration process. 4.3 National Wastelands Monitoring At the behest of Department of Land Resources (DoLR) of Ministry of Rural Development, identification and inventorying of wastelands using satellite data on 1:50,000 scale was initiated in 1986 and completed in 2000 and the National wastelands atlas was brought out in the year 2000. The extent of wastelands at that time was 63.85 M ha. Consequent to the request from the Ministry, National Wastelands Updation Project was taken up by NRSC at the behest of Ministry of Rural Development, Govt. of India, during 2002-03 to update the earlier wasteland maps by using one time 2003 satellite data. This was completed in 2005 and the extent of wastelands was 55.64 M ha. In order to assess the impact of various wasteland rehabilitation programmes taken up across the country, National Wasteland Monitoring Project was taken up by DOS at the instance of MRD, using three seasons‟ data (Resourcesat-1 LISS-III) for the year 2005-06. The study has been completed and it reveals that the extent of wastelands in the country is reduced to 46.88 M ha (14.81% of the total geographical area)

## 11. Conclusions

In our country, explosive growth of population and their diverse needs has steadily increased the need for optimum utilization of our land resources. Now the country requires sufficient quantities of food grains to feed its huge population, various raw materials for a sound industrial base and creation of adequate job opportunities for the large majority of unemployed people. The systematically planned and proper way utilization of our land resources can play a major role in solving these problems. Sustainable land management technologies require reliable and repetitive information on the current status and utilization potential of natural resources. Satellite remote sensing data in conjunction with collateral data proved to be very effective in meeting these requirements. Geographic Information system (GIS) served as a very effective tool in the storage, manipulation, analysis, integration and retrieval of information. The synergistic use of these front line technologies helps to evolve a strategy that could be useful in planning for sustainable management of land resources. Data base on Soil types and erosion features, obtained from traditional sources, can be linked to each land cover mapped unit as attributes into a GIS system. This resulted in a comprehensive database, which provides useful information for agriculture, forestry and urban development planning, for environment protection, and for many other applications.

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