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Application of Remote Sensing and GIS in Inventorying Natural Resources and Land & Water Resources planning for Sustainable Development in Arunachal Pradesh

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Abstract: Remote Sensing and GIS is effectively used in mapping and monitoring of natural resources available in the state for their proper and judicious utilization. The state has been facing problems of geo-hazards, land degradation, shifting cultivation, difficult terrain condition, besides inadequate road communication network connecting various parts of the state and lack of basic amenities and infrastructure in many parts. Keeping the above problems in view and their impact on environment and ecology a number of mission-mode projects have been initiated and executed during the last 15 years.

Keywords: Remote sensing, GIS, Natural Resources, Land and Water resources planning, Sustainable development, Arunachal Pradesh

I. INTRODUCTION

Increasing population and their pressure on land resources and their injudicious utilization have been considered as serious problem in India. The situations have led to the development of various strategies for these resources management with appropriate science and technology intervention. Until the use of aerial survey during '70s the natural resources survey and mapping were conducted using conventional methods and these methods are found to be more expensive, time consuming and with limited accuracy as compared to advanced state-of-the-art remote sensing technique. The remote sensing technique has been found to be multidisciplinary activity dealing with inventory, mapping, monitoring and assessment of natural resources through analysis of aerial and satellite data.

Remote sensing programme was started in the year 1970 when aerial survey was conducted to study coconut yield disease in Kerala. Till 1988 India had to use exclusively the data obtained from LANDSAT satellite of USA. India had successfully launched first IRS (Indian Remote Sensing) series of satellite IRS-1A in the year 1988 and this was followed by launching and operationalisation of a series of satellites IRS-1B, 1C, 1D and recently RESOURCESAT, CARTOSAT, OCEANSAT satellite. These satellites have higher and higher resolutions, repeativities and more applicability in diversified fields. The easy availability of repetitive data in the temporal domain from remote sensing techniques provides a new dimension to spatial information processing and monitoring the features of the Earth and generates a large volume of information.

1.1 Advantages of Remote Sensing

1. The entire study area including inaccessible areas could be brought into the laboratory and seen on the images for analysis.
2. Availability of data on temporal basis.
3. Availability of multispectral data.

1.2 Limitations

1. Cloud cover
2. Spectral similarities of the objects also pose problems while interpreting the satellite images.

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This means that features like fallow versus cultivated lands (when crop was not present), scrub, vs. degraded forest areas, barren area vs. open lands etc. could not be easily separated with one season satellite images. Categories such as double crops, deciduous and evergreen forest also needs multi-season satellite images for meaningful interpretation and mapping.

II. METHODOLOGY

Using Digital Image Processing (DIP) softwares like ERDAS and ArcGIS, interpretation of various themes are carried out using multi-spectral and multi-temporal satellite data depending on the requirement of various studies. The base information like settlements, drainage, roads are extracted from the Survey of India (SOI) toposheets of corresponding scale and updated using the satellite images. Thereafter, the interpretation is carried out using interpretation keys based on tone, texture, location, association etc. The land and water resources action plans are prepared following Department of Space standardized guidelines (Fig.1). Cadastral mapping is carried out using high resolution images from IKONOS, Ground Control Survey with Differential GPS and Total Station and Ground measurements.

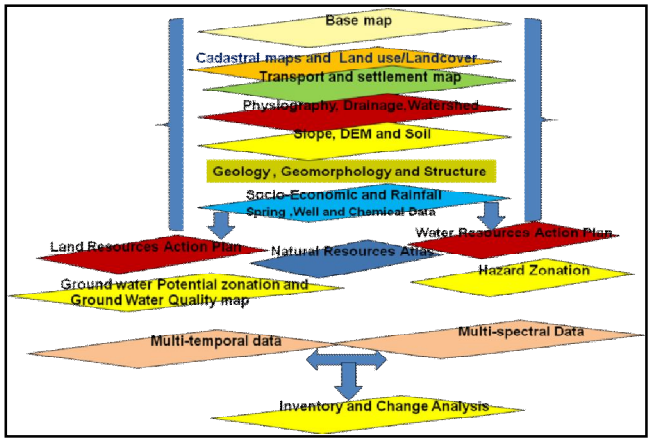

Fig.1 Layer stacking depicting methodology for resources inventory and action plan maps for land and water resources

III. DISCUSSION

In the following segments we discuss on how the thematic maps on Land use/ Land cover, Geomorphology, Slope, Soil, Drainage & Watershed, Settlement and Transport network were generated on 1: 50K scale under various projects. The thematic maps were integrated with the socio-economic database to generate Action plans Land and Water resource development. Further, we are continuously inventorying the Land use/Landcover status of the status and doing change analysis to understand Land use dynamics in Arunachal Pradesh.

3.1. Land and Water resources development plan

In the following paragraphs we discuss the various programmes wherein and action plans are prepared for Land and Water resources Development.

3.1.1. Integrated Mission for sustainable development (IMSD)

A study was taken up in parts of East Siang, covering 850 sq. km. area and encompassing four circles viz. Pasighat, Bilat, Ruksin and Oyan. Thematic maps on Land use/ Land cover (Fig.1), Geomorphology, Slope, Soil, Drainage & Watershed, Settlement and Transport network were generated on 1: 50K scale. The thematic maps were integrated and the socio-economic conditions of the people were considered to generate Action plans Land and Water resource development.

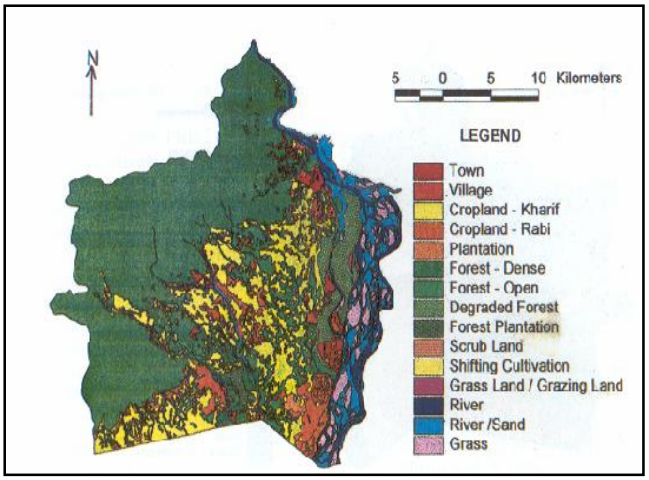

Fig. 2. Land use/cover map of Pasighat area

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3.1.2. Model Village Developmental plan

Developmental plans for thirteen villages of Arunachal Pradesh were prepared to develop each village as an ideal / model village with respect to food production, health, education, economic activities and other amenities etc. The Action plan map of Ramsing village of Upper Siang District in given in Figure 3.

Fig.3. Action plan map of Ramsing Village, Upper Siang District, Arunachal Pradesh

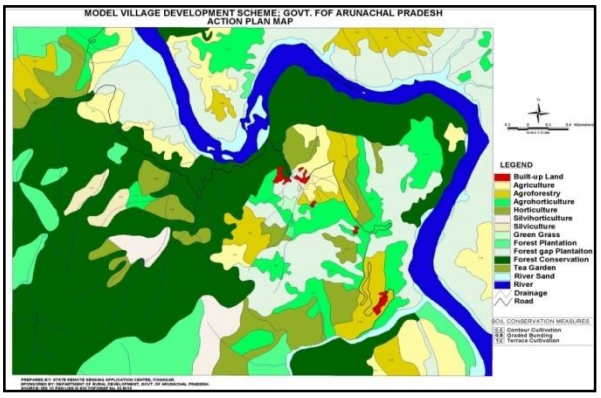
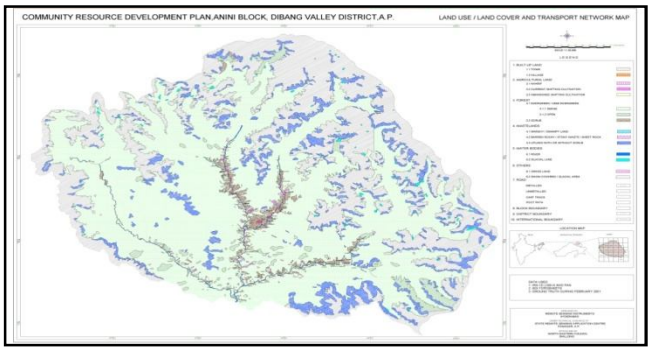


Fig.4. Cadastral map of part of Itanagar Capital complex



3.1.3. Cadastral Surveys

The cadastral surveys were carried out in Itanagar capital complex (from Banderdewa to Chimpu), Laaying-Yangte and Yachuli and cadastral maps were prepared along with Land holding registers. A part of Itanagar town is shown in Figure 4.

3.1.4 Community Resources Development plan

The thematic maps on Landuse / Landcover (Fig.5), slope, geomorphology and soil, drainage and watersheds were prepared and socio-economic data are collected. Based on these thematic information, action plans for Water resources and Land resources were suggested for parts of uplands area of Anini block, Dibang Valley and Lohit District.

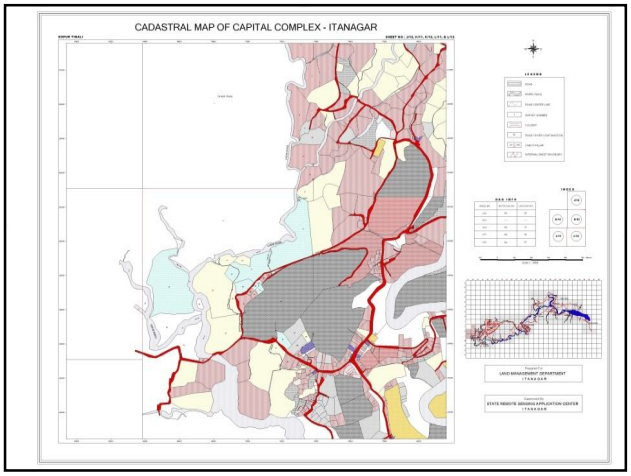


Fig.5. Land use/Land cover and Transportation network map of Anini block of Dibang Valley

3.1.5 Reconnaissance survey in Hydro Electric project sites

Thematic maps such as land use/ land cover, slope, soil erosion, geomorphology, lineaments, geology were prepared on 1: 50K scale for the entire catchment and 1:12500 scale for the dam site area. Digital elevation models (DEMs) are prepared using contour information from Survey of India Topomaps to generate 3D perspective view of the Damsite area. The DEM (Fig.6) and slope map generated using Remote Sensing and GIS techniques helped in the identification of the elevation differences and the slope variations along the study area. Demarcation of the landslide sites has further helped in knowing the direction of debris flow movement and thus

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information is utilized to align the approach road, which is less prone to landslides.

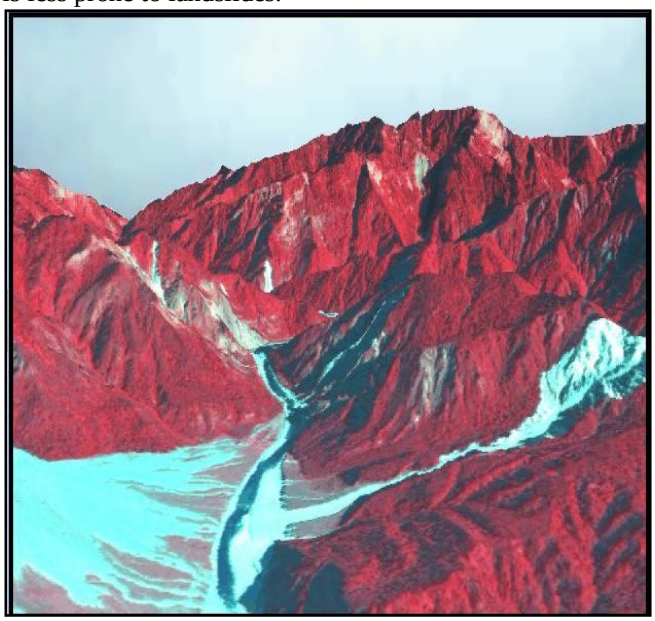

Fig.6. DEM of Lower Dibang Valley

3.1.6. Urban management Information System and Decision Support System

Perspective Land use and Transportation plans were prepared for the Itanagar capital complex for urban renewal. This was a landmark project initiated by the Technology Information Forecasting Assessment Council, Department of Science and Technology, under the MATURE Sub-programme. Based on Traffic analysis and existing land use in the capital city, plans for 30m ROW, 20m ROW were designed in CAD which is being implemented by the Urban management Department (Fig.7). A customized GIS tool for Decision Support System (DSS) is created using ESRI AVENUE and VISUAL BASIC. A Menu system was developed to perform spatial queries.

Further, mapping is initiated in Aalo and Daporijo town under National Urban Information System (NUIS) programme of Indian Space Research Organisation. Landuse/landcover, geomorphology, physiography, soil, transport, drainage and water bodies and lithology maps are prepared using CARTOSAT data on 1:10,000 scale and Urban Information System was created.

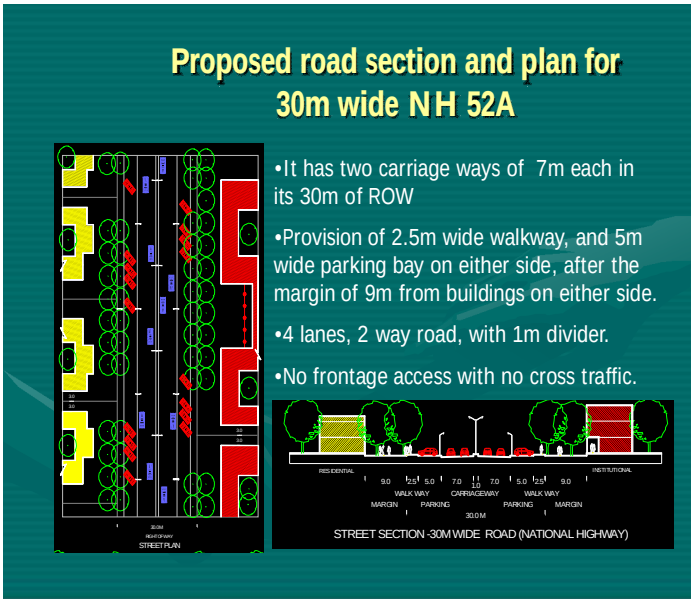

Fig.7. CAD aided plan for 30m ROW NH-52A

3.1.7. Rajiv Gandhi Drinking Water Mission

Groundwater potential zonation maps (Fig.8) were prepared for entire state on 1:50K scale. Further land suitability was also studied for the locating recharge structures and recharge pits. Further, ground water quality maps are being prepared in coordination with Public Health and Engineering department, Government of Arunachal Pradesh using ground water and surface water chemical data.

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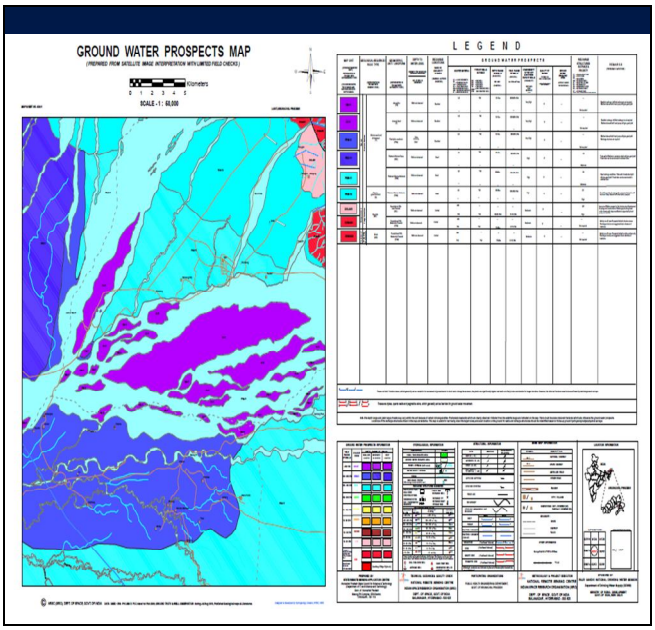

Fig.8. Ground water prospect map of part of Lohit District

3.2. Geo-Hazard mapping and mitigation measures (Earthquake/Landslide/Flood Hazards)

Arunachal Pradesh has been very much prone to disasters especially Flood, earthquake and landslide. Every year flooding affects people, livestock, agricultural lands and public property. This is a common problem at Seijosa in East Kameng, Likabali in West Siang, Pasighat in East Siang, Roing in Lower Dibang Valley, Tezu & Namsai in Lohit District, Diyun in Changlang District (Source Water Resources Department, Govt.of Arunachal Pradesh). Action plan maps have been prepared for the entire study area on 1:50K scale suggesting action plans for different flood hazard zones and also for the catchment area. Among the general actions suggested are strengthening of existing bunds / embankments and construction of new bunds and embankments where required and construction of rehabilitation shelters at safe levels. In the severe and very high flood zones it is suggested that construction of permanent houses and buildings be avoided and stabilization of slopes through terrace cultivation. In the high flood hazard zones it is suggested to take up agricultural activity after the monsoon season. Planned developmental activities can be under taken in these zones. In the low and moderate flood hazard zones developmental activities like agricultural plantation, terrace cultivation should be taken up and new settlements can be contructed. For effective flood management and mitigation, treatment in the catchment area is absolutely necessary as the rivers and their tributaries carry a lot of top soil from the catchment area during floods. The measures suggested are conservation of existing forests, afforestion in open and degraded forests and in abondoned shifting cultivation areas, channel diversion and decongestion of streams and rivers wherever required and soil conservation measures like construction of suitable structures like check-dams, brush wood dams etc.

The integration of maximum magnitude, percentage probability maps, lithology, structure Earthquake Hazard zonation maps are prepared to demarcate areas likely to experience earthquakes of certain magnitude with certain percentage probability in the study area. From this integration six hazard zones have been identified and delineated. Considering the vulnerability of terrain with thrusts / faults, high fracture density / frequency and flat and gently sloping landforms, which are normally the sites of human habitation and settled cultivation, the earthquake hazard zones have been modified giving due weightage to these factors. The six hazard zones identified are severe, very high, high, moderate, low and very low.

Factors causing landslides have been identified and have been assigned appropriate weightages. Based on the cumulative weightage of all the possible causative factors for each slope facet like lithology, structure, landforms, slope class, relative relief, land use/land cover, rainfall and anthropogenic activity etc. landslide hazard zones have been delineated into 5 classes viz. very high, high, moderate, low and very low on 1:50K scale maps (Fig.9). Information on the spatial distribution of active or dormant landslides as identified on the toposheets and satellite imagery was used to validate the methodology. Maps on earthquake zonation, landslides zonation and flood prone areas were prepared for entire state. Vulnerability analyses of villages were carried out with respect to each hazard and Disaster Management Information System was generated.

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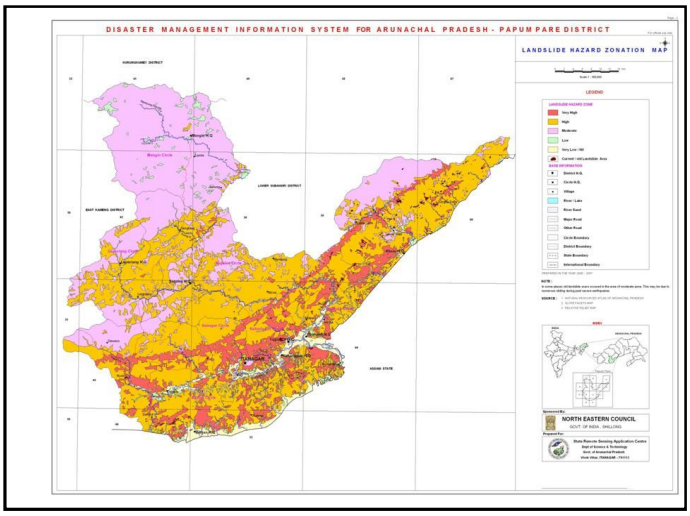
Fig.9. Landslide hazard zonation of PapumPare District



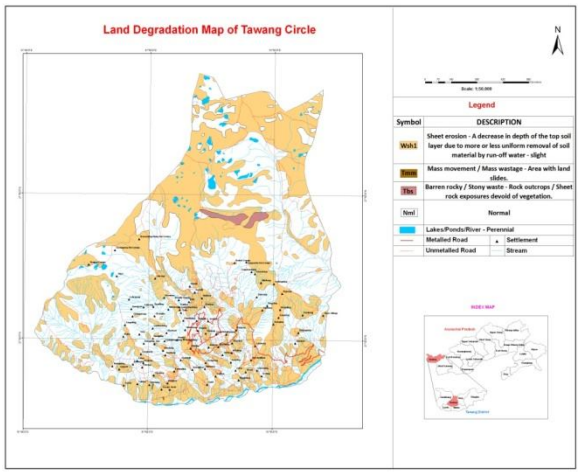


Fig.10. Land degradation map of Tawang circle

3.3. Land Degradation and Soil erosion

Using satellite data areas of sheet erosion, mass movements barren rocky areas etc. were mapped and statistics were generated for entire Arunachal Pradesh (Fig.10). The database was found very useful for the planners and researchers.

IV. INVENTORY AND CHANGE ANALYSIS

4.1. Natural Resources on 1:50K

. The technology, over the last two decades, has matured to provide valuable and timely information for a variety of resources. Digital database in the form of an Atlas on various natural resources like land use/land cover, forest types, slope, hydro-geomorphology and soil resources of Arunachal Pradesh was prepared on 1:50K scale (Fig.11). The inventory provided information on 1:50K and proved to be a milestone work till date, as the database is being used by all the line departments.

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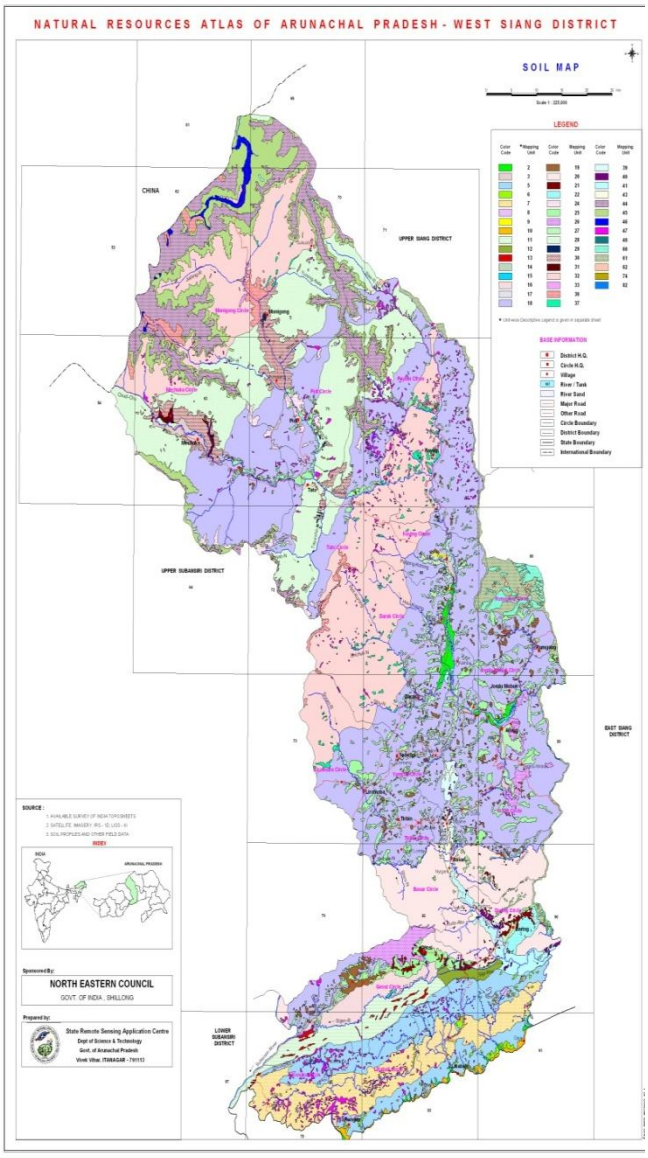

Fig.11. Soil map of West Siang District

4.2. Wasteland Change Analysis

Mapping of various categories of wastelands (Fig.12) as per Govt. of India Wasteland classification was done in all the districts of Arunachal Pradesh on 1: 50K scale. The wastelands in the State has and percentage (%) of change from 2005-06 to 2008-09 were analysed. Arunachal Pradesh have witnessed (+) 10.93% of change over 2005-06. This is due to conversion of non-wasteland into wasteland because of various reasons like shifting cultivation, etc,.

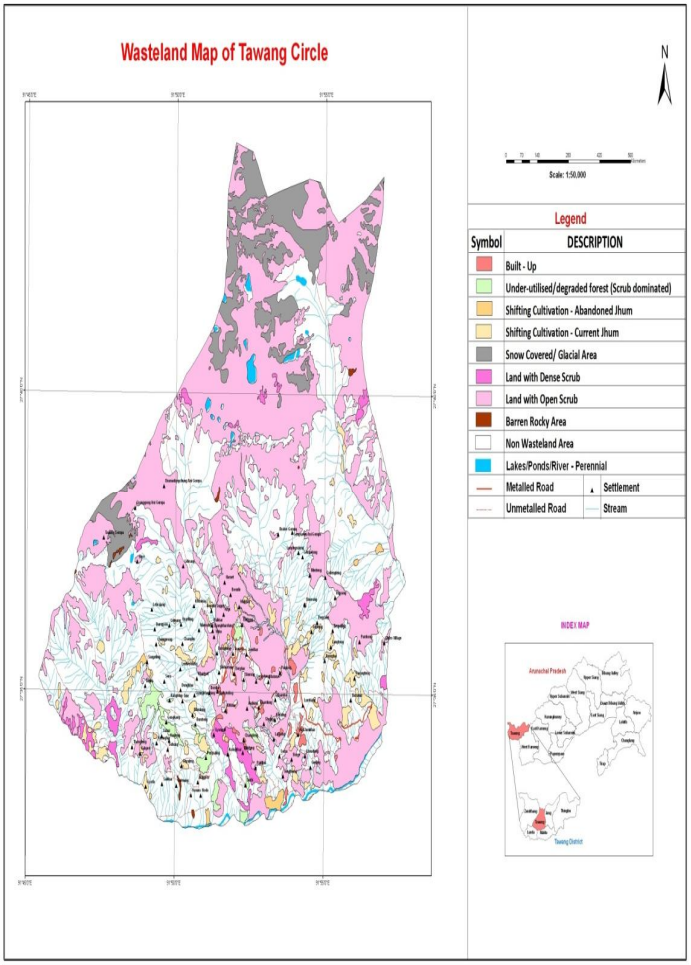

Fig.12. Wasteland map of Tawang Circle

4.3. Shifting cultivation area change Analysis

Spatial distribution of shifting cultivation areas and recommendation of suitable settled/permanent cultivation is essential in the state. Therefore, to study the changes in the extent of shifting cultivation areas

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over the last 10 years at an interval of 5 years starting from the year 2000-01 to 2005-06 and from the year 2005-06 to 2010-11, mapping is being initiated using multi-temporal satellite data in ArcGIS . An Action Plan will be prepared based on the existing Landuse /Landcover and the topographic information like slope, suggesting the areas suitable for settle cultivation.

V. CONCLUSION

Various studies were taken up in the Centre with an objective of utilizing Remote Sensing and GIS technique for inventory, mapping and monitoring of the vast natural resources and generating sustainable development plan for land and water resources and also for effective planning for any developmental activities of the State, addressing various problems of the state. The outcome of the various studies is shared with the User Departments for implementation of Action Plans.

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