6.1

MONITORING OF THE DIARA LANDS OF EASTERN INDIA WITH RESPECT TO VEGETATION, WASTELAND, SOIL EROSION AND INUNDATION THROUGH REMOTE SENSING TECHNIQUES

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INTRODUCTION

The term "Diara" has been derived from the word ‘Diya’ meaning earthen lamp. Keeping in conformity with the shape of the ‘Diya’, the bowl like systems on the surface (depressions) situated between the natural levees on either side of the river appear like small ‘Diyas’ when rain water gets accumulated in them during the rainy session. The lands braided by two rivers are called ‘Doabs’ which are technically known as ‘channel bars’. These pieces of lands also contribute partially or fully towards the diara lands. Although the diara lands of eastern India, namely Brahmaputra Diaras, Ganga Diaras, Saryu Diaras and Mahanadi Diaras have some commonalities among them, they are typical of themselves in respect of their physiography, soils, climate and socio-economic and cultural background, and hence their problems need to be tackled individually instead of collectively. Diara lands of eastern India remain inundated during the monsoon session, ranging between 3 to 4 months, thereby drastically reducing the crop-growing season. Diara lands are extensively found in Uttar Pradesh, Bihar, Assam and Orissa. In Uttar Pradesh and Bihar the diara lands have been estimated on the basis of 3 km of diara land width for every kilometre length of the river in the plains of various river systems. Accordingly, Uttar Pradesh has flood-prone diara lands of 1.5 million hectares in various river systems, namely Ganga, Yamuna, Ghaghra, Saryu, Sharda, Ramganga, Kalindi and Gomti. In the state of Bihar, the area under diara lands has been reported to be 0.9 million hectares. It is speculated that the extent of diara lands area in Assam alone may exceed 2.3 million hectares as about 30% of the geographical area of the state is flood prone. For Orissa, the exact extent of diara lands was not available. However, 1.0 million hectares may be a moderately good estimate. The flood-prone areas are located mainly in the Mahanadi delta. Diara lands are, in general, associated with two natural calamities, viz. flood and drought. During rainy season, flood waters inundate the diara lands for varying periods in different locations depending on their climatic conditions and physiography. Drainage congestion in diara lands aggravates the problems in increasing the duration of inundation and thereby reducing the length of growing periods of crops. Transportation network in diara lands has been found usually poor. Even whatever approach roads are available get badly disrupted due to inundation.

OBJECTIVES

- To characterize the diara lands of eastern India with respect to their physiography, hydrogeomorphology, soil, vegetation (both natural and cultivated), climate and agro- climatic zones, and
- To map the current land use that may be improved to raise the economy of the diara inhabitants.

STUDY AREA

The state of Uttar Pradesh, Bihar, Assam and Orissa

METHODOLOGY

Diara lands have been classified differently on the basis of some themes. Considering the distance of the diara lands from the main stream, these can be classified as lower diara lands, middle diara lands and upper diara lands. Lower diara lands are those lands which are located in the main river beds that have fine sand to courses and deposits on the surface and are available for cultivation of different crops and vegetables during non-monsoon seasons (November/December to May/June). Middle diara lands are those lands which are located on the banks of the rivers. The width of such lands varies considerably as the areas are frequently inundated during rainy seasons by swelling flood waters. The depth of flooding however varies considerably at different locations.

Upper diara lands are those lands which, during the course of continuous depositions get elevated and are less frequently flooded, in comparison to the middle diara lands. The characteristics of these areas are not very different from normal non-diara lands. The members of the National Productivity Council (NPC) had also classified char lands into 4 types of following categories according to the land suitability for crops/vegetation:

- Sandy- Silty-Clayee: These soils are of good quality for cropping.
- Sandy-Silty: These soils are of medium quality for cropping
- Areas with Wild Grass (kahua), and
- Completely Sandy and Waterlogged Areas: Not suitable for crops.

RESULTS/ OUTPUTS

It was found that a considerable part of the diara lands of eastern India had become drainage congested and hence water stagnation continued even after the recession of floods. A large number of palaeo-channels identified from satellite imageries confirmed that sedimentation of the natural drainage lines, in course of time, had caused drainage congestion in diara lands. Moreover, landfills for construction and other developmental works had also contributed substantially towards the drainage congestion of diara lands. Diara soils are subjected to drought conditions after the recession of floods due to their high hydraulic conductivity and internal drainage. It was, therefore, realized that there was an urgent need for the development of infrastructure to provide irrigation to crops through tube-wells and lift irrigation systems to have sustainable crop production in the diara lands.

The figures of cropping intensities of the diara lands of eastern India, computed from satellite imageries, showed that there was sufficient room for improvement in this field. It was, therefore realized that this could be achieved by educating and encouraging the diara farmers, through participatory training on adoption and management of economically viable agricultural production systems that might also include fishery, dairy, poultry, goat and sheep-rearing, piggery, etc. The creation and dissolution of diara lands due to cutting and deposition processes were observed to be the primary cause of drifting of river channels in the diara lands. In fact, shifting the river course was one of the major concerns of the diara people, because it brings uncertainty in their life and living. The creation and dissolution of the diara lands did not allow permanent land tenure system to be followed effectively.

Flood plains of the eastern India in general and of the diara lands in particular, hold the key to our national food security. It was, therefore, found imperative that data must be collected and compiled on all the existing knowledge base about the flood plain agriculture with reference to its social and environmental dimensions. It is through the analysis of such knowledge-base that methodologies for management of floods and flood plain agriculture including those of the diara lands can be formulated. Economic condition of the diara land inhabitants, in general, was found poor, coupled with poverty. These people face increasing uncertainty from the apparently increasing flood magnitude; weak land tenure and social violence, leading to uncertainty of harvest.

6.2

A RAPID ASSESSMENT OF BIO-DIVERSITY USING REMOTE SENSING/GEOGRAPHIC INFORMATION SYSTEM TECHNIQUES IN MEHAO WILDLIFE SANCTUARY (MISHMI HILLS) ARUNACHAL PRADESH

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INTRODUCTION

The major global environmental concern for the 1990s and beyond is the problem of conserving what is left of the 30 million odd species. The unbridled expansion of one species, *Homo sapiens* on the earth has posed such a monumental problem that the scale and magnitude of needed preventive and palliative action has no parallels in the three billion evolutionary histories, with the exception of cataclysmic events of the geological past. The problem of affording protection to the remaining biota is accentuated manifold due to our singular ignorance on the organisms. We are, as yet, not certain of the number of species existing on the earth. The study of bio-diversity, thus, would mean documenting composition, structure, function, understanding the role and function of genes, species and eco-systems in both man modified and near natural state and suing this understanding to support sustainable development .

India is amongst the top 10 mega diversity nations of the world and two of the eighteen world's 'hotspots' of diversity, located in the Western Ghats and East Himalayas. The latter are currently facing a threat that Western Ghats experienced till mid-1980s. The threats relate to deforestation, degradation and loss of bio-diversity. The East Himalayas, with our highly inadequate understanding on the extent of biodiversity is presumed to harbor 3,500 endemic higher plants, 20 endemic species of reptiles and 25 endemic amphibians. Notwithstanding these impressive statistics, our knowledge on the composition of biota is so meager that it may be safely assumed that several hundred manyears are required to merely conduct an inventory, and not to speak of the study of natural history and ecology. While these studies are indispensable and are required for evolving comprehensive management planning, there is also a pressing need to evolve a Rapid Bio-diversity Assessment (RBA) methodology.

OBJECTIVES

- To investigate the feasibility of application of remote sensing and Geographic Information System (GIS) techniques to assess the adequacy of protected area (PA) sizes,
- To identify hotspots of bio-diversity, and
- To disseminate the above information to as wide an audience as possible.

STUDY AREA

Mehao Wildlife Sanctuary, Arunachal Pradesh.

METHODOLOGY

An intensive quantitative field data on plant and bird taxa was obtained by sampling at altitudinal gradients of 200 m elevation. The altitude of the sampling stations in Mehao ranged from a low of 400 m to a high of 2,600 m. The sampling was done based on a preliminary visual interpretation of 1:50,000 scale geo-coded IRS-1B False Colour Composites (FCCs). As the number of vegetation classes was found to be 3, sample strata were designed as: (i) low (altitudes of <1,000 m), (ii) mid (altitudes of 1,000 to 2,000 m), and (iii) high (altitudes of > 2,000 m). The study made extensive use of modern spatial technologies like remote sensing and Geographic Information System (GIS). A total of 41 plots of 0.1 ha were sampled for vegetation and 48 plots of 1 ha for avian diversity. In all, 29 tree species in 45 families were sampled. In contrast, 134 avian species were recorded. The sampled tree and avian diversity was around 50% of the recorded checklists of species

A habitat categorization was done using LANDSAT TM digital data in bands 2, 3, 4 and 5. Standard enhancement, band combinations, Principal Component Analysis (PCA) and image ratioing were carried out. These operations enabled a better discrimination of habitat categories. Supervised and unsupervised classifications were done to obtain a total of 18 categories. These included shadows, vegetation types and various land-use categories. A high fidelity Digital Terrain Model (DTM) was developed for terrain analysis. The variables of slope and aspect along with elevation forming 3 important physical variables of interest predicted hotspots of plant diversity, vegetation succession, pheasant and endangered mammal habitat. GIS overlay analysis was extensively used in predicting these 4 thematic features of relevance to bio-diversity assessment and monitoring.

RESULTS/OUTPUTS

The observed field patterns on species diversity indicated high levels of species diversity at the altitude of 1,600-1,800 m and low levels at altitudes of 400-800 m and 2,200-2,600 m. The observed avian diversity broadly matched with that of tree species diversity. There were no clear zonations in the distribution of species or species communities, except in the low altitude broad-leaved forests and high altitude conifers. The avian diversity was found to be at its peak at 1,600-1,800 m altitude. However, altitudes below 1,000 m harboured higher number of feeding guilds.

For the first time, use of ecological pattern analysis at landscape level was conducted on the classified digital images to gain an understanding on bio-diversity issues of Mehao, in particular and East Himalayas, in general. The issues studied were related to the patterns in richness, dominance, diversity, fragmentation and related indices across the altitudinal gradient. The other issues addressed also included whether these indices supported the patterns observed in field sampling and whether these indices served as surrogate measures to the field measures. It was concluded that these indices have an important role to play in the assessment and monitoring of biodiversity.

A relatively new class and less-used statistical tools that deal with spatial phenomena and regionalized variables, viz. the geo-statistical techniques were employed to decipher quantitative patterns observed in the landscape analyses. Variogram was constructed for the observed diversity patterns at low, mid and high altitudes. It has been suggested that the results of variogram analyses be incorporated into new and as yet little developed and implemented methods of image classification for biodiversity-related issues.

In order to monitor the changes in diversity, a simple but powerful index called Q Index which has been developed very recently, was employed. It was found that Q Index tracked the species richness much better than the Shannon Wiener Index H. It was therefore suggested that the new Q index be incorporated into the suite of ecological pattern analysis of classified digital images. Finally, application of remote sensing and GIS in mapping, assessment and monitoring of biodiversity in Arunachal Pradesh was found quite useful.

6.3

MONITORING AND IDENTIFICATION OF SHIFTING CULTIVATION AREAS OF EAST KHASI HILL OF MEGHALAYA BY USING REMOTELY SENSED DATA

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INTRODUCTION

In the North-East India, particularly in Meghalaya, the practice of shifting cultivation is predominant as out of the total geographical area of 22,429 sq. km, an area of 760 sq. km is under shifting cultivation and about 3,44,000 people depend on it. Due to increasing population pressure, the jhum cycle has been reduced to 4-5 years, which has adversely affected the process of soil fertility replenishment through natural regeneration. This is also leading to natural forest degradation and reduction in the number of crops. Finally, if this process continues, a stare of desertification may be reached and land may not remain fit for cultivation at all. The extent of damage caused through such practices in terms of the loss of natural vegetation and environment degradation cannot be analyzed through purely conventional techniques. Therefore, modern tools and techniques like remote sensing technique provide recent and accurate information pertaining to forest loss and give an opportunity to provide scope for rational land-use planning and management.

OBJECTIVES

- Characterization of various types of land-use/land-cover patterns in the study areas using remote sensing data,
- Identification and monitoring the shifting cultivations areas in Meghalaya,
- Studying the shifting cultivation over time for detecting change and its subsequent monitoring, and
- Studying the cropping pattern in the shifting cultivation areas.

STUDY AREA

Meghalaya

METHODOLOGY

IRS I-B LISS-II False Colour Composite (FCC) print product generated from bands 2, 3 and 4 of December 1994 on 1:50,000 scales were used to prepare the land-use/land-cover maps and shifting cultivation area maps. Survey of India (SOI) topographical maps on 1:50,000 scale were used for the preparation of base map. Ancillary data collection on socio-economic aspects was undertaken.

Intergraph (U.S.A) MGE-PC GIS software was applied that run integrally with Micro station PC and Oracle-6, thus was used to analyze data and generate computerized digital cartographic maps.

Land-use/land-cover maps were prepared through visual interpretation of the satellite data. Thematic maps including those of shifting cultivation, land-use/land-cover maps and other information were integrated using modular GIS environment PC- based software.

RESULTS/OUTPUTS

Analysis of the remote sensing data show that in the Garo Hills during the year 1994-95, out of the total area, 328.69 sq. km area was under shifting cultivation while 1655.11 sq. km was under forest cover. It was also ascertained from the land-use/land-cover map which was prepared using satellite data. The area under shifting cultivation in the hill ranges was predominantly found along the rivers Simsang in West Garo Hill district. The major portions of the hill slope have been brought under rice cultivation along with other crops like plantation, yam, cucurbit, sesame, etc.

Some parts of the Western Garo Hill, especially in the scene area, covering sheet number 78/K/1 and 78/K/7 showed a big contrast. The forest cover was intake and grass and bush covers were not found which indicated that shifting cultivation practice degraded vast areas of forest cover. In this way, a positive relationship between agriculture practice and forest degradation was observed.

6.4

SATELLITE DATA AND GEOGRAPHICAL INFORMATION SYSTEM FOR INVESTIGATION AND MONITORING OF DESERTIFICATION

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INTRODUCTION

Due to alarming increase in desertification hazard, the International Convention to Combat Desertification (CCD) in 1994 defined desertification as "land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors, including climate variations and human activities". In this context the desertification is treated as one of the land-based degradation process, which affects the global environment. This International Convention also recommended creating a monitoring system to control desertification. Assessment and mapping of desertification hazard-prone areas was the primary step in monitoring, which was attempted in the present study. Desertification causes loss of primary productivity of land, which appears as one of the important environmental constraints for sustainable development. The monitoring of desertification at an interval of 5-10 years is thought essential for a nation like India to find causes and consequences of this process towards degradation of water and biomass. It would control the spread of an incurable disease, i.e. irreversible loss of land quality in dryland zones. In 1997, a team of UNEP had attempted to incorporate remote sensing technique for the estimation of NDVI to improve world map monitoring of the desertification. Similarly, several institutions/ organizations have attempted to develop and improve the monitoring technique.

The present study has been carried out over 27, 275 sq. km area in the semi-arid regions of Aurangabad, Jalana and Parbhani districts of Maharashtra. The water shortage in the network indicates water degradation over such dryland. The tendency of agro activity gives the signature of the stress on this susceptible dryland. Since it is essential to monitor the desertification in this area regularly, it was thought significant to select this area for a research study, particularly to analyze the satellite data over desertification and to use geographic information system (GIS) for decision-making of different degrees of intensity of desertification and monitoring aspects.

OBJECTIVES

- To analyze satellite data on desertification,
- To analyze man's contribution to desertification, and
- To analyze statistical data and develop meteorological indices using Geographic Information System (GIS) for decision-making of different degrees of intensity of desertification and monitoring aspects.

STUDY AREA

Semi-arid regions of Aurangabad, Jalana and part of Parbhani districts of Maharashtra bounded by 18°58′ and 20°41′ North latitudes and 7°435′ East and 77°27′ East longitudes.

METHODOLOGY

The remote sensing data was used in an optimal way keeping the coverage of area in view and the time span was selected as per the availability of the data. In this study, the overall duration was 1980-1997. The total span was divided into two equal time zones, viz. the first half of the total available time period was treated as phase-1, while the second half as phase-2.

The initial condition of the each index was averaged for its first half data. Similarly, the latest condition was averaged for the second half data. Then the phase-1 and phase-2 were represented by the years 1989 and 1998, respectively for convenience. The increasing or decreasing tendency of each parameter was evaluated and indexed to assess the intensity of desertification.

The assessment of desertification was done by analyzing the variations in related parameters over the time span selected for the study. The individual parameters were evaluated using several techniques and the parameters were integrated using knowledge-based modelling.

RESULTS/OUTPUTS

The influential drought parameters were identified and indexed to quantify its severity. These parameters were based on: (i) precipitation, (ii) river discharge, (iii) soil moisture stress and vegetation covers, and (iv) human population. These were representatives of meteorological, hydrological, agricultural and socio-economic droughts, respectively. As described in the methodology above, the total selected study period was divided into two equal time zones and using this methodology a drought watch table was prepared which represent integrated drought intensity over the area.

The soil instability index was a parameter which represented the probability of soil degradation due to both wind and water erosions. In semi-arid climatic zone, the barren soil when gets eroded, the brightness values in visible band get increase. The soil instability was a terrain feature, indicating erosion or depositional characteristics which were evaluated using Principal Component Analysis (PCA). The first 3 principal components (PCs) gathered more information about the terrain features from a multi-channel and multi-temporal images of same area. The principal components 1, 2, 3 were computed using bands 1, 2, 3 & 4 of the two temporal scene data. The principal component 1 was a measure of brightness which was a weighted sum of all bands and principal component 2 represented the contrast between visible and near infra red (NIR) bands. The first three principal components were scaled into 0-255 digital ranges. The composite map was clustered into 6 soil classes to assess the intensity of soil instability. The features of this thematic layer were comparable with the soil erosion layer developed by the National Bureau of Soil Survey and Land Use Planning (NBSS&LUP).

The evaluated parameters were indexed into five categories. The indices were: Primary Indicator of Land Degradation (PILD), Index of Soil Erosion (ISE), Drought Recurrence Intensity (DRI), Population Pressure Index (PPI), Index of Ground Water Depletion (IGWD) and Bio-Physical Degeneration of Land (BPDL) through Indicator of Vegetation Index (INDVI), albedo (IALB) and Soil Instability (SI).

The approach was to bring all data on one platform and the generated maps or images and procured maps, derived from different resources with different scales were geo-transformed and geo-registered using RS-GIS interactive packages as EASI/PACE and in-house developed GRAM++.

The generated map-layers included (i) Land-use/land-cover, albedo, NDVI and soil instability using satellite image processing technique;(ii) Precipitation and groundwater levels in micro-watersheds using concept of homogeneity in polygon through GIS, soil erosion class by reusing the output map and attributes developed by NBSS & LUP; and (iii) Administrative boundary based human population pressure in the study area. Several attributed data were indexed in 5 categories depending on their intensity, viz. micro-watershed based groundwater table depth, tehsil-based population pressure, and micro-watershed based drought, and soil class-based soil erosion. The thematic maps from the attributed data were delineated. A knowledge-based model was also developed for integration of degradation processes and hence for zonation of desertification hazard. This was in fact the major achievement in this research work.

It was a 8-layer spatial model which was based on prioritization of the thematic layers of the land degrading parameters. The prioritization was arrived at by considering the logical significance of each parameter of a particular land unit, in the process of desertification. Hence, the justification of prioritization was the most important aspect of the model.

The model was built giving first priority to Primary Indicator of Land Degradation (PILD), as land degradation could be directly assessed from temporal change in land use in the rangeland (100% weightage). All other land degrading parameters were given second priority. The ISE, IGWD and PPI were considered as primary parameters under second priority as soil erosion, groundwater depletion and population pressure were primary reasons of land degradation through both climate vulnerability and manmade activity. IALB, INDVI and ISI were considered as secondary parameters under second priority as increase in albedo, degeneration in vegetation and probable instability of land surface were the bio-physical indicators of land degradation. The occurrence intensity of drought was the tertiary factor under second priority for land degradation as drought was a climatic factor, which accelerated land degradation. By considering all these factors logically, the model finally classifie the terrain giving severity zonation of desertification hazard.

6.5

EVALUATION OF NATURAL RESOURCES AND ENVIRONMENT OF KOLLI HILLS, TAMIL NADU USING REMOTE SENSING AND GEOGRAPHIC INFORMATION SYSTEM

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INTRODUCTION

In developing countries like India, dependence of people on forests is inevitable. Therefore, the pressure on the forest by the ever-increasing population is logarithmic. As a result, there is loss of forest cover at an alarming rate. Though it is widely believed that the natural vegetation in the tropical regions is experiencing losses of biodiversity at unprecedented rates, the exact and authentic information about the rate of habitat loss is lacking.

For effective planning, management and sustainable utilization of forest resources, the needed information includes: (i) present forest cover status; (ii) the changes it has undergone at a specific time period, preferably the latest; and (iii) the forest area that is likely to be affected in near future. Remote sensing technology can play a vital role in providing accurate and reliable landscape details with lower cost and lesser time compared to other methods. Use of GIS in decision-making and that too in environmental problems is well established. Use of remote sensing and GIS for resource mapping, spatial analysis and decision-making has been widely reported by many researchers.

The Eastern Ghats of India are a broken chain of hills that extends from Orissa to Tamil Nadu. Because of such a topography, the hilly terrain and surrounding plains are densely populated and accessibility to the forests is rather easy. The forests in the Eastern Ghats are the most affected, compared to the Western Ghats and Himalayas, as they are experiencing heavy pressure on all sides. Though several studies have been carried out in the Western Ghats and Himalayas with respect to forest cover status and change detection, however no detailed report is available about the Eastern Ghats on these aspects. Since the Eastern Ghats are well known due to their species richness, though in a highly degraded stage, and cannot be ignored. The present study pertains to the evaluation of natural resources and environment including these regions.

OBJECTIVES

- To take stock of the resources, analyze their status, potential and preparing an area-specific treatment package for sustainable utilization, conservation and development,
- To map the forest cover on 1: 50,000 scale,
- To estimate changes in the forest area that occurred between 1990 and 1999, and
- To identify forest regions which are prone to degradation in the near future.

STUDY AREA

Kolli hills of Tamil Nadu that lie between 11°10´54" to 11°30´ North latitude and 78°15' to 78°30' East longitude and are situated in the Namakkal district of Tamil Nadu, above the river Cauvery, covering an area of about 503 sq. km.

Physiographically, it is a hilly region with altitude ranging from 180 m at the foothill to 1,415 m at the plateau. The slope of this region varies from gentle to very steep. The annual mean rainfall is 1,318 mm. Kolli hills receive maximum rainfall in southwest monsoon (719 mm). The mean maximum and mean minimum temperatures are 37˚ C and 18˚ C, respectively.

METHODOLOGY

Primary and secondary data collected on various resources from field and various government agencies and departments were utilized to generate spatial and non-spatial database. Resource status, potential and changes through time were analyzed with prepared database. Changes occurred in land-use/land-cover and in forest area were also analyzed. In the present study, Landsat TM digital data of 23rd April 1990 of path: 143 row 52 and IRS 1C LISS-III digital data of 26th February 1999 of path: 101 and row were used. Survey of India Toposheet No. 58 me /7 and 8, and secondary data such as working plan of Salem forest division were also used.

The 1990 TM digital data was corrected geometrically taking several ground-control points from Survey of India (SOI) toposheets. The two scenes of IRS 1C LISS III were corrected geometrically taking the corrected Landsat TM image as the reference and mosaiced. From the toposheets, the reserve forest boundaries were traced and digitized using Altek A-0 digitizer in ARC EDIT module of ARC/INFO software. The reserve forest areas were taken as subset from the full image using the reserve forest boundary in order to avoid misclassification. False colour composite (FCC) was generated with the following band combinations: 3, 2, 1 and 4, 3, 2 in RGB in LISS III and TM, respectively.

Forest cover map of 1999 of the study area was prepared by on-screen visual interpretation method using ERDAS IMAGINE 8.3.1 software. The forest cover information was transferred to base map printed on 1: 50,000 scale and verified by ground truthing. Necessary corrections were made in the forest cover map of 1999 and a final cover map was also generated. Accuracy assessment was undertaken following Congalton by estimating commission and omission errors. About 160 randomly distributed checkpoints were studied. The number of checkpoints for each cover class was proportionate to the area.

RESULTS/OUTPUTS

It was found that Forests in Kolli Hills occupied comparatively more area (271 sq. km) than the non-forest area (232 sq. km). Evergreen, semi-evergreen, deciduous, thorn and scrub were the major forest types present. Major portion of the forest area was occupied by the thorn and scrub forests (203 sq. km). In the non-forest area, maximum was under wasteland (50%). Single crop and double crop cultivation was practised. Tapioca was the major cash crop and there was no industry in Kolli Hills. Total population of Kolli Hills according to 1991 Census was 33,888 and among them 95% belonged to tribal category. The literacy rate was very poor (27%) and the economic status of the population was also not satisfactory. They had very poor awareness about environment and family planning. The economy of the people mainly depended on agriculture and livestock rearing. The results were certainly alarming and warranted serious efforts to conserve the existing resources and recover the lost. Finally, conservation and developmental packages for sustainable utilization and management on various resources were given for the entire area. The developmental packages were prepared with data derived from 50,000 scales. Therefore, for micro level implementation, it was recommended to go for further detailed mapping based on large-scale data. The change detection and weighted overlay analysis of the present study revealed the dynamic situation of all the forest-cover types in Kolli hills. Results of change detection analysis were found very useful to take necessary action to conserve the forests. Change of forest cover was noted invariably in all the classes.

6.6

SERPENTINES OF ANDAMANS: A GEO-BOTANICAL STUDY FOR RESOURCES SURVEY AND MANAGEMENT

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INTRODUCTION

Serpentines or ultra mafic soils produced by weathering and pedogenesis of ultra mafic rocks are characterized by high levels of the metals Ni, Cr, and sometimes Co, but contain low levels of N, P, K and Ca. Their physical properties include shallowness, coarse or stony texture and poor waterholding capacity. All these characters in various degrees and combinations impart infertile nature to serpentines in general. Floristically, the serpentine vegetation, both in temperate as well as in tropical regions harbours a number of endemic taxa and adapted races of wide spread species. The serpentine localities of Andaman being geomorphologically unique require comprehensive survey and inventorization for an understanding of this ecosystem.

OBJECTIVES

To provide systematic baseline data on serpentine ecosystem as it occurs in Andaman for assessment of its uniqueness in the perspective of bio-prospecting and conservation.

STUDY AREA

Andaman and Nicobar Islands of India

METHODOLOGY

The present investigation was directed and aimed at application of methodologies of floristic and microbial surveys, geo-botanical and bio-geochemical investigations, remote sensing analysis and screening for resistance/ hyper-accumulation of the constituent elements.

RESULTS/OUTPUTS

Data obtained from this study indicated that serpentine areas of Andaman could be differentiated from the surrounding non-serpentine areas by their characteristic vegetation, occurrence of Ni or other heavy metal-tolerant bacteria, fungi and higher plants, though their numbers are great many. Stunting or dwarfism was seen as a typical character together with the openness or sparseness of the vegetation. Remote sensing analysis showed promises of application towards the identification of such vegetation types. Hyper-accumulation of Ni, Zn and Co manifested in some of the plants. The range of accumulation sometimes was quite high, indicating their adaptation to this particular soil type and endemism. How these plants or microbes could be exploited for phyto-remediation or other applications needed further investigation. The serpentine hills, it appeared, had good water-storing capacity in their rocks, as the streams flowing from them were perennial. The Kalpong Project in N. Andaman covers some of the hills adjoining the Saddle hill.

Serpentine localities, being a unique ecosystem, deserved special attention for conservation. They required comprehensive surveys and inventorization for the assessment of their potential bio-resources and conservation as ‘hot spots’.

6.7

DELINEATION OF SHIFTING CULTIVATION AREAS AND FOREST COVER MAPPING IN THE EASTERN REGION OF ARUNACHAL PRADESH USING REMOTELY SENSED DATA

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INTRODUCTION

In the hilly rugged areas of Arunachal Pradesh, shifting cultivation is widely practised. This form of agriculture is ecologically unsustainable but is suited to the primitive technology available in such areas where level land for settled cultivation is extremely scarce. In certain areas of this state, shifting cultivation is the main source of livelihood of the people and it is hardly surprising considering the low level of socio-cultural technology and the negligible proportion of level land available in the state. In the hill slopes, the tribal farmer has little other option than to resort to "jhum" cultivation, as shifting cultivation is generally referred to, in North East India.

The State of Forest Report, 1997 (FSI, 1998) has pointed out that in North-East India 'shifting cultivation remains the largest factor for the loss of forest cover'. However, information regarding the aerial extent of shifting cultivation is not available. This lack of information becomes problematic and a serious handicap for planning agencies and decision-making authorities. Most studies relating to shifting cultivation in the North-East India normally tend to cite the 1983 data provided by the Task Force on Shifting Cultivation, constituted by the Ministry of Agriculture in 1983. Although State of Forest Reports, of Forest Survey of India (FSI) do provide data on shifting cultivation, this data only relates to the impact of shifting cultivation on forest loss but not on the aerial extent of shifting cultivation. It was therefore felt essential to quantify the area under shifting cultivation, for which the present study has been devoted.

OBJECTIVES

- To inventory and monitoring the shifting cultivation area,
- Characterization of various types of land-use/land-cover pattern using IRS data and identifying temporal changes in the extent of shifting cultivation in order to detect change and its subsequent monitoring, and
- Cropping pattern in the shifting cultivation sites, and forest cover mapping.

STUDY AREA

Tirap district of Arunachal Pradesh

METHODOLOGY

The remote sensing data used were IRS 1C LISS-II (1996) FCC imageries and IRS 1B LISS-II (1994) FCC imageries on 1:50,000 scale while the collateral data was also used including Survey of India (SOI) Topographical sheets on 1:50,000 and 1:250,000 scales, District Census Handbook of Tirap District, Census of India 1991 (Series 3) and various reports from the State Government/Tirap district authorities.

A base map on 1:50,000 scale was prepared for the study area and IRS-1B and IRS-1C FCC imageries were interpreted to delineate the shifting cultivation areas along the preparation of land-use/land-cover (LULC) maps for 1994 and 1996. Interview of village elders and ground truth to verify certain doubtful features and necessary rectification were made to the pre-files maps. Planimetric measurements were carried out, accuracy estimation on selected test sites and digitizing the maps into a Geographic Information System (GIS) were also carried out. Finally, changes in shifting cultivation as well as temporal change in various categories were delineated.

RESULTS/OUTPUTS

It was found that remotely sensed data, particularly IRS 1C FCC (LISS III) and IRS 1B FCC (LISS II) in the study had proved very useful in mapping the land-use/land-cover (LULC) classes. Satellite data used in the present study gave 82% accuracy in the LULC/shifting cultivation areas delineation. As the objective of the present study was to monitor the spatial distribution of jhum lands, the categories of current and abandoned jhum lands were not segregated into shifting cultivation-freshly burned or abandoned with re-growth of grass/vegetation less than two years old, recently.

While a nominal loss of forest area was recorded between1966-1996, as far as forests as a whole were concerned, during the period 1994 to 1996, there were clear signs of improvements and encouraging gains. In particular, dense forests were improved during 1994-96. During the years 1994 and 1996, there were 4.03 % and 2.41 % of the district's area under jhum cultivation, respectively. This amounted to 95.19 sq. km area under jhum in 1994 and 36.99 sq. km area under jhum in 1996, showing a decline of roughly 50 % of the 1994 jhum extent. This indicated the variable nature of the practice.

Rather than jhum cultivation alone being responsible for forest loss/ degradation, the two agents of logging and shifting cultivation seemed to be responsible. It appeared from collateral data that timber logging had been the more important in this regard. Additionally, underlying causes included the land tenure systems and stemming from population growth and reduced land availability, a shortened jhum cycle. Using GIS techniques, buffer zones created around shifting cultivation areas and degraded forest polygons showed the tendency of both to be located in close proximity to settlements, suggesting a linkage between jhum areas and degraded forests. Cropping patterns, jhum cycles and jhum cultivation in areas of steep slope were also identified. The non-permanent nature of jhum cultivation made it difficult to identify 'set' of 'fixed' areas of higher slope where jhum was practised, though such areas were delineated for the years 1994 and 1996. A holistic approach to jhum, was thus necessary than simply identifying areas of steep slope under jhum cultivation. Harvesting commercially valuable species needed to be explored; these could be easily started in the grassland areas or even in certain wasteland areas currently lying unutilized.

6.8

GRASSLAND MAPPING IN GUJARAT, HIMACHAL PRADESH AND TAMIL NADU (IN DIFFERENT BIO-CLIMATE REGIONS) USING REMOTE SENSING AND GIS TECHNIQUES

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INTRODUCTION

Grasslands and savannas cover nearly one-third of the earth surface, providing livelihoods for nearly 800 million people along with forage for livestock, wildlife habitat, and carbon and water storage. Conservation of grasslands/savannas has become a major concern due to their rapid degradation in terms of reduction in productivity, invasion of weeds and land-cover changes. For instance, North American Prairies have declined by an average of 79 % over the past century. In case of India, it is very critical that 80% of Indian grasslands/pastures are considered as very poor in their productive potential. As the milk production increased rapidly over the years, from 21 million tonnes in 1968 to 78 million tonnes in 2001, the pastures on the other hand, have not increased, instead they are getting reduced or degraded. This has created a wide gap between the availability of fodder and demand for it, which in turn, will have wide ranging consequences on the balance of the eco-system.

Hence, it is very important to monitor and assess the state of grasslands and grazing resources. Considering the large area covered by the grasslands, ~2Mha in India, it would be very difficult to assess them by ground-based methods. In this regard, satellite remote sensing offers an effective tool to monitor and assess them periodically in short time and cost effective manner. In view of this, the present study was taken up on mapping of grasslands/grazing resources at 1:50,000 scale using IRS LISS-III data.

Three different bio-climatic regions namely, Western Himalayas (humid tropics), Gujarat (semi-arid) and Tamil Nadu (tropical) were chosen for the study.

OBJECTIVES

- To prepare grassland maps on 1:50,000 scale in the sates, namely Himachal Pradesh, Gujarat and Tamil Nadu at district level using remote sensing and geographical information system,

- To develop methodology for assessment of carrying capacity/grazing capacity for one district each in Himachal Pradesh, Gujarat and Tamil Nadu in GIS environment, and
- To attempt hybrid / digital image analysis and GIS for better discrimination of grassland associations and strategic planning for development of West Banni grasslands.

STUDY AREA

The study area included parts of three states, viz. Gujarat, Himachal Pradesh and Tamil Nadu. In Gujrat, the study area fell within 20º to 25º North latitude and 68º to 73º East longitude, covering an area of 1,09,991 sq. km. In Himachal Pradesh, the study area was located between 30º to 33º 14´ North latitude and 75º 32´ and 79º 02´ East longitudes covering an area of 45,448 sq. km, comprising Hamirpur, Bilaspur, Una, Chamba, Lahul and Spiti, Kinnaur, Kulu, Shimla, Kangra, Sirmaur, Mandi and Solan districts . In Tamil Nadu, it covered 6 districts, viz. North Arcot, Dharampuri, Periyar, Salem, Coimbatore and Nilgiri.

METHODOLOGY

Mapping was done on 1:50,000 scale in the light of the experience gained in pilot studies carried out in Banni-Kachchh, Shivpuri, Kinnaur and Coorg districts. Geo-coded/transparencies of IRS-LISS II/III False Colour Composites (FCCs) on 1:50,000 scales were used for mapping. Visual interpretation techniques were applied. However, for Kulu, Banni and Nilgiri districts detailed study-using digital / GIS techniques was also carried out.

In this study, grazing capacity of different grasslands types were estimated for the forage availability and the animal requirement. After obtaining the baseline data of the grasslands on 1:50,000 scales, stratified random sampling in different types of grasslands was undertaken and productivity estimations were made after harvesting the unit area grasses. Requirement of the animal needs on the area have been estimated.

RESULTS/OUTPUTS

Gujarat: In Gujarat, the districts like Jamnagar, where quality of grass was poor due to over-utilization, needed artificial seeding with superior quality species, e.g. *Dichanthium annulatum*, *Cenchrus setigerus* and *Sehima nervosum* as per habitat requirements. During the study, it was seen that the reserved vidis and forest vidis were well-protected, though very little activity was undertaken for improvement. They were still supporting some good, palatable grasses like *Apluda*, *Sehima*, *Dichanthium*, *Themeda* and *Sporobolus*. On the other side, non-reserve vidis, gauchers and revenue wastelands were overgrazed or overexploited and yielded poor quality, often unpalatable or less palatable grasses like *Aristida*, *Heteropogon* and *Melanocenchrus*. Heavy or marginal grazing in grassland areas, gauchers and revenue wastelands had also encouraged encroachment of dangerous weeds like *Lantana*, *Neurocanthus*, *Cassia tora*, *Triumfetta*, *Xanthium*, etc. The area calculations have shown that out of the total area, about 8.56%, i.e. 9,41,500 ha area was under *Prosopis juliflora*. Total grass area covered grass palatable, grass under tree cover, grass saline and grass on hills was 14.93% of Saurashtra and Kachchh, encompassing 16, 42,632 ha. Its growth was not merely restricted to the areas where it was planted initially, but had spread like wildlife. It had invaded the grasslands. The alarming rate at which *Prosopis* was spreading should serve as an eye-opener to the concerned authorities. Maximum *Prosopis* was found in the Surendranagar district, in 8.45 % of the total geographical area, i.e. 88,632 ha. It was also very alarming to note that another 1,88,277 ha area, which was 17.45 % of the district, was found highly prone to *Prosopis* invasion and appropriate steps were needed to combat this problem. Maximum grassland area was represented in Bhavnagar district, i.e. 24.02% of the total geographical area and grass area was 2, 07,921 ha. However, Kachchh being the largest district had grass cover under 6,77,019 ha, which was 14.83% of the total geographical area of the district.

Himachal Pradesh: In Himachal Pradesh, it was evident from the pilot study carried out in Kinnaur district of the state in 1992 that visual interpretation gave higher accuracy as far as mapping of grasslands in hilly and mountainous terrain was concerned in particular. The high accuracy of visual interpretation of grasslands was due to the fact that the grasslands were dependent on altitudinal zones. These zones could be identified visually from topographic maps. In the areas like alpine pastures, a grassland stretch could be easily identified visually based on their location between the tree line and perpetual snow. Temperate and sub-Montane zones of Himachal Pradesh offered little difficulty but interpretability of grasslands in sub-tropical region was a little cumbersome. It required a lot of ground truth collection, ground control points for validation of results due to over-mixing of grass species and shrubs. Since, grasslands have been considered associated land cover to forests, depiction of forests was considered essential on grassland maps. These grassland maps could serve a valuable data sources for estimating the carrying capacity of grasslands and its planning and management. The total alpine, temperate and subtropical grasslands in the district have been found to be 1,18,286 ha, 37,336 ha and 18,430 ha, respectively.

Tamil Nadu: In Tamil Nadu, digital analysis of multi-season IRS LISS-III satellite data provided better delineation of different grasslands/grazing resources. The overall accuracy of classification was 86.4%. Grazing resources as undergrowth of tree and shrub canopy systems namely, open forests and scrub woodland were more prevalent in most of the districts chosen for the study. Only Nilgiris and Coimbatore districts contained extensive open grasslands. In Nilgiris, tropical wet grasslands, scrub woodland and open forests which supported the grass growth in different intensities covered 13.12%, 16.36% and 25.84% of the total forest area, respectively. Dense forests occupied 43.27% of the total forest area. Grasslands and open forests covered 5.18% and 30.39% of total forest cover in Coimbatore district and were largely distributed in southern part of the district represented by Indira Gandhi Wildlife Sanctuary. Scrub woodlands covering 23.46% were predominant in northern part of the district. Dense forests constituted 36.03% of the total forest area. 42.45% of the total forest was covered by dense forest in Erode district.

Grass supporting systems like open forests and scrub woodlands covered 19.44% and 23.24% of the total forest cover respectively. Grass supporting systems in Dharmapuri were represented by open forests, scrub woodlands and open scrub covering 15.76%, 35.29% and 6.41% of total forest area respectively. Dense scrub areas supporting least grass growth covered 22.35% of the total forest cover. Scrub woodlands and open forests constituted 33.84% and 13.12% of the total forest cover in Salem district respectively. Open scrub supporting thin grass in the openings constitutes 8.47% of the total forest cover. In Vellore district, scrub woodland and dense scrub pre-dominated the total forest cover constituting 33.7% and 24.52% of the total forest cover respectively. Open forest and open scrub covered 13.66% and 10.42% of the total forest cover respectively. Salem, Dharmapuri and Vellore districts predominantly represented scrub woodland, dense scrub and open scrub. However, open forests was also distributed in relatively undisturbed areas. The prevalence of scrub formations indicated relatively more degradational levels in these districts.

ENVIRONMENTAL ASSESSMENT AND MONITORING OF KALRAYAN HILLS, EASTERN GHATS, TAMIL NADU USING REMOTE SENSING AND GEOGRAPHIC INFORMATION SYSTEM

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INTRODUCTION

The Kalrayan hills are a major hill range of Eastern Ghats situated in the north-east of Salem district of Tamil Nadu, the altitude ranges from 600 m to 1000 m and are endowed with rich natural resources. The vegetation types of Kalrayan hills are scrub jungles of altitude 400 m (foot hills), deciduous forests between 300 m and 900 m (slopes), semi-evergreen forests between 800 and 1,300 m (plateau) and sholas at the sheltered pockets on the plateau.

The rich natural resources of the Kalrayan hills make these susceptible to exploitation. The modernization, deforestation and the growing awareness on environmental degradation and its consequences have resulted in the increased number of studies in the field of environmental assessment of forest eco-systems. Except for a few botanical and anthropological studies, the Kalrayan hills have not been explored much. Thus, an attempt was needed to make a detailed study of the environmental status and natural wealth of Kalrayan hills which would be helpful in the evaluation of the present natural resources and preparation of an Environmental Management Plan. The application of newer technologies like remote sensing and Geographic Information System (GIS) would make the results of the investigation more appropriate and available in a short period of time and also more reliable and cost-effective. Therefore, to make a detailed study about natural resources and present status of environment of Kalrayan hills using remote sensing techniques had become imperative.

OBJECTIVES

- To assess the current state of the environment of the study area, Kalrayan hills, such as geology, soil, climate, water resources, biodiversity – flora and fauna, forests and the existing land-use/land-cover categories in an integrated manner through ground-truthing and Geographic Information system (GIS),

- To identify and evaluate the current environmental problems such as soil erosion, loss of bio-diversity, groundwater movement/water table, land settlement/ land use, shifting cultivation and deforestation during the past 20 years, and
- To prepare an Environmental Management Plan (EMP) based on the identified environmental problems and to execute the same through the Forest Department, Government of Tamil Nadu under the Joint Forest Management Programme (JFMP) to promote eco-regeneration and sustainability of the study area.

STUDY AREA

Kalrayans hill range of Eastern Ghats, which lies between 11°20′ and 12°05′ North latitude and 78°28′ and 79°05′ East longitude and is spread over an area of 1,095 sq. km.

METHODOLOGY

The standard methods for community analysis and plant dynamics, as recommended by United Nations Educational, Scientific and Cultural Organization (UNESCO) were followed for cataloging of all species of higher plants occurring in the study area and their abundance and preparation of taxonomic diversity indices. The details of flora and fauna were obtained from the field studies by line-transect methods. Natural resources of the area including forests, soil, water bodies and rock types along with the geological structures and land-use/land-cover database was generated and finalized with appropriate field checks and by interpretation procedures. Multidate thematic maps were generated to analyze the change detection studies for forests and land-use/land-cover. Information regarding drainage, slope, relief and relative relief were generated from the Survey of India (SoI) toposheets. Data and information regarding rainfall, temperature, humidity, wind, sunshine and other climatic factors were collected and analyzed by following the procedures of India Meteorological Department (IMD). A Geographic Information System (GIS) for the study area was developed by integrating all the required information. Environmental assessment and preparation of Environmental Management Plan (EMP) were carried out using the Batteles' techniques/network analysis, as proposed by John Rau and Wooten (1980). Detailed Environmental Monitoring was also proposed based on the above information.

RESULTS/OUTPUTS

Water harvesting, soil and moisture conservation measures in Kalrayans hill provided catchment areas for Gomukhi dam and Manimuthar dams. Increasing the soil fertility and flow of water and its quantity in jungle streams were very important. Conserving the soil and moisture assumed special importance in the light of shifting cultivation practice which denuded the soil. Soil was getting washed into the dams and reservoir because of the clear felling of the vegetation to cultivate crops; dams and other structures were getting silted up prematurely, thereby reducing the storage capacity.

The conservation measures included planting *Agave* rows along contours, semi-circular bunding on the lower side of individual trees, gully corrections, both by vegetative and masonry works, check daming all the streams and nallahs, diversion of water from the upper boundary of plantations, if any, into natural streams at convenient places so as to avoid scouring and gully formations on the entire slopes, creation of percolation ponds, construction of waste-river surplus river in every stream or nallahs, planting of native species in all gaps in the watershed areas, stream bank stabilization works by vegetative methods, raising green belt along the boundary and planting tall trees/plants along the contours.The management plans/programmes needed to be implemented through Joint Forest Management Programme (JFMP) to benefit the tribals and the forest eco-system.

6.10

KEY CONSERVATION ISSUES IN THE SEMI-ARID DECCAN PLEATEAU AND USE OF GIS TO STUDY ECOLOGICAL DEGRADATION AND SUGGEST MANAGEMENT STRATEGIES FOR CRITICALLY ENDANGERED GRASSLAND AREAS IN THE DECCAN PLEATEAU

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INTRODUCTION

The rapid industrial development of Maharashtra is leading to serious loss of 'natural' and marginally man-modified habitats. Maintaining ecological integrity has not been included in the spatial planning for development in the Deccan Plateau. This has led to several conflicting situations in which mitigative measures may yet lead to conservation gains if rapidly instituted. One situation that needs urgent attention is the dispersal of blackbuck populations due to the creation of a large number of Drought Prone Area Programs (DPAPs) in the grassland ecosystems of the Deccan Plateau. The hyperdense population of blackbuck leads to crop damage for which mitigative measures need to be identified. This should be based on mapping the density and gradual movement of blackbuck populations in the region in response to changes in land-use.

The project funded through the man and biosphere program entitled *"Key Conservation Issues in the Semi-arid Deccan Plateau"* extended over a vast area. It was once a homogenous area of rain-fed agricultural land, which is now undergoing a rapid patchy redistribution in terms of its land-use patterns. The project when first developed had a smaller but much needed focus on its protected areas. If, the whole area had to be looked upon as an integral unit of land management, there was a need to use Geographic Information System (GIS) to evaluate land-use patterns on a spatial basis and predict future trends based on indicators species that are likely to be affected by new forms of land management. These include the spread of irrigation facilities and development of rural small-scale industries.

OBJECTIVES

- Identification of critical blackbuck habitats,
- To identify the existing corridors between the blackbuck populations,
- To study if there are impediments to their dispersal leading to hyperdense populations,

- The possible effects of new agricultural patterns after irrigation water is brought into these areas, where cropping patterns will change from bajra and jowar in which blackbuck feed (especially during fallow periods) into sugarcane fields which are not used by blackbuck, and
- The impacts of the growth and spread of rural industry on sub-optimal and optimal blackbuck habitats.

STUDY AREA

Deccan Plateau

METHODOLOGY

This project was based on the GIS evaluation of the land-use patterns and the spread of irrigation into this region. The extension of the project envisioned mapping the landscape elements such as village agricultural lands both rainfed and lift irrigated, Reserved forest used for social forestry and DPAP to generate fuelwood and fodder, small hillocks described locally as wastelands and the protected areas of Nannaj and Rehekhuri and their spatial relationships. GIS was utilized to identify the scale at which new irrigation facilities will in the future reduce optimal and sub-optimal blackbuck habitat. This may be used to generate a rational land-use strategy for the region.

The GIS is not generally used to develop land management strategies based on ecological parameters. The Principal Investigator used it in 1989 to find the effect of fragmentation of forests in the Surat Dangs. The area of the project extended over 3 Talukas in which blackbuck and wolf populations have been leading to conflict issues. In the Ahmednagar, Sholapur and Phaltan areas, these problems have been escalating in the recent past.

The GIS-related work required extensive field studies. These grassland areas were intensively surveyed during different seasons for the density of blackbuck through interactions with local people as well as by direct observations. This was plotted using GIS. The extent and changes in agriculture and grazing areas were documented and ground truthing done to identify these landscape elements on satellite images. The present canal-irrigated areas and their possible extension were mapped to observe the possible loss of blackbuck habitat.

RESULTS/OUTPUTS

The project has provided specific inputs into a strategic plan for understanding the need for conservation measures in a ‘developing’ area. As irrigation expands into the semi-arid and drought-prone zones, the land-use changes will impact seriously on available blackbuck habitat. This will thus be of practical relevance in identifying future management policies for this vast region. The Forest Department has requested the Principal Investigator to suggest a rational set of management options for the local Protected Areas at Nannaj and Rehekhuri. This data has been collected and analysed through GIS to develop a more comprehensive and objective regional management plan as blackbuck and wolf are both found extensively outside the Protected Areas. There is an urgent need to involve local people in retaining conservation values of this area. A set of posters on grassland issues and biodiversity values was developed for explaining conservative objectives and was discussed in various local settings.

6.11

TEMPORAL ASSESSMENT OF FOREST COVER CHANGES IN EASTERN GHATS OF TAMIL NADU – A REMOTE SENSING APPROACH

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INTRODUCTION

India is one of the mega bio-diversity centers in the world and harbours forests in the Himalayas, Western Ghats and Eastern Ghats. Among them, Eastern Ghats is the most neglected region as far as scientific studies are concerned. Though Eastern Ghats has its extent from Orissa to Tamil Nadu, the present study focuses only on the Eastern Ghats of Tamil Nadu. As it is a broken chain of hills with a large number of settlements on its hills and due to easily accessible physiography, it has received maximum pressure on the forests. Consequently, the forests are depleting at an alarming rate. Conservation of forests needs an accurate spatial database on the forest resources of the present and the past. Similarly, studies on forest-cover density and types for two different periods are also essential. Some of the factors responsible for forest-cover loss may be taken into account as an attempt to identify the possible factors responsible for forest degradation.

OBJECTIVES

- To map the forest cover (type and density) on 1:50,000 scale using IRS-1A LISS-II satellite data of 1989 and IRS-1D, LISS-III satellite data of 1998,
- To analyze and identify the forest cover change detection for the study area over a period of ten years (1989-1998),
- To examine and estimate the current status of the forest variables like timber volume, bio-mass and growing stock of the study area,
- To relate the socio-economic aspects such as human population, occupation, income and livestock population with the changes in the forest cover in the past ten years, and
- To transfer the forest cover changes into slope and watershed map for micro-level planning purposes.

STUDY AREA

The Eastern Ghats of Tamil Nadu, covering an area of about 6,000 sq. km in 13 prominent hills, including the Jawadi Hill which is the largest one covering 1,860 sq. km and the Alagar Hill which is the smallest one which covering 70 sq. km. The altitude ranges from 180 m to 1,700 m above MSL. There were 180 reserved forests in the Eastern Ghats of Tamil Nadu covered in about 30 Survey of India (SOI) toposheets on 1: 50,000 scale.

METHODOLOGY

The satellite data such as IRS 1C LISS-III and other were used. The entire forest area was classified under 10 forest types with different density classes. The criteria used to classify the forest were also clearly explained.

RESULTS/OUTPUTS

Among the forest types, the southern mixed dry deciduous forest type dominated most of the area. The southern thorn and southern thorn scrub forest types completely occupied the foothills in almost all the hills. The tropical dry evergreen forest was situated as pockets in between Jawadi, Elagiri, Shevaroy, Kolli, Pachaimalai and Sirumalai hills. The change detection analysis between a period of 10 years in the forest cover revealed that change had occurred invariably in all the forest types. Dense forest cover of all the forest types had been converted into open and degraded forest covers. The study has pointed out that: (i) several forest types, ranging from evergreen to southern thorn scrub, were present. (ii) presence of large extent of thorn and scrub forests pointed out that heavy damage had been done to the virgin forests in the past 10 years. Growing Stock (GS) being an indicator of the intactness of the forests was estimated in the sample quadrates for different forest types and forest covers considering the height of the tree, basal girth and top girth. Using suitable regression line GS of various forest types and cover density was estimated for 1990 and 1999. Loss of GS was found in almost all the forest types, except degraded forest types like southern thorn and southern thorn scrub. However, the increase in the GS in these two forest types was not due to the increase in the stand density but was due to the addition of area resulting from degradation of forest types like evergreen, semi-evergreen and deciduous. The relationship between GS loss and population was dealt in the socio-demography section.

All the forests being situated in the hilly terrain, the influence of slope on vegetation was also analysed. Slope map was prepared for all the hills and the present and past forest cover status in each slope class was analyzed. Then, it was understood that most of the dense forests in the Eastern Ghats were situated in the medium (5 - 15%) and high (15 - 35%) slope classes. The low slope class possessed only the degraded forest covers. Results pointed out that conservation and developmental planning was needed in these two slope classes. Watershed map of Eastern Ghats was prepared and the forest cover map was overlaid on it and the composition of the forest type and cover density in each watershed was delineated. The Eastern Ghats basically belongs to 3 basins (A, B & C), 6 catchments, 12 sub-catchments, and 31 watersheds. The forest cover status in these watersheds during 1990 and 1999 has been discussed. The products thus generated gave useful information for both conservation and reforestation planning.

6.12

ANALYSIS OF FOREST COVER AND LANDUSE DYNAMICS IN THE UPPER CATCHMENT OF MANIPUR RIVER USING REMOTE SENSING AND GEOGRAPHIC INFORMATION SYSTEM

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INTRODUCTION

Deforestation, particularly in tropics is a growing concern all over the world. The hills of Manipur, once rich in forests and plant genetic resources have been depleted of their potential of forest production and genetic resources in order to meet the requirement of fast increasing human population. Major factors of degradation of forests are cutting of forest for timber, fuel wood requirements and shifting cultivation. This largely results in frequent flash flood in the valley area as the rainwater can not be retained at the upper catchment. The climate of the area is also significantly changed.

OBJECTIVES

- To generate information like micro-watershed wise land-use/land-cover, forest slope and aspect, soil, drainage and watershed, settlement and transport network and demographic data, and
- To detect changes in forest cover and land-use/land-cover by preparing micro-plan of forest management.

STUDY AREA

The upper Manipur river catchment covering an area of 4, 55,723 ha, located between 24^{o}20'43" North to 25^{o}24'3" North latitude and 93^{o}40'88" East to 94^{o}25'36" East longitude.

METHODOLOGY

- Ancillary data such as Survey of India topographical maps, other published reports.
- Visual interpretation of satellite remote sensing LANDSAT TM (1987), SPOT MLA (1990), IRS-IA-LISS-II (1993), IRS-IB-LISS-II (1995), IRS-IC-LISS-III & PAN (1998) data (FCC) in conjunction with various collateral data by adopting standard interpretation keys.
- Digital image analysis, both supervised and unsupervised classification approach using ERDAS.

- Thematic data integration and socio-economic analysis through ARC/INFO GIS software.

RESULTS/OUTPUTS

It was found that there are 49 micro-watersheds in the study area, having size ranging from 4202 ha to 21,774 ha, with the average size of 9300.469 ha. Maximum area under forest cover type is open forest with area of 93,357 ha (20.49%) of the total geographical area of the catchment. The other non-forest/wasteland types identified were land without scrub, upland with or without scrub, current jhum and abandoned jhum. The highest area was under the abandoned jhum (>5 years) estimated to be 92148 ha i.e. 20.22% of the total geographical area of the catchment.

Shifting cultivation was found the single largest factor responsible for forest degradation and overall transformation of forest in north-eastern India. Continuous increase in human population was having increasing pressure on forest resources for food and fodder. This calls for the development and rational use of forest resources since indiscriminate exploitation may result in irreparable environmental damage culminating into a state of ecological crisis. Jhum cycle which once was of more than 15 years, has now reduced to less than 5 years. It clearly shows that very limited fertile land is available for cultivation in the region.

The hills of Manipur are inhabited by different tribes. Agriculture is the main occupation for the people and jhumming is the main source of food. The terraced cultivation was confined on the slopes and was under rain-fed crops of rice, millets and pulses. The productivity was too low because of continuous erosional practices and the prevailing dry conditions, particularly during a drought year. The valley cultivation was found on the banks of rivers/streams and was mostly devoted to paddy because of irrigational facilities.

6.13

GEOGRAPHIC INFORMATION SYSTEM BASED FOREST DENSITY STRATIFICATION AND TIME SERIES ANALYSIS FOR RESOURCES MAPPING AND MONITORING IN J&K STATE USING REMOTE SENSING TECHNIQUES

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INTRODUCTION

The forests of Jammu and Kashmir (J&K) are mostly confined to the Jammu and Kashmir divisions and are located in inaccessible areas, as these are found in the altitudinal zonation of 400 m to 3500 m. These forests are highly diverse in nature due to unique geo-climatic differentiation of the regions in which these occur. In the Jammu region, the sub-tropical forests with species like chirpine, shisum, bamboos and thorny forests are found. In the Chenab valley, moist evergreen forests with vast patches of broad-leaved species like willows, oaks, walnut, etc. are encountered. The Kashmir valley has dry temperate evergreen forests with broad-leaved species occurring in the valleys like walnut, maple, oaks, ash, elm, etc. The prime evergreen species include: Deodar, Kail, Fir and Spruce. The deodar and fir are found in the northern aspects, while as the kail forests are found in the southern aspects. The Ladakh region being a cold desert has scanty vegetation. Under such a situation, assessment of the forest cover in J & K is not only difficult but also time consuming, due to which by the time the results of conventional surveys are published, these become outdated for chalking out management and conservation strategies. The remote sensing technique has emerged as a powerful tool to map and monitor the natural resources economically, accurately and within a short span of time. The present study was therefore attempted with such a method.

OBJECTIVES

- To study the density stratification and change analysis using remote sensing and GIS in the J&K state,
- To quantitatively assess the forest cover density of the J &K state,
- To analyse change of forest cover density over the period 1994 – 2004, and
- To assess forest cover density at the district and forest division level.

STUDY AREA

Jammu & Kashmir state lies between 32º 15´ to 37º 45´ North latitude and 72º 30´ to 81º 15´ East longitude

METHODOLOGY

Digital Supervised Classification of the multi-temporal datasets pertaining to the years 1994 and 2004 was undertaken and data was analyzed for different density classes as per classification scheme adopted by Forest Survey of India (FSI), Dehradun.

The limited groundtruth verification was also conducted and necessary corrections were incorporated using knowledge-based post-classification recoding technique.

Further, accuracy assessment of the digital classification based mapping was conducted which revealed Kappa (measure of accuracy) to be 0.8964 with overall accuracy of 92.31% for the mapping pertaining to the year 1994 and 0.8635 with overall accuracy of 90% for the mapping pertaining to the year 2004.

In the study, a forest mask was generated based on the digital territorial forest boundaries supplied by National Geospatial Data Centre (NGDC), Survey of India (SOI), Dehradun, and the administrative boundaries were digitized from the Working Plan Maps supplied by Photo-Interpretation Division of the J&K Forest Department.

RESULTS/OUTPUTS

The analysis of the various density classes in the forest of J&K State, only up to Line of Actual Control, revealed that the very dense category of forest has reduced from 1935 sq. km to 1,646 sq. km during the assessment period of ten years showing net negative change of 289 sq. km. The moderately dense category of forest has reduced from 6,278 sq. km to 5,364 sq km during this period showing the net negative change of 911 sq. km Regarding open category, there has been an increase in the spatial extent from 5,235 sq. km to 5,440 sq. km, showing a net positive change of 205 sq. km. The scrub category had reduced from 1,084 sq. km to 879 sq. km, depicting a net negative change of 205 sq. km. The blank category had increased from 9,307 sq. km to 10,510 sq. km giving a net positive change of 1,203 sq. km. Besides, the forest divisional mask enabled generation of forest division-wise density maps for the assessment year 2004, which was an exercise conducted for the first time in the state. Such maps with area statistics would go a long way in assisting the forest administrators and planners to chalk out judicious forest management and conservation strategies in the state.

6.14

Monitoring and Modelling Land-Cover/Land-Use and Biodiversity in Dehang-Debang Biosphere Reserve, Arunachal Pradesh

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INTRODUCTION

Biosphere Reserves aim to fulfill three complementary functions: (i) conservation function, (ii) development function, and (iii) logistic support function. For achieving these functions, there is a need to improve the present status of biodiversity science as well as management, including evaluation of the spatio-temporal dynamics of biodiversity in cultural landscapes around biosphere reserves.

OBJECTIVES

- Mapping of land-cover/land-use at two points of time in a segment of area in/around Dehang-Debang biosphere reserve in Arunachal Pradesh,
- Mapping of important factors driving land-cover/land-use and vascular plant diversity dynamics using topographic and other information,
- Estimation of vascular plant diversity at a range of spatial scales within each of land-cove/land-use stratum mapped and modelling of vascular plant species diversity-area relationships,
- Analysis of spatio-temporal patterns and land-use/land-cover changes, evaluation of applicability of available land-use/land-cover change models and the implications of changes for conservation, and
- Identification of strategies for rehabilitation of degraded areas and for minimizing the threats to conservation.

STUDY AREA

Dehang-Debang biosphere reserve between 28^0 20’ - 28^0 44’ North latitude and 94^0 08’ - 94^0 44’ East longitude in the East Siang district

METHODOLOGY

Land-use/land-cover maps were generated based on interpretation of Landsat TM data of the year 1988 and the IRS P6 data of the year 2004. Eighty-five interpretation accuracy was taken as the threshold for finalizing classification scheme. The classes which could be mapped with 85% interpretation accuracy were: (i) Highly dense/diverse forests characterized by three layers of tree crowns/canopy (> 90% crown cover and top canopy trees > 25 m tall) and a less dense under storey of shrubs and herbaceous component, (ii) Moderately dense/diverse forests characterized by one or two layers of tree crown (50-70% crown cover and top canopy trees 20-25 m tall) and a dense under storey of shrubs and herbaceous species, (iii) cultivation and associated land uses, including (a) wet paddy cultivation, (b) cropped fields and younger fallow fields of shifting cultivation and young plantations characterized by poorly developed tree crowns, (c) older fallow fields of shifting cultivation and young plantations characterized by a discontinuous tree canopy (20-50%) and a dense herbaceous vegetation or bamboo brakes, and (d) mature plantations characterized by an almost continuous single layer of tree crown with a sparse ground vegetation, (iv) water, and (v) other land-use/land-cover types. The inputs to regional scale spatio-temporal analysis included: (a) land-use/land-cover maps, (b) slope map, (c) elevation map, (d) aspect map, (e) drainage map, and (f) road map.

RESULTS/OUTPUTS

Land-use/land-cover in relation to elevation: Highly dense/diverse forests (HDF), moderately dense/ diverse forests (MDF) and cultivation (+ associated land uses) covered 91.6%, 2.0% and 5.4% of the total geographical area, respectively, in 1988 and 84.3%, 4.2% and 10.5%, respectively in 2004. Thus, the area under HDF decreased by 8.66% while area under MDF and under cultivation and associated land uses increased by 107% and 95%, respectively, over a period of 16 years (1988-2004). About 70% of total loss of HDF, increase in MDF and increase in cultivation area occurred in < 900 elevation zone.

Land-use/land-cover in relation to slope: All the three changes, viz. loss of HDF area, increase in MDF area and increase in cultivation area were most prominent in 15-30 degree slope class, followed by 5-15 degree and < 5 degree slope classes.

Land-use/land-cover in relation to aspect: Magnitude of loss of HDF was most prominent in flat land, increase in MDF in north and west facing aspects and increase in cultivation area equally on all aspects except west-facing aspect where rate of agricultural expansion was lowest.

Changes in landscape ecological attributes*:* The landscape of the study area could be viewed as a matrix of HDF with interspersed patches of MDF and cultivation. Patch density increased by 143% and mean patch area decreased by 62% in HDF during 1988-2004 period. In the case of MDF, patch density increased by 37% and mean patch area by 54%. In the case of cultivation, patch density decreased by 13%, while mean patch area increased by 124%. Spatial analysis showed: (i) construction of roads almost parallel to major streams at lower elevations, (ii) concentration of forest conversion and forest degradation near roads, (iii) abandonment of shifting agriculture resulting in recovery of tree cover in areas far away from roads, and (iv) a trend of establishing forest tree plantations in forest openings created around roads.

Village landscape scale analysis*:* Population increased by 85% in easily accessible village (Domo), but decreased by 48% in highly inaccessible village (Yegong) over the past 20-year period. Contrary to a common belief of a uniform increase in population, a mosaic of villages was observed with increasing and declining population.

Land-use/land-cover heterogeneity and landholdings*:* All land within the village boundary has a status of private ownership (though without any proper legal sanction) but sale-purchase of land has so far not come up. Even forestlands of individual families have been demarcated. In the easily accessible village, mean landholding size was about 19 ha compared to 211 ha in the highly inaccessible village. Though there are some limitations of the methodology adopted for village landscape analysis, land is not at all scarce in the present biosphere reserve.

Land-use/land-cover changes*:* In the easily accessible village, 39% area of natural forests is being used for shifting agriculture, 11% for plantations, and 1% for wet paddy cultivation over the past two decades. Coexisting with this change of loss of natural forests, tree plantations and settled wet paddy cultivation has been established over 23% and 3% of shifting cultivation area, respectively. There are no significant changes in highly inaccessible village, except development of wet paddy cultivation over 9% area of shifting cultivation. There is no direct and linear relationship between population pressure and loss and gain of natural forests.

Species richness*:* Quantitative analysis of species richness was confined to the tree component. A total of 87 tree species represented by 41 families were sampled. Lauraceae, Moraceae, Euphorbiaceae and Fagaceae were the richest families represented by 8, 7, 6 and 5 species, respectively. The more accessible village landscape showed a higher tree species richness (70 species), compared to 44 species in the less accessible one, reflecting a positive effect of improvement in accessibility, increase in population pressure and associated changes on tree species richness. Direct uses of 34 species were identified. The timber species were further classified as: (i) best quality timber species, including *Morus laevigata*, *Terminalia myriocarpa*, *Altingia excelsa* and *Duabanga grandiflora*, (ii) medium quality timber species, including *Castanopsis* spp., *Chaerospondias axillaris*, *Cinnamomum* spp. and *Artocarpus heterophyllus*, and (iii) 16 other species with average quality timber. *Cinnamomum glaucescens*, *Sarchochlamys pulcherima* and *Syzygium assamicum* were valued more for their indirect values in terms of providing preferred food of wild animals, a source of meat to local people, than their direct values. No species contributed more than 15% of total mature trees per unit area. Species dominance in terms of numerical abundance was not always correlated with that in terms of basal area. The order of species dominance in regenerating component differed from that in mature tree component. A strong similarity in species dominating the regeneration and top canopy in less accessible village Yegong indicated near-climax vegetation in the area.

Community diversity*:* Detrended Correspondence Analysis (DCA) was applied to numerical abundance and basal area of both regenerating and mature tree components of 170 sample plots. The eigenvalues of first and second axis in all data sets exceeded 0.5, indicating a good separation of species along the axes. However, the first three DCA axes explained hardly 17% of total variation. Gradient lengths of first three axes exceeded 4 standard deviation, indicating that several samples had few species in common. However, variations within and between land-use/land-cover classes were so wide that some sample plots closely resembling in species composition belonged to divergent classes (e.g., plantations, natural forests and managed fallows) and some sample plots differing in species composition belonged to the same land-use/land-cover classes. Six species, viz. *Livistona jenkinsiana*, *Artocarpus heterophyllus*, *Castanopsis indica, Dysoxylum gobara, Lithocarpus listeri* and *Morus laevigata* were found as mature trees or as seedlings/saplings or both in all land uses on sloping land but their abundance and population structure varied partly because of natural factors and partly because of human interventions. *Altingia excelsa, Castanopsis indica, Diospyros cerasifoliaa, Morus laevigata* and *Terminalia myriocarpa* can be considered as the climax species, as they are able to regenerate under their own canopy and are represented by giant trees (dbh > 100 cm). Land-use/land-cover types differed more in terms of basal area and species composition than in terms of species richness, evenness and diversity. Timber plantations were as species rich as natural forests in the easily accessible village, while 4 to 8 year fallows were as species rich as forests in the highly inaccessible village. Four species, viz. *Alangium* spp, *Betula alnoides*, *Litsea cubeba* and *Meliosma simplicifolia* were most sensitive to disturbance, whereas *Ficus roxburghii* was most favoured by disturbance.

Species richness – Area modellin*g:* More than 85% of variations in species richness within a land-use/land-cover class was explained by the size of the area sampled. However, the degree of increase in species richness with increase in area varied by land-use/land-cover type. In case of 1 to 3 year old shifting cultivation fallows, species richness reached almost an asymptote at sample area of about 700 m^2. In contrast, species richness was not saturated even when the sample area reached a value of 1500 m^2 in case of older fallows and forests.

Shifting cultivation: The area around Dehang-Debang biosphere reserve has resisted intensive agricultural land-use for centuries. Landholdings are fragmented and conversion of primary forests to shifting cultivation is altogether absent. A family cultivated an area of 1-2 ha every year with an average fallow length of 5-8 years. The method of plot selection in shifting cultivation was very different from the common trends in other tribal areas where land belonged to the community and the village headman had the authority to allot land for cultivation. In Remote villages where population pressure was low, the village territory was divided into 10 blocks. Cultivation rotated among blocks. A block was cultivated at an interval of at least 8 years and selection of a block for cultivation is made based on density of vegetation. After selection of block, the households, who did not own land in the selected block, contacted other families for cultivating part of their land. Such temporary transfer of cultivation rights was guided by socio-cultural values and not by any profit motive. In more accessible villages where population pressure was high, apart from private lands, a cluster of neighboring villages had some common territory for shifting cultivation. Unlike some other areas where some trees were not cut for their ecological values, in the present study area it was found that farmers do not cut *Artocarpus heterophyllus*, *Terminalia myriocarpa* and *Morus laevigata* trees for their economic values. Ecological values of these species need to be evaluated.

Crop diversity: With increase in population together with an improvement in accessibility, (i) the length of cropping period had increased from two to three years, (ii) millets was replaced by paddy and (iii) crop diversity at farm or village landscape level was not significantly influenced. Exotic weed *Ageratum conyzoides* was more widely distributed compared to *Eupatorium* spp. and *Mikania micrantha*, the latter being dominant in highly disturbed landscapes characterized by high population pressure, shorter cultivation cycles and connectivity by motorable roads, e.g., Domo village. These species were given special attention by farmers while weeding. While shifting agriculture is valued as an agricultural production system resilient to climatic fluctuations, producing a balanced diet, enforcing social integration and equity and providing a buffer zone between human habitations and natural ecosystems rich in large mammals, wet paddy cultivation is valued most for its high productivity of staple food. Shifting cultivation is only a component and not the sole occupation of tribal farmers. Traditional wet paddy cultivation is more productive than many modern agricultural systems. Farmers have not been able to expand it for two broad reasons: (i) lack of indigenous knowledge and capacity to establish community irrigation systems, and (ii) lack of effective policies promoting community irrigation. Raising plantations and thus reducing dependence on shifting agriculture was found as an indigenous effort triggered by a cultural transformation from subsistence to market economy.

The notion that subsistence farmers need not or do not intend to sell any of their products was not found to hold true now. The entries of the communities into the market economy had increased the dependence of subsistence farmers on monetary resources. Our data showed that (i) people depend more on non-timber forest products if such resources are accessible and geomorphological setting is such that local requirements of staple food is ensured from wet paddy cultivation, (ii) people can spend substantial time and energy in travel and transport for wet paddy cultivation and rarely tend to maximize returns to labour possible from shifting cultivation, (iii) income in easily accessible villages with small landholdings is higher compared to that in villages with large holdings and poor accessibility, (iv) irrespective of the ecological and accessibility attributes, people tend to pay attention to income from agriculture after they have ensured local production based food security, (v) local people view shifting agriculture, wet paddy cultivation, plantations and natural forests as complementary rather than competing land uses, (vi) increasing pressure on land coupled with increasing aspirations for cash income have catalysed indigenous innovations towards crop diversification by domesticating a few wild species demanded in the market; indeed farmers have not been able to cultivate many potential economic species, e.g., canes pointing a need of policy intervention, (vii) shifting cultivation seems not as severe a cause of environmental degradation as commercial logging and conversion of natural forests to plantations, and (viii) indigenous culture promotes a reciprocal exchange of labour and hence development projects geared to the success of only a few individuals will not be immediately accepted by the community.

Modelling and predicting Land-use/land-cover changes: Hardin's theory of commons that attributes deforestation to the misuse of communally owned resources does not explain land-use dynamics in the study area. Two phases of conversion of forests were evident: (i) a phase when rate of forest conversion to shifting agriculture exceeded the rate of population growth – during historical times, i.e., several decades ago, (ii) a more recent phase of conversion of forests to shifting agriculture at rates much slower than the rate of population growth. In the latter phase, that seems to have set in since past 20-30 years or so, several land-use changes have emerged almost simultaneously. Straightforward and simple linear relationships between land-use change rates as dependent variables and driving forces, e.g., population growth, per capita food production, slope, elevation, aspect and accessibility as independent variables were not observed. Population pressure and market integration had brought in a change in biodiversity but necessarily not environmental degradation and loss of biodiversity so far in the study area. Factors and processes related to land-use/land-cover and biodiversity changes were found so varied and complex that prediction of scenarios in small areas and over short period of time, particularly in the recent past, based on simple models depicted a high degree of uncertainty.

6.15

APPLICATION OF REMOTE SENSING FOR BIORESOURCES CHARACTERIZATION OF GANGETIC GRASSLAND ECOSYSTEM IN AND AROUND HASTINAPUR WILDLIFE SANCTUARY

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INTRODUCTION

In spite large-scale destruction of natural biomes in the Gangetic Plaines of U.P., there are few areas that still possess some natural elements. But these are threatened and need conservation efforts. A biome is a climatically and geographically defined area of ecologically similar climatic conditions such as communities of plants, animals, and soil organisms, and are often referred to as eco-systems. Biomes, in fact, are based on factors such as plant structures like trees, shrubs, and grasses, leaf types like broadleaf and needle leaf, plant spacing such as forest, woodland, savanna, and climate. Unlike eco-zones, biomes are not defined by genetic, taxonomic, or historical similarities; these are often identified with particular patterns of ecological succession and vegetation. The bio-diversity characteristic of each biome, especially the diversity of fauna and subdominant plant forms, is a function of a biotic factors and the biomass productivity of the dominant vegetation. In terrestrial biomes, species diversity tends to correlate positively with net primary productivity, moisture availability, and temperature. One such biome is the Gangetic Grasslands, locally known as Khadar. Till the middle of twentieth century, there were extensive tracts of Khadar with rich faunal diversity all along the Ganga river. However, after independence of the country, Gangetic grasslands have received heavy influx of people and today the entire region is heavily cultivated by Pakistani emigrants during 1950s and recently in 1980s by Punjabi emigrants after the insurgency in the state. Today, the Gangetic Khadar is one of the highly threatened biomes of India. During the past few decades, efforts have been made by the Government to protect example of each of the existing natural biomes by establishing a protected area network. Considering the importance of Gangetic grasslands, the Government of UP in 1987 declared an area of 2,073 sq. km as Hastinapur Wildlife Sanctuary (HWS) along the Ganga. However, since its inception this sanctuary is facing several conservation problems due to exploitation of resources and change in land-use pattern. Moreover, no systematic study has ever been attempted to document the bio-resources of Gangetic grasslands or to address the dependency of people on the resources in this region. It was therefore felt necessary to understand the current status of bio-resources and changes brought about by the anthropogenic factors, so that a comprehensive strategy for long-term conservation of this biome can be prepared.

OBJECTIVES

- To map spatial distribution of Gangetic grasslands in and around Hastinapur Wildlife Sanctuary (HWS) in relation to other land-use practices,
- To detect temporal changes in the grassland cover between 1990 and 2000,
- To assess the floral, mammalian and avian diversity in various patches of grasslands,
- To assess the nature and extent of human dependency on bio-resources, and
- To identify the viable areas for bio-diversity conservation

STUDY AREA

Hastinapur Wildlife Sanctuary (HWS), Uttar Pradesh

METHODOLOGY

Mapping spatial distribution of Gangetic Grasslands was undertaken, following the standard procedures for image restoration, enhancement and geo-referencing of the digital data that was subjected to a hybrid classification using supervised and unsupervised classification methods, in order to map extents of Gangetic Grasslands in relation to other land-use practices in the sanctuary. Eight distinct classes were identified under the land-use/land-cover category; these were Tall wet grasslands forest including plantations, agricultural land, scrub, built-up areas, dry grasslands, sand beds and water. For change detection, a comparison between 1992 and 2000 data was made. Assessment of floral, mammalian and avian diversity was also made, though it was not in the scope of the present study. Plant species richness, diversity and densities were calculated using standard sampling methods and applying statistical techniques**.** Based on the floral and faunal diversity and richness, extent of grassland patch, geographical location and nature of the area, various grassland patches were categorized from the point of view of conservation potential. Human dependency was studied by conducting socio-economic survey.

RESULTS/OUTPUTS

In spatial distribution it was found that about 69% of the total sanctuary area was under cultivation and only about 18% of the sanctuary's geographical area was under natural vegetation. Water constituted a little over 4% and sand beds were covering an area of about 6 %. While studying change diction, marked differences were revealed in land-use/land-cover of the sanctuary. The maximum change occurred in the area of Tall Wet Grasslands. The extent of these grasslands had reduced by about 53 % during a short period of eight years. The built-up areas had also witnessed a marked increase from 13 sq. km in 1992 to 22 sq. km in 2000; an increase of about 67%. Agricultural area had increased by about 7% from 1,153 sq. km to 1,235 sq. km, while the coverage of waterbodies including the Ganges had reduced considerably within a span of eight years and it was reduced by about 20 %. A total of 123 families were recorded as occurring in the study area. Of these, 98 families (79.67%) belonged to dicotyledones and 25 families (29.32%) to monocotyledones. Among dicots, polypetalae accounted for 52 families (53.0 % of dicot families and 42.2 % of total families), gamopetalae accounted for 30 families (30.6% of dicot families and 24.3 %

of total families) and monochlamydeae accounted for 16 families (16.32% of dicot families and 13% of total families).Thus, vegetation of Hastinapur Wildlife Sanctuary was dominated by dicotyledonous species and polypetalae was the largest contributor to the flora. A total of 441 genera were collected. 335 genera (75.96%) belonged to dicot families while 106 genera (24.03%) were of monocot origin. Among dicots, highest number of genera (150) belonged to polypetalae, followed by gamopetalae (144) and monochlamydeae (41). Among monocots, 55.66% of total monocot genera (59) belonged to Poaceae, while Poaceae and Cyperaceae together accounted for about 65.09% of total monocot genera. A total of 716 species of flowering plants were collected. 518 species (72.34% of total species) belonged to dicot families and 198 (27.65%) belonged to monocot families. Only 19 families (15.4%% of total families) accounted for 478 species (66.65% of total species). Among dicots, polypetalae accounted for 236 species, gamopetalae for 207 species and monochlamydeae for 75 species. Ten different patches of Tall wet grasslands were identified and mapped. A total 941 plots were sampled along transects, randomly established in various grassland patches. Plant richness, diversity and densities differed significantly in various patches of grasslands. Plant species richness varied from a minimum of 0.446 to a maximum 1.43 among various grassland patches. Similarly, the plant diversity varied between 0.201 and 0.460.

The mammalian fauna of the study area included swamp deer, Nilgai, hog deer, wild pig and rufous tailed hare. The current population of swamp deer was estimated between 450 and 550, which was a viable population outside its stronghold in Dudhwa National Park. The abundance of swamp deer varied significantly among various grassland patches and it was maximum in Jogawala area of the sanctuary. The abundance of rufous tailed hare was low in almost all the patches. A total of 198 species of birds were identified among various habitat types in the study area. The maximum number (37) of species was recorded in marginal forest, followed by the water bodies (36 species) while the lowest number of bird species (27) were recorded in Tall wet grasslands. The bird diversity and richness marginally differed between different grassland patches. However, the species composition differed among different grassland patches. A total of 530 villages were within the boundary of the HWS. Villagers were dependent on it in terms of fire wood, collection of grasses for fodder, extraction of Phragmites grass for commercial purposes and for grazing. More than 20,000 cattle heads belonged to the villagers were dependent on the area of about 350 sq. km, while nomads coming in during summer season additionally exert pressure on the grasslands. Most of the cattle concentration was near the barrage where sizable grassland extent exists. The extent of human dependence varied among various patches. The extent of pressure was found maximum on the northern side of the HWS where people from about 30 villages extract Phragmites grass. The extraction of Phragmites grass started just after the monsoon, during last September and early-October and reached its peak during December to early-March. During the peak season, an average of 98 truck load of grasses was extracted while non-peak season it varied between 40 and 50 trucks per day. While identifying of viable areas for conservation, it was found that grasslands between Bijnor barrage and Jogawala were the most suitable sites for long-term conservation and preservation of the representative of Gangetic Grassland Ecosystem. These patches were also found most vulnerable due to the high biotic pressure; nevertheless they could rejuvenate to their original state if protection was accorded to them. Other patches were too small, isolated and surrounded by the cultivation and hence, were found more vulnerable to extinction as conversion into crop field was easy.

Gangetic grasslands and *Kholas* had existed in the HWS since antiquity, while agricultural fields and roadsides represented disturbed habitats, the result of anthropogenic activities. Unhindered flow of floodwater was the lifeline of any swampy eco-system as it recharged the swamps, which dry up during summer season. Construction of a barrage across Ganga in early-1980s had largely altered the character of swamps in the sanctuary by controlling the flow of floodwater. Moreover, construction of roads in this area had rendered the swamps and *Kholas* vulnerable to human encroachment.

6.16

DEVELOPMENT OF GIS BASED INFORMATION SYSTEM FOR THE COAL MINING AREAS OF WEST BENGAL

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INTRODUCTION

Coalfields of West Bengal comprising mainly of Ranigunj coalfield with smaller pockets forming the Bajora and Birbhum coalfield cover an area of approximately 1500 sq. km in these districts. Ranigunj coalfield is the birthplace of coal mining in India where the coal mining operations were started by Summer & Heatly way back in 1774. Currently, the coalfields contain good quality non-coking coal reserves of nearly 25890 million tonnes locked up in 104 blocks. Out of these, 59 blocks are being worked by Eastern Coalfields Limited (ECL), a subsidiary of Coal India Limited (CIL). In the coming years, ECL plans to expand its mining operations to 22 more blocks. Out of the remaining 23 blocks, 13 have been identified for captive mining and 10 are still free-hold.

The area is characterized by intensive coal mining operations, both opencast and underground. ECL runs 116 mining units, while 44 new projects are either planned or at various stages of implementation. Besides mines, there are two major steel plants, thermal power stations, and a number of small-scale coal-based industries in the area. The area is also interspersed with two major railway routes, a number of state highways and a national highway.

Various industrial and related operations leave a marked effect on the environment of the area. Surface subsidence and opencast mining operations have degraded vast tracts of land. A number of fire zones also exist in the area. Immense amount of solid wastes, industrial effluents and air pollutants are generated daily by the coal mining and other related industrial activities. All these affect the riverine systems of the two major rivers of the area, groundwater, air quality and pubic health. Therefore, these environmental systems in the area need a systematic assessment so that future planning of industrial operations in the area can be made in a cost-effective and sustainable manner. Development of an environmental information system is a primary and vital step towards that direction.

OBJECTIVES

To develop an information system, for storing, retrieving and analysis of environmental data of mining areas of West Bengal

STUDY AREA

The districts of Burdwan, Birbhum, Puruliya and Bankura in West Bengal

METHODOLOGY

- Collection of secondary information,
- Generation of primary data, and
- Data synthesis and analysis with Geographic Information System (GIS).

RESULTS/OUTPUTS

All the maps/plans and data were collected from different agencies. GIS package was used to store the data and to create different maps for analysis. The analysis capability of GIS was used to analyse the data. A dynamic data exchange environment was created by using Visual Basic software. The front-end of the MIS is a package developed in Visual Basic, which instructs and gets all the work done by the GIS software. Shell programming was done to create menus with which a non-GIS user will be more comfortable and could use the package without any problem. In every module, necessary helps were provided which could be used in the case of any problem in operating the package. The program is user friendly and to make the program more useful to the user, two types of help have (Context sensitive help and a min help) been provide. All the intricacies of GIS were programmed as script programs and these script programs were executed by the Visual Basic (VB) interface which was totally understandable by the user. This eliminates the requirement of having knowledge of GIS by the user.

Various environmental maps, as required periodically, could be generated by the program at ease. Users if interested can use some of the commands of ILWIS GIS if familiar with it. The program had an inbuilt database design to maintain the environmental data of the coal mining areas of West Bengal. There was no duplication of data so chances of redundancy of data were eliminated. The raw data generated by the industry could be directly stored by the program and maintained in a systematic manner.

6.17

INVENTORY AND MONITORING OF SHIFTING CULTIVATION AND FOREST ECO-SYSTEM IN MANIPUR

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INTRODUCTION

The North- East (NE) mountain regions are characterized by the permanent conflict between the need for conservation of natural resources on one hand and constantly growing population and land-use pressure on the other. They are fragile regional eco-systems in which the increasing deforestation and forest degradation have direct impact on the entire ecological infrastructure, e.g. hydrological and soil resources. A conflict-prone frontier is formed between the traditional home of various hill tribes, characterized by a wide variety of ethno-specific land-use systems like shifting cultivation and fast-expanding population of the lowland areas. These problems are typical for the region's tropical mountain areas, in other words, these are not area-specific. The present study was an attempt to make inventory and monitoring of shifting cultivation and forest eco-system in Manipur.

OBJECTIVES

- To assess the current state of vegetation patterns in an integrated manner through remote sensing (RS) and Geographical Information System (GIS),
- To make inventory and monitor the ecological changes due to shifting cultivation in forest areas by GIS and remote sensing through evaluating the spatial and temporal change analysis, and
- To prepare soil conservation plan based on identified environmental problems and which may be executed by State Forest Department.

STUDY AREA

Five districts of Manipur state, namely, Chandel, Churachandrapur, Senapati, Tamenglong and Ukhrul.

METHODOLOGY

In the present study the forest cover of 1988 was analyzed by using the Landsat satellite data which was found to be 14, 263 sq. km. Image extraction, noise removal and radiometric calibration, geometric correction and cloud masking of the satellite data were undertaken. In data analysis, spectral characterization for land-cover mapping was done by season selection, Normalized Difference Vegetation Index (NDVI) and advance red, green, and blue (RGB) clustering were also done. The land-cover classification was made by digital image processing (DIP). Land-cover change detection and monitoring were also done. The Moderate Resolution Imaging Spectroradiometer (MODIS) data was used to monitor the forest fires and present shifting cultivation processes.

The study has indicated an increase in the forest cover from 1988 to 2003, which is about 2610 sq. km. The average rate of shifting cultivation in all the hill districts was 690 sq. km approximately. Based on the databases of vegetation and shifting cultivation, it was clearly inferred that the loss of the vegetative cover was not only due to the shifting cultivation, but other factors such as logging, etc. also contributed to the forest loss. The reforms in the customary / traditional tribal laws as well as contribution (scientific input and financial assistance) from the state government are required to maintain the forest ecosystem in a sustainable manner. The entire process was followed by accuracy assessment for vegetation maps prepared for the period 1988-2003 and identification of portions that required major modifications.

RESULTS/OUTPUTS

The study has revealed the status of forest ecosystem, deforestation and forest degradation, the extent of the shifting cultivation practices, their impact on the forest land and the ecological changes in the hill districts of Manipur. The application of the remote sensing data and GIS was done to acquire the information for the past 15 years (1988-2003). It was found that there were lot of changes in the vegetation cover in Manipur; however, the growth of vegetation was compensated by natural regeneration due to tropical condition.

The hill districts of Manipur constituted an area of 20,000 sq. km approximately, in which the forest cover was 17,418 sq. km, 17,071 sq. km, 16,688 sq. km and 16,870 sq. km in 1997, 1999, 2001 and 2003, respectively (FSI, 1997, 1999, 2001 and 2003). It indicated that the total loss of the forest from 1997 to 2003 was of 548 sq. km. It was observed that in Manipur, shifting cultivation was mainly practised by tribal families in the five hill districts, viz. Chandel, Churachandrapur, Senapati, Tamenglong and Ukhrul. The 1997 assessment showed that the maximum shifting cultivation was practised in Churachandrapur district at an area of 29.32 sq. km (6.41%), while the minimum i.e. 8.46 sq. km (1.86%) in the Ukhrul district. The forest in Churachandrapur was decreased by 162 sq. km, while the forest cover of Ukhrul increased by 315 sq. km. The extent of shifting cultivation had increased in all the five hill districts of Manipur in a span of 15 years (1988-2003). The satellite data revealed that shifting cultivation was practised maximum in Churachandrapur and least in Tamenglong. The reason was more population in the district. The geographical area of Ukhrul was found maximum, whereas the population was less than that of Churachandrapur district. The Senapati district had minimum shifting cultivation area as it was located along NH-39. The farmers were more involved in cash cropping and the sites of shifting cultivation were not being shifted frequently. The less population in the Tamenglong district, which was quite isolated due to lack of road network, had very less cash cropping and as a result, the rice cultivation was more encouraged. The shifting cultivation practice was done mostly during the long fallow period which gave a scope for natural regeneration of the forest cover.

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EVALUATION AND GENERATION OF GEOCODED SPATIAL DIGITAL DATABASE ON VARIOUS NATURAL RESOURCES OF THE EASTERN GHATS OF TAMIL NADU: PHASE-II

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INTRODUCTION

From the time mankind came into existence on earth, it has depended on the natural resources on it for most of its needs. Due to population explosion, limitations in the non-renewable resources and disrespect to the sustainability of any resource, availability of various natural resources for the coming generations is at stake. Therefore, conservation and sustainable utilization of the natural resources have emerged as two most important aspects of 'Resource Management'. Hence, taking current stock of the various natural resources available and planning for their judicious utilization have assumed greater significance. Hills are the major repository of several natural resources and render a great service to the mankind. The resources in the hills are unsustainably extracted resulting in irreversible loss of several precious natural wealth. More over the information available on the status of natural resources in the hilly terrain is very scant. Among the three major hill ranges, viz. Himalayas, Western Ghats and Eastern Ghats, the Eastern Ghats has experienced very high degradation due to extreme anthropogenic activities. Eastern Ghats, a rugged hilly terrain running almost parallel to the eastern coast of India, constitute the watersheds of many rivers. The Eastern Ghats broadly cover three regions namely,(i) Southern Orissa highland, (ii) Chittoor and Cuddapah district of the Rayalseema region in Andhra Pradesh, and (iii) Hills in Tamil Nadu. The present study is aimed at evaluating various natural resources in the Eastern Ghats of Tamil Nadu. Computer and software have emerged as effective and efficient tools in almost all walks of life. Geospatial technology is one of such modem disciplines in which spatial and non-spatial information on earth and its resources is digitally managed. Hence, the present study envisages generating digital database on the natural resources on common reference, viz. geographic latitude/longitude, to facilitate integration of more than one theme for the preparation of a resource management package or identify a location to our specific need.

OBJECTIVES

- Preparation of multi-thematic spatial layer on 1: 50,000 scale on natural resources such as landform; forest cover, land-use/land-cover, soil, minerals and water,
- Transferring of thematic spatial data to Geographic Information System (GIS) environment for integrated resource management plans, according to administrative units like district, taluka and block,
- Collection of socio-demographic data and storing it in a GIS layer for modelling purpose,
- Undertaking spatial modelling for selected objectives like land suitability assessment from the thematic layers generated, and
- Preparation of geocoded spatial digital database in CDs form, to be incorporated in any information system and used for monitoring, planning and decision-making.

STUDY AREA

The Eastern Ghats (EG) of Tamil Nadu. In Tamil Nadu, it starts from the Jawadi and extends up to the Alagar hills and comprises, Jawadi, Elagiri, Shevaroy, Chitteri, Kalrayan, Bodamalai, Kolli, Pachaimalai, and Semmalai, Aiyalur range, Karandamalai, Sirumalai and Alagar hill. In the Nilgiri district - a mountainous region rising at the tail end of the Eastern Ghats, and it is the meeting point of the Western and the Eastern Ghats. Most of the tributaries of many perennial rivers like Pennaiyar, Palar, Vellar, Cauvery and Vaigai originate from these regions. The area of each hill ranges from 70 sq. km to 1,860 sq. km. The minimum and maximum altitude of this region ranges from 180 m above mean sea level (MSL) to 1,700 m above MSL at the foothill and Sholaikaradu of Shevaroy hill, respectively.

METHODOLOGY

All relevant, primary and secondary data were collected from all possible sources. Thematic maps like base map, administrative boundary map, contour - slope map, drainage density map, and watershed were prepared using the Survey of India (SoI) toposheets. These were digitized using AO size digitizer. Forest type and cover density maps were prepared from the latest IRS ID LISS III image and digital data of 7 March 2003 using visual interpretation and digital image processing techniques, besides ground verification. The base map, reserve forest (RF) boundary map and administrative boundary map showing range/section/beats boundaries from Tamil Nadu state forest department maps were prepared and overlaid on the forest type/cover density map using ARCIINFO 8.0.2. Landform map was prepared from the IRS ID LISS III data and the corresponding SoI toposheet were traced and digitized at 1:50,000 scale using AO size digitizer. Maps for all the 13 hills were prepared using remote sensing data, socio-economic and field data. For preparation of soil map, sufficient pits were excavated which were well distributed in various landforms and soil samples were collected from various horizons and analyzed for their physico-chemical properties. From the results, soil taxonomy, texture, capability, irrigability and soil suitability, etc. were assessed and maps were generated for all these spatial themes with the help of results of field data and the IRS 1 D LISS III FCC. Similarly, for preparation of water map, surface and groundwater potential were assessed following run-off co-efficient approach and rainfall recharge method, respectively. Water level in different seasons, i.e. pre-monsoon,

monsoon and post-monsoon were recorded from the existing wells and water samples were also collected from various sources like tank, well, pump and streams.

Data on the human and cattle population was collected from the Census India, 2000 and population profile was studied to understand the legitimate demand of the local population on the forest produce and the potential status of the forest resource to respond to the needs of the people. Integrating various thematic layers of soil, water, forest and other physiographic characteristic in the GIS domain, land potential and utilization status were assessed to identify the area with high resources potential but with low utilization status, as these were the potential land resources for further development. Using the various thematic layers, modelling was designed to identify areas of special interest for conservation and development using GRID module of ARC/INFO.

RESULTS/OUTPUTS

All the thematic maps were digitized and stored in the GIS domain (Arc GIS/Arc View) on common geo-reference. Modelling protocols were developed for selected themes. Various classes in each thematic map were ranked and weightages were assigned to each theme for a specific package and the map was generated using Arc GIS by weighted arithmetic overlay analysis. Such an exercise was, however, conducted only for limited objectives, though; the concept could be followed to any query by suitably selecting the thematic layers and ranking the classes. The product thus produced was transferred to the digital database. The 'Data Mining Tools' were also developed. It was felt that digital database needed to be in usable form or retrievable form to the user's specifications. In other words, the utility value of the database, which was presently standalone, could be enhanced only by making it easily retrievable with minimum computer knowledge. Hence a 'Value Added Digital Data Base' on the natural resources of Eastern Ghats of Tamil Nadu was generated. This tool could be further improved by making it a web-based tool, accessible to users by providing facility of downloading on the computer. The capability of the tool could also be enhanced considering the user's need. The present study could be considered as a model to generate digital database on natural resources in other regions.

IDENTIFICATION AND MAPPING OF LESSER FLORICAN BREEDING SITES TO DEVELOP A FODDER PRODUCING GRASSLAND NETWORK IN WESTERN INDIA

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INTRODUCTION

Once common and wide spread, hunting pressures and loss of habitat have resulted in the Lesser Florican *Sypheotides indica*, being critically endangered today. The Lesser Florican breeds during the south-west monsoon in the western India in grasslands where the grass is allowed to grow long. Such grassland sites, known as *beed*, *vidi*, *rakhal* or *jod*, are owned by individuals, collectively or singly, and by the Government. The grass *beed* is traditionally protected from livestock grazing during the monsoon and the grass is harvested, baled, stored and used during summer or droughts. These protected grasslands are, therefore, crucial to the well-being of agrarian and pastoral economies. Less than 7000 sq. km of grass *beed* is left now (less than 2000 sq. km of which is suitable to the Lesser Florican) and is seriously threatened by conversion into agriculture or degradation into grazing lands.

In the western Indian context, the protected fodder-producing grass *beed*, will form the corner stone for any initiative to develop a network of conservation areas in the region. While surveys in the past have identified many of these grassland sites, there is an urgent need to map these areas so as to better manage and protect them, and most importantly, to assist managers in preventing encroachment and conversion. Proper maps of these grasslands can also form the basis on which legislation can be enacted, that prevent the conversion of valuable fodder-producing grasslands to other uses.

OBJECTIVES

- Ti identify new grassland sites where significant populations of the Lesser Florican breed, so as to develop a comprehensive conservation area network for this species and other grassland-dependent species,
- To define the boundaries of grassland clusters where the Lesser Florican breeds to develop pragmatic and well-defined sites for this species and other grassland-dependent species, and
- To advocate the management and restoration of grasslands for people and Lesser Florican.

STUDY AREA

Twelve clusters of grassland sites in Saurashtra and Kutchchh, the Malwa Plateau (western Madhya Pradesh, southern Rajasthan and eastern Gujarat) and central Rajasthan

METHODOLOGY

- Surveying the grassland and its periphery on foot/vehicle measuring latitude longitude readings at periodic intervals using a GPS. As grasslands occur in clusters, four clusters of grasslands will be surveyed each year.
- Superimposing the GPS readings of the boundaries of the grassland of each cluster on PAN data from satellite imageries and producing maps showing the boundaries of the grasslands with reference to villages, towns, agricultural and grazing lands.
- The population of the Lesser Florican assessment total counts of displaying males.
- Surveying on foot to estimate the population of the floricans visiting the site and assess the quality and suitability of the grassland. The new sites will also be mapped.

RESULTS / OUTPUTS

This report has collated the data collected on the Lesser Florican in western India between 1989 and 2007, and has provided a detailed account of the issues facing this critically endangered species, prescribing management and conservation measures that will lead to the increase in fodder production in western India. The report has also mapped the grasslands in which the species currently breeds.

The Lesser Florican was found to breed in three distinct clusters of grasslands in western India. These clusters were: (1) Malwa Plateau, (2) Saurashtra and Kachchh, and (3) Central Rajasthan. The number of floricans that breed in each cluster varied. The most consistent breeding took place within the Malwa Plateau, since compared to the other two areas, the Malwa Plateau has the highest rainfall, the maximum number of rainy days, and the least monsoon variation between years. Breeding was less consistent in Suarashtra, and the least consistent in Kachchh and central Rajasthan, since these areas are more drought-prone and inter year variability in monsoon is high.

In the Malwa Plateau, there were four distinct sub-clusters of grasslands in which the floricans were found breeding: (1) Panchmahal district, Gujarat, with a population of about 10 -15 males; (2) Jhabua and Dhar districts, Madhya Pradesh, where between 25 and 50 males breed; (3) Ratlam district, Madhya Pradesh, where between 75 and 100 male Lesser Florican breed; (4) Pratapgadh Tehsil, Chittaudgadh district, Rajasthan, where between 30 and 50 male Lesser Florican breed. In central Rajasthan, the Lesser Florican were found breeding in both east and west of the Aravallis, and there were three sub-clusters: (1) in the Ajmer district, the Lesser Floricans were found breeding in the grasslands and croplands mosaics and about 20-30 males were present. (2) Around Shahpura, in Bhilwara district, about 20-30 males were also found. (3) In Palli district, very few Floricans were found and probably 10-15 males were found scattered in mosaics of grassland and cropland. The Lesser Floricans were found breeding in a number of places in Sausrashtra and Kachchh, and four distinct sub-clusters were evident: (1) Velavadar National Park, Bhall, Bhavnagar where about 40-50 male Floricans were found breeding, (2) Junagadh district, where less than 10 males were settle to breed, (3) Rajkot and Jamnagar districts where up to 60 displaying makes were found, and (4) the Nalliya / Vengaber / Konathia / Bachunda *don* in Abdasa taluka in Kachchh where over 100 displaying males have been recorded.

There has been a little change in either quality or extent of government-owned grasslands between 1989 and 2007. The situation with privately-owned grasslands was however alarming. Based on the known loss of habitat (qualitative) amongst areas that have been studied in the past, it was estimated that in the Malwa Plateau, between 50% and 70% of private grasslands had been converted to agriculture or leased to grazing between 1989 and 2007. It is a very alarmingsituation because: (a) the Malwa Plateau is the most important part of the breeding range of the Lesser Florican as this area is the least drought-prone, and (b) the majority of the florican's grassland breeding habitat in the Malwa plateau are privately-owned. In Rajasthan, apart from the loss of privately-owned grasslands, whose extent appears to be similar to that of the Malwa Plateau, the government-owned grasslands had been considerably degraded due to infestations of the weed *Prosopis juliflora*. The result was that many of these grasslands had little value for both fodder and the Lesser Florican. However, the Forest Department has begun actively eradicating this weed from some of the Grasslands (e.g. Gudda Endala *jod*, Pali), which should improve the quality of these grasslands in the coming years. There has been loss of privately-owned grasslands in Gujarat, but the government-owned reserved *vidis* continue to be in very good health.

It was found that hunting with guns or snares, continues to be widespread. In the 1999 survey, at least in two localities there had been hunting incidence, being done by the local villagers. `Sportsmen' from cities and towns also shoot florican still. The actual extent of hunting pressures and the number of birds killed is still unknown.

Insects form a large part of the diet of the Lesser Florican. The birds extensively use crop fields during the breeding season and presumably throughout the year. The effects of the indiscriminate use of pesticides in agriculture on the Lesser Florican are unknown.

ASSESSMENT OF BIODIVERSITY AND PREPARATION OF CONSERVATION PLAN FOR THE FOREST OF NORTH GUJARAT REGION, GUJARAT

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INTRODUCTION

Now-a-days the loss of earth's biological diversity has become one of the most critical environmental and developmental issues. Inspite of India being one of the six mega diversity countries and having two hotspots, the surveys on biodiversity have been restricted to few regions. In India, biodiversity assessment has been carried out in parts of Western Ghats and Himalayas. There is a strong emerging consensus that it is imperative for conservation that efforts are extended beyond protected areas. Literature review has shown that there has not been any detailed and holistic biodiversity assessment of the forested areas of the North Gujarat Region (NGR), which is highly essential for framing a proper strategy to conserve the landscape and its biodiversity. The present study aims at the preparation and evolution of conservation strategies based on sound field-based data.

OBJECTIVES

- Assessment of biodiversity, and
- Preparation of conservation plan for the forest of North Gujarat Region (NGR).

STUDY AREA

North Gujarat Region (NGR) is located in the northern part of Gujarat state with its northern boundary bordered with Rajasthan state and comes to 2,768 sq. km. It lies between 23^{o} 35´ 13.0" to 24^{o} 30´ 57.0" North latitude and 72^{o} 10´ 28.0" to 73^{o} 24´47.0" East longitude.

METHODOLOGY

The approach followed for assessing the biodiversity was compilation of existing information from the secondary sources, mapping of vegetation and biodiversity using GIS and remote sensing and field-based data. Collection on floral, fauna, habitat and threats was done by putting grids in the entire area map into 30 sec x 30 sec. Minimum 5% of grids were selected for sampling in each vegetation type according to their extent. In each vegetation / forest type species and component specific methods were used for data collection. All the information was fed into GIS domain to derive various biodiversity hotspots. Based on this, conservation plan was also prepared. The determination of disturbance regime study was done in two ways, firstly by using the field-based data and deriving the disturbance regimes using GIS and secondly, by using the GIS-based analysis carried out on the image and vegetation map prepared from the image. Distribution and extent of CBAs and hotspots was also undertaken. The distribution maps of disturbance and floral and faunal diversity of each grid were brought into GIS domain to integrate different layers along with the fragmentation map. Indigenous knowledge survey was also undertaken in 6 taluka.

RESULTS/OUTPUTS

Forest was the most predominant land-use type in mapping of forest/vegetation types, covering 1,638 sq. km (59.18%), of the total study area. Agriculture was the second dominant land use with 622 sq. km (22.5%) and was very common in the valleys that also included encroachments. Rocky barren extended to about 485 sq. km (17.5%), while mining areas were spread over 15 sq. km and water bodies were spread over 8 sq. km. The forest area was further classified into different types, which resulted in 4 categories, viz. (i) Dry Deciduous Forest (DDF) , extent of 802 sq. km (48.96%), (ii) Moist Deciduous Forest (MDF) , extent of 37 sq. km (2.26%), (iii) Open Scrub Forest (OSF), extent of 586 sq. km (35.78%), and (iv) Tropical Thorn Forest (TTF) , extent of 213 sq. km (13%).

On studying diversity of flora and fauna, it was found that out of overall 414 plant species, 335 were dicots and 79 monocots. The total species in the study area, recorded through grid sampling, belonged to 251 genera and 77 families. They were represented by 16 life forms or habits, which was dominated by the herbs with 147 species belonging to 89 genera and 33 families, while large trees with 81 species of 56 genera and 31 families were the second dominant form. The abundance status of flora based on grid-based quantification showed that a majority of the species were very rare (72.71% & 301 species). Among different forest types, DDF had the maximum number of species, i.e. 362 belonging to 223 genera and 74 families at a diversity of 4.35 and a ground cover of 36.4 %. In the faunal group among invertebrates butterflies were marked by the presence of 86 species belonging to 64 genera, 17 sub-families and 5 families and spiders 50 species of 31 genera and 13 families. Among vertebrates, a total of 36 (amphibians 8 and reptiles 28) species of herpeto fauna was recorded, belonging to 16 families and 27 genera with an overall diversity of 2.6. Birds were predominant, represented by 228 species of 139 genera and 47 families and at a high diversity of 4.17, while mammalian group recorded in total 27 species from 25 genera and 17 families. The herpeto faunal taxonomic diversity in different forest types showed that DDF had a comparatively high species richness of 29 belonging to 24 genera and 14 families at a moderate diversity of 2.53. Birds were more in Open Scrub Forest (OSF) with 195 species of 123 genera, 44 families and a high diversity of 4.12. Mammals were found to be more in DDF with 27 species similar to that recorded in the entire study landscape. Group and guild-wise diversity and abundance status was also studied. There were some threatened species as well in the study area. On the whole 33 species of flora and fauna recorded in NGR were under threatened and near threatened categories Among this threatened biodiversity, 8 were floral species and rests were faunal species. Within the faunal species, 6 were herpeto fauna, 14 were birds and 5 were mammalian taxa.

The magnitude of threats were discussed in terms of temporary threats like habitat degradation, pollution and developmental work and also permanent threats such as habitat loss that included mining, encroachment, tree/wood cutting, soil loss, soil removal, stone removal, spread of invasive species and human settlement. The areas of high, moderate and low disturbances were identified and the distributions of these areas were discussed pertaining to conservation of biodiversity. Biodiversity hotspots and critical areas were also identified. The floral and faunal data was used to identify the diversity and was given positive scores, while the disturbances or threats were given negative scores. Both these were added and were further classed into high, moderate and low biodiversity hotspots, in addition to identifying Critical Biodiversity Area, (CBA) which were the areas having both biodiversity and disturbance at higher level. A large portion of the study area fell under CBA, identified and evaluated using the grid based sampling data subjected to GIS analysis, which needed immediate attention, from the conservation point of view. Further, the diversity at different bio-diversity hotspots was studied using permanent transects and the details were obtained. Inventory of landscape and different forest types was made. In addition, the inventories were carried out in the entire NGR which provided information on the overall list and based on which the status was observed. The overall status of the flora in the NGR landscape was 743 species belonging to 394 genera and 105 families. This included 19 life forms of which herbs were dominant with 268 species of 143 genera and 51 families. The forest-wise assemblage revealed that maximum species richness was recorded in OSF, which had 539 species of 321 genera and 87 families with 160 species documented only in this forest. Among the faunal groups, in total 41 species belonging to 29 genera and 16 families were documented through inventory in the study landscape. Among these 8 species were amphibians of 6 genera and 3 families, while reptiles were represented by 33 species from 23 genera and 13 families. The total number of bird species in the landscape was 292 out of which 73 were wetland birds species belonging to 169 genera and 53 families, which included 9 guilds. The mammalian fauna in the entire landscape based on diversity revealed the presence of 32 species belonging to 28 genera and 17 families. It was observed from the indigenous knowledge survey that since the majority of the villages inside the forest were from Amirgadh and Danta taluka, therefore the maximum villages i.e. 19, belonged to Danta and 11 villages to Amirgadh taluka. In total 101 respondents were interviewed to collate information on conservation and availability status of the resources/biodiversity. Information on status of forest, resource dependency, fodder management, past and present status of minor forest produce and strategies for sustainable resource availability were collated and used in the preparation of conservation plan.

For making conservation plan, exercise of determination of disturbance regime was undertaken. The analysis showed that a majority of 57 sample grids, which formed 46.72% had high disturbances, followed by 53 (43.44%) with moderate disturbance and 9.84% (12) of the 122 grids sampled with low disturbance. It was, thus, apparent that the entire forest region was subjected to high to moderate disturbances. A majority of the study landscape, i.e., 2,019.26 sq. km area was under moderate level of disturbance, which formed 73 % of the total study landscape. The area with high and low levels of disturbance was spread over 391.35 (14 %) and 359.43 (13%) sq. km of the study area, respectively. While studying the spatial distribution of biological richness, the analysis showed that, overall 56 grids had high floral and faunal diversity, which formed 45.90% of the grids sampled. 50 grids forming 40.98% had moderate diversity, while 16 (13.11%) grids secured low diversity status. It was thus evident that the forest of NEG harbour high to moderate floral and faunal (biodiversity) diversity. The extent of different diversity status showed that 59% of the NGR was with high floral and faunal diversity. The moderate diversity was recorded over 36% of the area, while only 5% of the area with low diversity, which clearly showed that the study of landscape had high to moderate floral and faunal diversity.

During identification of hot spots and critical biodiversity areas (CBA) and conservation priority areas (CPA), the analysis revealed that 36.89% or 45 of the grids sampled were High Biodiversity Hotspots (HBH), while maximum of 51 grids or 41.80% were identified as Moderate Biodiversity Hotspot (MBH) and only 26 or 21.31% of the grids had Low Biodiversity Hotspot (LBH). The forest type-wise hotspot analysis revealed that HBH were more in MDF (71.4% of grids sampled) and TTF (61.11% of grids sampled), while in DDF and OSF, MBH were more which formed 48.08% and 42.22% of grids studied, respectively. Distribution and extent of CBAs and Hotspots was undertaken. The distribution maps of disturbance and floral and faunal diversity of each grid were brought into GIS domain to integrate different layers along with the fragmentation map. This clearly showed that the maximum area of 1574.40 sq. km in the study landscape fell under critical areas with a spread of 57% of the total study area. These areas were with high floral and faunal diversity, which was also influenced by moderate to high disturbance factors and were of immediate concern from biodiversity conservation point of view. The extent of area with high biodiversity was very less, which covered 184.37 sq. km and formed only 7% of the total area, while areas with moderate and low biodiversity were 545.20 sq. km or 20% and 464.70 sq. km or 17% of the study area, respectively. The critical bio-diversity areas (CBA) and the hotspots (LBH, MBH and HBH) identified based on the study aided in identifying the priority areas for biodiversity conservation. High conservation priority needed to be given to the CBAs and the areas of different levels of biodiversity identified within it. In total there were 89 grids that were selected for sampling the biodiversity within the CBA of which least number of 18 or 20.23% of the grids were with low biodiversity, while maximum of 40 or 44.94% were with moderate biodiversity. High biodiversity was recorded in 31 or 34.83% of the grids. Conservation strategies for priority areas and for low biodiversity, moderate diversity and high diversity areas were detailed, in addition to specific strategies for the CBAs.

The problems and strategies to develop connectivity of Linking Corridors (LC) was also studied. Striking balance between the long-term objectives of biodiversity conservation and immediate needs of the communities living in an area was one of the most pressing challenges facing resource managers. Therefore, these strategies have been developed. Habitat Restoration Plan of the study area was made. Seven sites were identified in the entire landscape for Habitat Restoration (HR), which was presently faced with the threat of forming a larger gap between patches within mainly the central (Balaram-Ambaji) part, where 6 HR sites (HR1 to HR6) were identified. The 7^{th} HR site was in the eastern part (Vijaynagar). Regional Environmental Plan was also laid down. Efforts were made to identify the major areas of biological diversity, which included HBH, MBH, CBA, area with high concentration of threatened species so as to keep out these areas when planning to lease out for different types of mines. Plans for conservation of sensitive and threatened species were also detailed. Strategies of Strict Regulation for Vehicular Traffic, Change in Forest (Conservation) Policy and Act and themes for Research and Monitoring were also given as part of conservation plan.

FOREST ENCROACHMENT MAPPING USING REMOTELY SENSED DATA AND GEOGRAPHIC INFORMATION SYSTEM IN THE MANIPUR STATE

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INTRODUCTION

Today, forests are more threatened than in the past, owing to the increasing population pressure and the forests being diverted to non-forestry land uses. In 2003, the forest and tree cover area in the country stood at 23.64 % of the country's geographical area. It is not at per the national policy of having the forest in 33 % of the geographical area as envisaged in the first Forest Policy enacted in 1952. The meagre amount of forest constitutes about 1.8 % of the global forest, which supports 17 % of human population and 18 % of bovine population. The Government of India has been initiating various activities not only to ameliorate the health of the forest but also to bring more areas under forest cover. An important task, in this direction, has been the identification of forest encroachment and removal of forest encroachers. In the National Forest Policy (NFP) enacted in 1988 and reviewed from time to time till 1992, Govt. of India had requested every state to implement this policy in letter and spirit and to remove the encroachment at the earliest, Earlier, Govt. of India had issued circular in 1990 laying down the procedure to be followed by the state governments to regularize eligible encroachers and the mechanisms for review of disputed claims. However, most of the state governments have ignored these circulars of Govt. of India and have not even constituted the Committees to oversee the implementation of the policy. Hence, the present project was perceived to map the forest encroachment using latest remote sensing data and Geographic Information System (GIS). As a pilot study, the project was taken up in the state of Manipur.

The Manipur state is bounded by a series of parallel hills, which cover 9/10th of the total geographical area of the state. The plains consisting of the Manipur Valley cover an area of about 2,238 sq. km. The state has sub-tropical monsoon to temperate climate, depending on the elevation. The rainfall varies from 1,016 mm to 1,778 mm a year. The valley is one of the most thickly populated areas in the country with a density of 633 persons per sq. km as compared to an all-India average of 324 persons per sq. km. The hills are sparsely populated with 52 persons inhabiting per sq. km. The state experienced a rapid growth of population, registering a decadal population growth rate of 30.02% during 1991-2001 against the national average of 21.34%. The three-valley districts cover 1/10th of the total geographical area of the state, whereas 9/10th of the total population is settled there only. Geologically, Manipur state belongs to the young folded mountains of the Himalayan system. The rocks in the State vary from upper cretaceous to the present alluvium. Altitudinal zonation of the state ranges from 40m above msl at Jiribam bordering Cachar district of Assam to 2995m (Mt. Iso) in Senapati district bordering Nagaland state. There are three distinct major river basins, viz. the Manipur river basin draining towards south, the Barak river basin draining into Assam/Bangladesh and the Chindwin (Myanmar) river basin.

OBJECTIVES

- To map and estimate recent status of forest encroachment using remote sensing data,
- To design and organize GIS database for the entire state of Manipur, and
- To work out statistics of total area under encroachment vis-a-vis total forestland.

STUDY AREA

Entire Manipur state situated between 92°59' to 94°45' East longitude and 23°50' to 25^{0}41' North latitude, covering an area of 22, 327 sq. km.

METHODOLOGY

Satellite data was analyzed using hybrid techniques of digital and visual interpretation as there were lot many overlapping signatures of the features such as actual fallow land and jhum fallow land, standing crop agriculture land and recently regenerated forest in abandoned jhum area, etc. The final analysis was carried out in GIS environment. Ground truth design maps at 1:50,000 scale were prepared for verification of classification accuracy. A list of doubtful areas was prepared identifying from interpreted map for ground verification. In selecting the point's accessibility, geographical positions were also considered. Ground truth survey was carried out in May 2006 along with the officials of Manipur Forest Department and scientists of Manipur State Remote Sensing Centre. The Hybrid Analysis was done. This procedure was a typical mix of visual and digital analyses. Standard product (FCC) with its pre-specified lookup tables did not provide significant contrast discrimination of various thematic features of interest. Therefore, to facilitate the core of the interpretation technique various digital enhancements were also generated for IRS-P6-LISSIII data. The best suitable enhancements were used for analysis.

A total of 95 points were checked for different classes, and 89 points were correctly classified. Only 6 points were found misclassified as agriculture instead of regenerated vegetation/grass. Various types of encroachment status in the Manipur state like under RF/PF/NP and also under unclassified forests was found.

RESULTS/OUTPUTS

The analysis carried out using March-April 2006 IRS-P6 LISS-I11 data, revealed the forest encroachment under various land-use/land-cover classes as given in the following table.

Status of Encroachment in Manipur State

Sl. No	Type of Encroachment	Encroachment under RF/PF/NP@ (sq. km)	Forest Land under Non-Forestry Use#
1	Current Jhum (Shifting Cultivation)	832.38	358.04
2	Abandoned Jhum	626.95	346.54
3	Permanent Agriculture	348.37	23.89
4	Settlement	51.94	6.95
	Total	1859.64	735.42

@: Total area under RF, PF and NP was about **5638** sq. km

#: Total area under Un-classed Forest was about **11581** sq. km

Thus the encroachment under RFIPFINP was 10.80% of the total notified forested areas and about 6.35% under un-classed forested areas. It showed that RF/PFINP was under more threat than un-classed forest.

Jhum cultivation was found as one of the main practices contributing to deforestation and degradation of forests in the state. In the North-Eastern region, over 64% of the geographical area comprises hills. High precipitation coupled with mountainous terrains gifted this region a habitat of a large number of widely spread forests tree species. In 1995, the dense forest area was 5,318 sq. km and in 1997 it was reduced to 4,937 sq. km, while the open forest area increased at the rate of 20 ha/day approximately.

In Manipur, jhumming was mainly practised by the tribal families in five hill districts, viz. Chandel, Churachandpur, Senapati, Tamenglong and Ukhrul. The system essentially consisted of felling of the forest on a hill slope in November-December and burning of the debris in April-May, before dibbling the seeds into the cleared soil.· Sowing in June was followed by weeding in July-August, and in September - October crops were generally harvested. As many as 30 species of crops were grown during the first year, and in the second year, only paddy, tapioca or bananas were mainly cultivated. The land was usually abandoned after two years of cropping as it losses the fertility by then and the jhummia family shifts to another site to repeat the similar process. The time gap called jhum cycle between two consecutive slash and burn events had shrunk with phenomenal increase in tribal population and had now reduced from 20-30 years in the past to about 5 years. The reduction of jhum cycle had transformed the lush tropical evergreen forests into barren rocky lands or degraded secondary vegetation, as it promotes growth and development of certain exotic weeds, which have now, became a real menace in the hills of Manipur. These weeds not only reduced the fertility of the soil but they also competed for the available space, thus resulting in meagre crop yields.

Some of the peculiar features prevailing in the hill districts of Manipur state were: The state had no well-defined, strictly, efficiently and uniformly enforceable property rights. Three distinctly different properties rights were found in the state. In the hills, the property rights system was governed by traditional unwritten laws and conventions. The hill areas were mainly occupied by the tribals that were broadly classified into NAGA and KUKIS. Among the Nagas, the community ownership was accepted. The entire village was said to have belonged by tradition to the Village-Chief. However, the individuals were permitted to operate with inalienable rights. The land-use pattern of the Nagas had certain clear-cut-divisions. First, they had house-sites which by and large permanently belong to them. Second, surrounding the house-sites there was protected area where no felling of trees was allowed. This protected area serves as a defensive well against fire and other attacks. Third, beyond this protected area, there was cultivated land. The Kukis had land under the ownership of the Chief only. He was by tradition, the sole authority over the use of land. The lands were however, made available to the individual members for agricultural purposes subject to the payment of grain - rent. The new phenomenon causing concern was the rising population of landless families. Besides, investment in land for improvement in both cases was not made in the absence of inspiring urge of individual ownership.

The third was the private-property ownership system that prevailed in the valley. Individual owners had sole rights of land-use and transfer. But, in the absence of effective public law, misuse of land was on the rise. The land in the hills was not cadastrally surveyed as it was not under the purview of the Manipur Land Reformation Act. In Naga Villages, most of the lands belonged to some handful of village individuals. Though historical records of jhum cultivation exist, sometime, villagers encroached on protected forest land for jhum cultivation destroying the forest. In most of the Kuki inhabited Villages, the land belonged to the community. However the village authority, though elected, is comprised of few individuals related to the Village Chief who had all the rights to the land, rendering mass of people landless. The Jhum period was reduced to 3-4 years, which resulted in mass conversion of hilly slopes into barren land. The people dwelling in the hilly terrain were accused for jhum practices, which had a negative role in the environment. But as such no solution had been suggested for an alternative means. They depend entirely on jhum cultivation just like farmers were dependent on their farm lands or agriculture field. There was no other alternative for a person living in this terrain for their source of livelihood. Transport bottleneck and lack of proper market had doubled their miseries. This hill terrain had high potential for plantation of citrus fruits, tea and coffee plantation, etc. But, due to lack of proper market, storage and roads it could not fetch any market value. The district of Ukhrul had a high potential for eco-tourism with breathtaking scenic beauty and the presence of the world endangered Shiroy lily (*Lilium mcleanium*) blooming in the Shiroy hills of Ukhrul district. Besides, the Dzuko valley situated at an altitude of 3000 metre above mean sea level (msl), which was like a paradise on earth, was bestowed with beautiful flowers and a number of hillocks. The valley was situated in Senapati district and had high tourism potential. The state of Manipur was also blessed with a number of lakes in the valley area which had a direct relation with the hills. Vigorous jhumming at the hills had resulted in heavy siltation in the valley areas, thereby leading to loss of a number of wetlands. Loktak, a Ramsar site and home of the world famous brow antlered deer Sangai (*Cervus eldi*) was in a critical condition due to heavy siltation from the adjoining hills of Senapati and Churachandpur districts.

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FOREST FIRE DYNAMICS AND VEGETATION REGENERATION ANALYSIS USING REMOTE SENSING IN BANDIPUR NATIONAL PARKS OF WESTERN GHATS

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INTRODUCTION

The gigantic Western Ghats of Peninsular India are among the 18 hotspots of the world selected for biodiversity conservation. Floristically, the Western Ghats is one of the richest areas in the country, harbouring as many as 4,000 species of flowering plants of which 56 genera and 2,100 species are endemic. Fire is the most spectacular natural disturbance that affects forests. The diversity of the forest landscape often bears witness to the passage of earlier fires. Fire has a devastating effect on the landscape, and its impact is felt at every level of the ecosystem. Nevertheless, fire is an essential factor in the maintenance of the diversity and stability of forest ecosystems. However, forest fires make sustainable forest management difficult. Fires cause negative effects on the stability of nutrients, flora and fauna, soil structure; and ecological stability. All these changes cause an unfavourable environmental impact and can contribute to global climatic changes. In certain areas, fire is of frequent occurrence and it necessary for the reproduction of forest tree species. Fire thus becomes part of the long-term dynamics of these ecosystems, in the same manner as climate. By affecting part of an existing forest, fire initiates secondary successions, thus renewing the vegetation through regenerating, involving a complete change of species, regeneration of the same species and diversification of the species. The present study was perceived to examine the forest fire dynamics and vegetation regeneration analysis using remote sensing in the Bandipur National Parks of Western Ghats

OBJECTIVES

- Analysis of 10-year satellite data to assess fire-prone areas,
- Identification of fire intensity zones on the ground,
- Generation of baseline information with respect to vegetation composition and soil characteristics,
- Assessing variations in fires season and soil moisture,
- Assessing the succession dynamics of forest regeneration and phonology,
- Detection of potential for fire incidences based on meteorological parameters like temperature, humidity, precipitation, wind speed and direction, etc., and
- Evaluation of the existing fire management system in the study area.

STUDY AREA

Bandipur National Parks of Western Ghats. The Bandipur Park and Tiger reserve are situated in Mysore and Chamarajanagar district of Karnataka, respectively. The area lies between 11°35´34" and 11°55´03" North latitude and between 76°12´and 76°51´ 32" East longitude. This national park was formed by including most of the forest area of the then Venugopala Wildlife Park and its sanctuary at Bandipur in 1974, but published in 1985 gazette, extending over an area of 874.2 sq. km and was named as Bandipur National Park.

METHODOLOGY

The present investigation was conducted using several data sources such as satellite images, topographic maps and other collateral data obtained from government and non-government organizations as well as through field surveys. These data were analyzed and mapped using advanced tools like remote sensing and Geographic Information System (GIS). The Survey of India (SoI) toposheets pertaining to the study area were used for geo-referencing of satellite images, creation of cultural features and ground truth collection. Satellite data of 10 years, i.e. between 1997 and 2006 was obtained from National Remote Sensing Agency (NRSA), Hyderabad. Preference was given to the late-summer season to ensure that all the fire events were covered. The satellite data so procured were digitally rectified and processed, for preparing different thematic maps, viz., land-use/land-cover, drainage network, forest type and vegetation mapping, etc. Mapping was done on 1:50,000 scale. Also, satellite data of multiple years was used to study the changes in cropping pattern, and delineation of waterlogged and salt-affected areas.

The burnt area estimation was carried out for summer season using Indian Remote Sensing (IRS) satellite. The ground truth data was collected keeping in view the severity of fire burns and the type of vegetation cover affected by visiting sample burnt area. All the satellite images were brought to a common database and further processed to estimate spatial extent. A combination of multispectral threshold and supervised classification as mentioned above using minimum distance criteria was adopted to discriminate and delineate burnt areas. The fire-prone regions were identified by integrating vegetation type, density, proximity to road and settlements, slope and past history of forest fire occurrence. The IRS multispectral data acquired for the period 1997 to 2006 was used for vegetation mapping using AX 11/780 image processing system. All the nine ranges of the Bandipur National Park were broadly classified into four major classes, namely (i) Semi Evergreen (SE), (ii) Moist Deciduous (MD), (iii) Dry Deciduous (DD), and (iv) Scrub Land (SL). Among these, DD forest occupied the largest area 451.49 sq. km, followed by MD forest i.e. 342.89 sq. km, SL 71.04 sq. km and least was recorded in the case of South East (SE), only 2.74 sq. km. The spatial extent of density was assessed. The major density classes were divided into four classes, viz. 0-10, 10-30, >30 and miscellaneous.

RESULTS/OUTPUTS

The results showed that among all the classes, density class of 10-30 had a larger area, i.e. 598.39 sq. km, followed by >30 class i.e. 213.55 sq. km. While 0-10 class and miscellaneous class recorded lesser density, the dry and sparse vegetation was obviously more susceptible to fire than the moist and dense ones.

The burnt area was assessed in all the nine ranges of the National Park from 1997 to 2006. The fire occurrence was found less during the period 1997 to 2006. The result indicated significant variations in fire incidence and area damaged in different ranges studies. The total burnt area during this period was 15.44 sq. km, of which the Gundre range suffered more fire incidences, followed by Bandipur and Moyar. In 1999, a wide variation in the extent of fire damage was observed in Gundre range, 72.63 sq. km, followed by N. Begur, 43.05 sq. km, and Ainur Marigudi range, 21.45 sq. km. The magnitude of fire damage was observed low in this year in all the nine ranges of the national park, accounting to 17.80 sq. km and minimum was in N. Begur, i.e. 2.01 sq. km. The fire incidences were not recorded in Ainur Marigudi, Gundre, Moyar and Bandipur ranges during this year. During 2001, the fire damage was considerably low in all the nine ranges of the national park. The fire incidence was absent in some of the ranges like Hediyala, Gundre, Maddur and Bandipur ranges. The Moyar range experienced maximum damage, i.e. 10.42 sq. km and minimum was in Moliyur range, i.e. 1.02 sq. km. During 2002, the extent of fire damage was observed to be moderate in all the nine ranges of the national park, accounting to 77.66 sq. km. Moliyur range, i.e. 23.32 sq. km experienced maximum damage, while it was least in Bandipur range, i.e. 0.2 sq. km. The value range between 16.21 sq. km in Gundre and 0.3 sq. km in the Moyar range.

During 2003, the prevalence of fire was found to be more in the Moliyur range, i.e. 23.89 sq. km and less in Bandipur range, i.e. 0.36 sq. km. It was in the range of 19.36 to 2.51 sq. km in Moyar and Maddur ranges, respectively. During this year, the fire damage was considerably high as compared to the during past five years. Gundre recorded a maximum of 48.64 sq. km, followed by Hediyala, 22.42 sq. km, while the fire incidence was not observed in some of the ranges like Moyar and Bandipur. The fire had its heavy toll in the year 2005 as compared to the previous 10 years wherein a total of 226.51 sq. km was subjected to fire damage accounting for 25.45 % of the total area. Among all the nine ranges, the fire damage was recorded maximum in Moyar, i.e. 98.12 sq. km, while was least in Moolehole, i.e. 2.56 sq. km. The extent of fire damage ranged between 56.15 sq. km in Moliyur range and 5.36 sq. km in Gunder range.

During 2006, the total area exposed to fire was 93.26 sq. km. The highest incidence of fire occurred in the Moliyur range, followed by Bandipur. The extent of forest burnt in Moolehole and Maddur was almost the same. It was evident from the above that a greater portion of Bandipur National Park faces the risk of fire almost every year. The repeated burning of this type, both ground and above ground levels had virtually introduced visible changes in the density of vegetation. Larger areas of this park had become the habitat of weeds; also patches of bamboos were seen here and there. The results of the fire intensity zone map clearly showed that the fire incidence had spread all over the National Park area of 305.21 sq. km over the period of time. The area under high fire intensity alone was recorded to be 78.25 sq. km and was in the high rise of fire occurrence in near future. Therefore, proper measures need to be taken to locate fire areas and employ effective fire management practices, thereby preventing large-scale destruction to the forest resource. Nearly 43% of the Bandipur National Park has experienced the fire during the past one decade. Fortunately, 14% of the total fire-affected area has experienced low intensity fires.

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CONSERVATION OF ECOLOGICALLY SENSITIVE AREAS HOTSPOTS IN INDIA - AN INTEGRATED APPROACH THROUGH REMOTE SENSING AND GEOGRAPHIC INFORMATION SYSTEM

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INTRODUCTION

The Indian subcontinent is one of the most distinct bio-geographical regions of the world with a rich repository of biological resources. As a consequence of unregulated exploitation, environmental and ecological degradation, the element of biodiversity is heading towards alarming depletion coupled with fragmentation of nature habitat. Habitat destruction, as a direct consequence of human activity, as reported by UNEP in 1995, accounts for the current species extinction rates exceeding historical global extinction rates by 1,000-10,000 times . So there is an urgent need to create reliable database in terms of qualitative and quantitative inputs for restoration, rehabilitation and conservation strategies in the Ecologically Sensitive Areas (ESAs) in the country. These ESAs are those specific areas having natural, cultural and geographical value or fragile/susceptible to factors of deterioration in the ecological balance. These areas have to be identified, inventoried and prioritized for conservation and restoration in ecologically similar and environmentally suitable locations. Keeping this in view, an attempt has been made to prioritize areas for conservation, locate areas for restoration and identify species composition to be rehabilitated in two test sites, viz. (i) Mudumalai Wildlife Sanctuary (MWS) in Tamil Nadu, and (ii) R.V. Nagar Area in Visakhapatnam, Andhra Pradesh.

OBJECTIVES

- To identify, inventoriz and prioritize ecologically sensitive areas-hotspots in India using remote sensing and GIS, and
- To evolve an integrated approach for the conservation and restoration of ecologically sensitive areas of India.

STUDY AREA

Two test sites, viz. (i) Mudumalai Wildlife Sanctuary (MWS) in Tamil Nadu, and (ii) RV Nagar Area (RVNA), Visakhapatnam in Andhra Pradesh. The MWS lies on the northern and north-western side of the Nilgiris between 11°32' and 11°43' North latitude and 76°22' and 76°45' East longitude on the inter-state boundaries with Karnataka and

Kerala and covers an area of 325 sq. km with rich bio-diversity. The RVNA range is situated between 17° 48' to 18° 00' North and 82° 02" and 82°16" East in Visakhapatnam, Andhra Pradesh and covers an area of 312 sq. km with high species diversity and wealth of medicinal plants.

METHODOLOGY

Multi-temporal satellite data were independently classified after geometric and radiometric normalization corrections. Using quadrate method, the vegetation along the gradient in terms of its structure and composition, biodiversity index, stems/ha and basal area/ha were studied with respect to altitude, slope aspect, rainfall regimes and drainage density. The one km buffered point location of rare, endangered/endemic and threatened species (RET species) were integrated in GIS domain and generated to get RET Index Map. Threat Index Map was also created by buffering the roads and settlements by one km. The forest-cover changes in 1 sq. km grid were analyzed from 1973 to 2005 for MWS and 1988 to 2008 for RVNA Range identify the grids having negative forest-cover/type changes to represent Sensitive Index Map. These maps were overlaid and classified into high, medium and low threatened categories.

The integrated study using sensitive index, threat index, RET index maps coupled with CMI maps proved to be of immense help in prioritizing the zones for bio-prospecting and biodiversity conservation strategy, Such prioritized zones were further recommended for conservation management plans as genetic pool areas. The study highlighted the usefulness of satellite remote sensing and Geographic Information System (GIS) for decision-making and implementation of conservation of high biodiversity areas, restoration and rehabilitation programmes in critical areas of protected areas in India.

The phyto-sociological data collected at different elevations, slopes and aspects in the study area were assessed for stand density, basal area per hectare and biodiversity index. Through GIS analysis, the areas of higher values of these 3 parameters were considered to be the best suitable conditions for prioritizing the conservation area representing as Conservation Measure Index (CMI) when segregated. Keeping this in view, very high resolution satellite data from IRS ID PAN and IRS P6 LISS IV was used for selection of the contiguous patches having more than 10,000 hectares. Out of the three such patches, two patches were discarded based on existence of frequent fire affected/disturbed areas and also in low rainfall regimes of dry deciduous open type of forest cover. Only one patch was fulfilling the criteria of having contiguous patch of more than 10,000 hectares in high rainfall and least affected fire zones associated with semi evergreen/moist deciduous forest zones. The areas were demarcated and identified as Very Potential Sites for Conservation Areas (VPSCA) and recommended for further intensive ecological studies and site level habitat conservation.

RESULTS/OUTPUTS

In Site-I, i.e. Mudumalai, a total of 90 sample plots of 0.1 ha size were laid in all vegetation types, viz. Tropical Semi Evergreen Forests (TSEF) - 11, Tropical Moist Deciduous Forests (TMDF) - 25, Dry Deciduous Forests (DDF) – 36, and Thorny Shrub Forests (TSF)-18. Care was taken to cover different elevations, slopes and aspects to study their influence on the number of individuals, and species, and Simpson index with special emphasis on stems/basal area per hectare and diversity. About 498 individual life forms, i.e. trees-156, shrubs-90, herbs-214 and climbers-61 were collected. The biodiversity index derived from Shannon and Weiner index was recorded high in TSEF with 5.26, followed by TMDF with 4.90, thorny scrub forests with 4.52 and DDF with 3.94. The Simpson index was recorded high for MDF and Scrub (0.94), followed by riparian (0.92) and DDF (0.86). The margalef species richness index was recorded high for TMDF (8.31), followed by DDF (6.28), riparian (5.61) and scrub (4.61). The Pielou index was recorded high for Scrub (0.12), followed by riparian (0.11) and TMDF & DDF (0.060).

In Site-II, i.e. R. V. Nagar area, a total of 45 sample plots of 0.04 ha size were laid and 188 samples from individual trees were collected. The high stems per hectare 719 in the case of TMDF but high basal area of 49.2 in TSEF was recorded. The biodiversity index derived from Shannon and Weiner index was recorded high in TMDF with 5.50, followed by semi evergreen with 5.27 and Savannah forests with 3.71. The Simpson index was recorded highest for TSEF (0.96), followed by TMDF (0.95) and Savannah (0.91). The Margalef index was recorded high for TMDF (9.50), followed by TSEF (9.13), and Savannah (3.04). The Pielou index was recorded high for Savannah (0.21), followed by TMDF (0.07) and TSEF (0.06).

The habitat of highly threatened species was characterized for identifying the similar areas for further exploration and subsequent conservation, restoration or rehabilitation. About 40 RET species in Mudumalai and 17 species in R.V. Nagar were collected. In Mudumalai, 5 species namely *Torenia hirsute* (herb), *Zmgiber cemum* (herb) and *Acttnodaphne malabarica* (tree), *Ampelocisus araneosa* (climber), and Andrograpnis lineate (herb) were found to be in high alert category. But in RV Nagar, Nothopegia heyneana was found to be only critically threatened category. All the point locations of RET species recorded have been recommended for protection and restoration of their habitat. Considering that these species were in danger of losing its entity, the ecologically similar and environmentally suitable areas have been identified to rehabilitate these species through conditioning of topographic and environmental inputs in GIS domain.