REMOTE SENSING AND GIS TECHNIQUES IN INDIA: A SYNERGISTIC APPROACH TOWARDS SUSTAINABLE NATURAL RESOURCES MANAGEMENT

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ABSTRACT

Remote sensing is the science (and to some extent, art) of acquiring information about the Earth's surface without actually being in contact with it. This is done by sensing and recording reflected or emitted energy and processing, analyzing, and applying that information. In other hand, A geographic information system (GIS) captures, stores, analyses, manages, and presents data, which is linked to locations or having spatial distribution. Realizing the importance of space technology in national development programmes, the department of space was established in 1972. The utility of aerospace data for management of natural resource was then demonstrated through R&D efforts and pilots study with the users. Indian Space Research Organization (ISRO), National Remote sensing Centre (NRSA) are important institutions for space research. Satellite Data- IRS P6- LISS III and LISS IV, Resource Sat, CartoSat and other latest data used for site-specific area mapping. Image Processing Software's are ERDAS Imagine, Geomatica& MGE workstation and GIS software's are ARC GIS, Map info, Arc View & ILWIS used for analysis of remote sensing data. Collateral Data used for GIS analysis- topographic map, cadastral map geology map, soil and vegetation map, rainfall map etc. Thus, paper presents an overview of the GIS and remote sensing applications in natural resources management in India and the information were taken from secondary sources.

Keywords: Remote Sensing, GIS, Natural Resource, Management etc.

I. INTRODUCTION

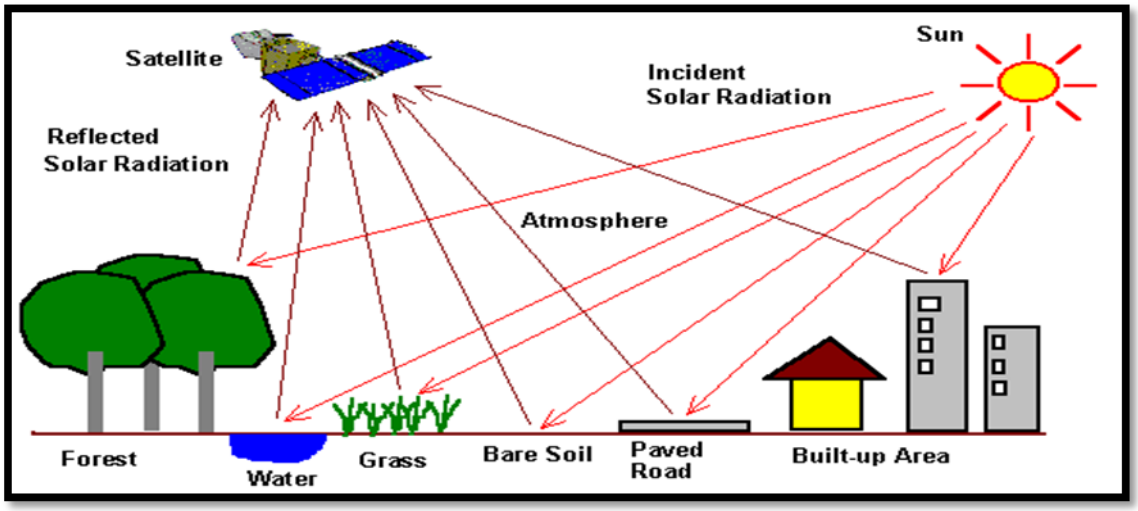
The socio-economic development of any country is based on their natural resources such as land resources and water resources. Due to increase in population, industrialization these resources are over stretched often leading to resource depletion. So, the management of the natural resource is essential for sustainable future. Remote Sensing (RS) and Geographical Information System(GIS) techniques can be applied effective measure to generate data and information regarding this type of management.Conventional ground methods for natural resource management are time consuming and require large manpower and therefore are done infrequently. The maps soon old with lime. In such cases remote sensingand GIS technique has proved to be a great value. Remote sensing has vast application since each band of data collected contains important and some unique information.

Remote sensing can be used for monitoring crop types, for detecting disease, for production forecast, for mapping forest. In weather analysis and forecasting, ice and snow monitoring, assessment of damage cause by flood by earthquakes. On the base of remote sensing data GIS construct the model for analyzing trends, identify factors that are causing them, reveal alternative paths to solving the given problems and indicate the implication or consequences of decisions. So, the science of remote sensing and GIS has become a critical and universal tool for natural resource managers and researchers in government agencies, conservation organizations, and industry.

II. CONCEPTAL DISCOURSE

Remote Sensing, in the simplest word, means acquiring information about an object without touching the object itself. When we are looking throughthe window we are gathering information about the objects located far away. Regarding this case our eyes act as sensing device and landscape features are the target objects being sensed. Of our five senses (sight, hearing, smell, taste and touch), the first three may be considered from of remote sensors, where the source of information is at some distance.Thus, the technically remote sensing defined as *"The technique of acquiring about an object by a recording device (sensor) that is not in physical contact with the object by measuring portion of reflected or emitted electromagnetic radiation from the earth surface."*

Figure: The Remote Sensing Process



Source: http://www.crisp.nus.edu.sg/~research/tutorial/intro.htm

According to The United Sate Geological Survey, *"A GIS is a computer hardware and software system designed to collect, manage, analyze and display geographically (spatially) referenced data."* A GIS is basically a computerized information system like any other database, but with an important difference: *all information in GIS must be linked to a geographic (spatial)reference* (latitude/longitude, or other spatial coordinates).

Natural resources occur naturally within environments that exist relatively undisturbed by humanity, in a natural form. Natural resource management is the taking care of natural resources such as land, water, marine and biological systems, with a particular focus on how the management affects the quality of life for both present and future generations. It's about the long-term implications of actions - thinking about the future and not just about now.

III. REMOTE SENSING AND GIS FOR NATURAL RESOURCE ASSESSMENT

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

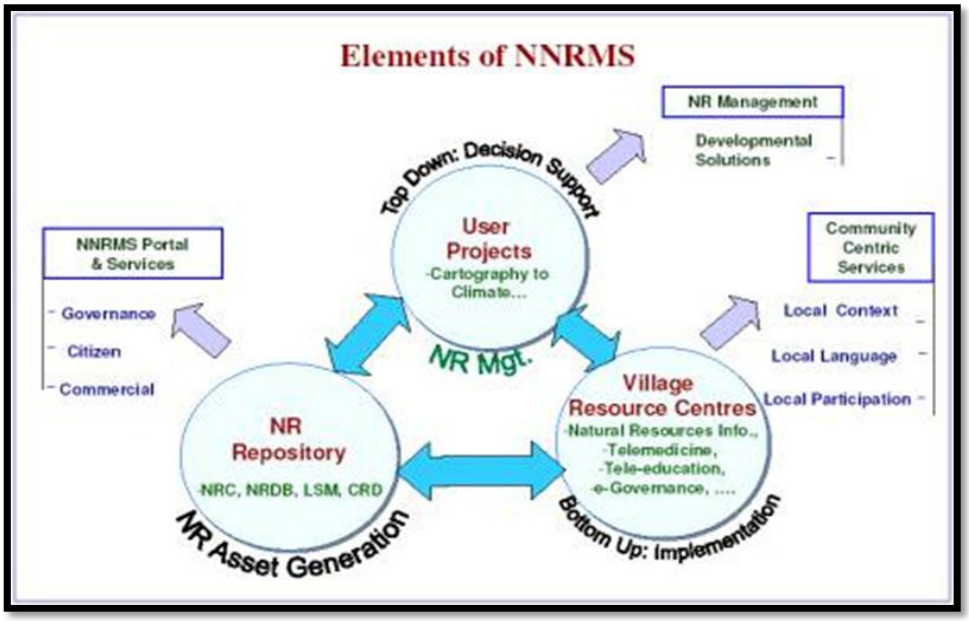
Natural Resources Management System (NNRMS) is a national level inter-agency system for integrated natural resources in country. NNRMS is established in 1983 and is supported by Planning Commission, Government of India. NNRMS supports the optimal utilization of country's natural resources by providing 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

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



Source: http://www.nnrms.gov.in/index.htm

4.1 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.

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).

4.4 Water Resources Information System

A major project on "Web Enabled Water Resources Information System in the country" (India-WRIS) incollaboration with CWC, New Delhi has been launched. India-WRIS will provide a comprehensive,credible, and contextual view of India's water resources data along with allied natural resources dataand information. India-WRIS will allow users to search, access, visualize, understand, analyze, Look intocontext and study spatial patterns. It is a 'Single Window' solution of all water resources and relateddata in a standardized GIS format in a national framework for Water resource assessment andmonitoring. The database will have more than 30 spatial layers grouped under 5 major heads havinglarge attribute data (about 179 sub components) collected for a period of 5 to 50 years.WRIS will use satellite images consisting of Cartosat-1, LISS III, LISSIV and, SRTM (900m and 90m) will beused. The proposed spatial layers are: Basin maps, river network, Digital Elevation Map, International,State, District, Tehsil boundaries, village boundaries, Town / villages location and extent,Infrastructure layers, Major tourist stations on river banks, water sanctuaries, waterfalls, etc., Locationof major & medium irrigation projects, location of hydroelectric projects, location of multi-purposewater resources projects, major and medium irrigation project command boundaries, water logging andsalt affected areas in major and medium irrigation projects, soil samples for major and mediumirrigation projects, canal network, surface water bodies, ground water observation wells data analysis,lithology data aquifer parameters, landuse/land cover, land degradation, wasteland maps, snow coverarea, flood inundation maps, drought prone area maps, inland navigation waterways, inter-basintransfer links(as per NWDA), hydro metrological sites of CWC, meteorological station (IMD & CWC),climate related layers and pollution monitoring system. Project

website has been launched onDecember 10, 2009 and the version 1.0 of Information system is ready for web hosting.

4.5 Groundwater Prospects Mapping

The occurrence and movement of groundwater is mainly controlled by many factors such as lithology,geomorphology, geological structures and hydrology. Satellite remote sensing derived maps providepotential information about these parameters for scientific source finding of groundwater. Under RajivGandhi National Drinking Water Mission, funded by the Department of Drinking Water Supply of theMinistry of Rural Development, ground water prospects and recharge zone maps on 1:50,000 scale andgeneration of digital data base pertaining to ground water prospecting was taken up in phases using IRSdata. So far, 14 states (Andhra Pradesh (Part), Madhya Pradesh, Rajasthan, Karnataka, Kerala,Chattisgarh, Gujarat, Orissa, Himachal Pradesh, Jharkhand, Assam, Punjab, Uttarakhand and UttarPradesh (Part) have been completed and the maps have been provided to State Ground Waterdepartments and other concerned departments. The maps have been used for locating well sites andrecharge structures. The feedback shows that 275,800 wells have been drilled and 9057 rechargestructures have been constructed. The work is under progress in the states of Jammu & Kashmir,Maharashtra, Uttar Pradesh-Part, West Bengal-Part, Haryana and Arunachal Pradesh.

4.6 Coastal Zone Studies

Inventory and Monitoring the Coastal Zone; Coastal Ecosystems (Vital/Critical Habitats); Coastal Zone Information System Coastal Zone Management, and Impact of sea level rise on the coastal environment are some of the application areas under coastal zone studies.

Models to study the impact of Sea Level Rise on coastal environment – Approach has been developed to assess coastal vulnerability due to sea level rise for AP, TN, Kerala and Gujarat coasts. Regional response zonation of the coast has been carried out.

- ✓ Satellite data has been interpreted using digital techniques to prepare coastal landuse, mangrove maps at dominant community level, coral reefs maps at eco geomorphological level, coastal landform maps on 1:25,000 scale.
- ✓ Ecological Status of Marine Protected Areas has been brought out by comparing maps prepared for the period 1989-91 and 2004-06.
- ✓ Models have been developed to study coastal landuse changes and their impact and methodology for cadastral mapping has been developed.
- ✓ Models for assessing health of mangroves as well coral reefs have been developed.
- ✓ A data base has been created in GIS for the coastal thematic maps and Coastal Zone Information System (CZIS) for entire Indian coast.
- ✓ Query shells were developed and a Coastal Zone Information System (CZIS) for entire Indian coast has been developed.

Models have been developed for preparing integrated coastal zone management plans and identifying suitable sites for mangrove plantation. An approach has been developed to map risk levels of different segments of Andhra Pradesh, Tamil Nadu, Gujarat and Kerala coasts based on Coastal Vulnerability Index (CVI).

Towards this, physical variables namely (1) coastal geomorphology, (2) coastal slope, (3) shoreline changes (4) mean tidal range, and (5) Significant wave heights which largely determine the nature of the coast and its dynamics, were analyzed. Regional response zonation of the coast has been carried out.

4.7 Natural Resources Census

The Natural Resources Census (NRC) project aims at generation of a set of thematic maps through systematic inventory & mapping using Resourcesat data and creation of GIS database of the same for the whole country. The project uses IRS images (55m, 23m & 5.8m) to prepare natural resources information layers viz., land use/land cover, soil, land degradation, wetlands, vegetation, snow & glaciers, geomorphology at 1:50,000 scale and land use/land cover at 1:250,000 scale, periodically for monitoring of natural resources.

Under NRC rapid National level landuse/ landcover mapping on 1:250,000 scale using multi-temporal IRS AWiFS data using digital techniques has been completed successfully consequently for the fifth year (2008-2009) and accordingly the land use/land cover map of the country and interim report has been generated. The net sown area (NSA) during 2008-09 was found to be 139.72 mha comprising 43% of the total geographical area. The statistics are compared with 2006-07. It is found that NSA is marginally reduced from 140.24 mha to 139.72 mha with considerable increase in states like Andhra Pradesh, Gujarat, Madhya Pradesh and Uttar Pradesh. Land use/ land cover (LU/LC) mapping at 1:250,000 scale using IRS AWiFS data for the 5th cycle (2008-09) has been taken up and the Kharif area assessment has been completed. The integrated land use status for the 5th cycle will be ready by December 2009.

The 1st cycle of the nation-wide land use/ land cover mapping at 1:50,000 scale using IRS data has been completed for the country (except for Jammu & Kashmir). Spatial database organization and generation of seamless database for entire country is in progress. Land degradation mapping at national level on 1:50,000 scale using IRS data has been completed for 70% of the geographical area of the country.

Nationwide geomorphological and lineament mapping has been initiated on 1:50,000 scale using LISS-III data jointly with GSI. A genetic based classification system will be adopted with around 360 landformsunits classified under 8 genetic classes. The project is planned to be executed in 3 year time frame.

V. CHALLENGES AND KEY ISSUES

Remote sensing and GIS are integrated system of information gathering and analysis of alternative method for natural resource management. The recent development in the field of remote sensing and GIS based site specific management is due to the successful launching of a series of remote sensing satellites equipped with advanced sensors. The use of Remote Sensing and Geographic Information System (GIS) gave scope for immense opportunities in the field of large-scale mapping, updating of existing geographical maps, project planning, decision-making and natural resource management.There are some limitations as well as challenges for utilization of these types of technology; such as:

- ✓ Since most remote sensing projects require some amount of field work, there should be significant benefits to a systematic approach to planning the field portion of the project. Certainly, the final product will be more reliable and defensible if the field work and the use of reference materials are planned and executed properly. Even weaknesses in the final results can be stated openly if the unavoidable deficiencies in field

work and reference materials are known and explained. There is a tendency among researchers to avoid mentioning weaknesses in their methods, even when those shortcomings are beyond their control. Eventually someone, perhaps in a thesis defence, will ask about field methods or ancillary materials used, and any shortcomings will come to light. It is best to avoid this embarrassment by recognizing and dealing with these details in advance.

- ✓ Remote sensing is based on measurements of surface physical properties such as reflectance, temperature, or SAR backscatter, not on an uncalibrated, uncorrected digital number (DN). So without special knowledge it is difficult to correction of these types of error.
- ✓ For use in a GIS, the images must subsequently be registered to map coordinates. So here also certain limitations like RS techniques.
- ✓ Data entered by multiple geologists may contain more inconsistencies than data entered by one person, making the database more difficult to query.
- ✓ Written descriptions convey to the reader detailed information through imagery that may not be communicated by the same data in parsed format.
- ✓ Geologists may be inclined to shorten text descriptions because they are difficult to enter (either by handwriting or voice recognition), resulting in loss of data.
- ✓ There are no original, hardcopy field maps or notes to archive. Paper is a more stable medium than digital format.

VI. CONCLUSION

Space technology has immense influence in the decision making process in almost all social spheres. It encompasses information generation on natural resource viz., land use, agriculture, climate, urban systems for better management of resources and in protecting ourselves from the impact of natural calamities like flood, cyclone, drought, forest fire and landslide etc. by being informed about the probability of occurrence and preparing contingency to face it. Natural resource management is dependent on the availability and quality of the geo-information on every sphere of human activity and its interaction with the environment. The recent advances in information technology and earth observation have facilitated unprecedented growth and need of spatial information in various facets of our life. National Remote Sensing Centre (NRSC) is carrying out various nationwide application projects so that the end use of remote sensing and Geo-information technology reaches common man at the grass root level. Capacity building through training creates skilled professionals in specific area of applications to bridge the demand and requirement of trained manpower in India. So, the integrated use Remote Sensing and GIS Application Area (RS&GIS AA) plays a vital role for natural resource management towards achieving the national goal of food, water, energy and environmental securities.

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