# Efficient Management of Natural Resources for Improving Livelihood of Tribal Cluster Village using Remote Sensing and GIS

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***Abstract* - Natural resources play an important part in the livelihood of tribal farmers of Bastar Region of Chhattisgarh state. Advanced tools like remote sensing and Geographical Information System (GIS) are capable of providing information for efficient management and planning of natural resources. False colour composite (FCC) of IRS-P6 LISS IV geocoded data merged with Cartosat PAN data was interpreted in conjunction with survey of India (SOI) toposheet on 1:50000 scale to extract information on existing land use/ land cover, slope, aspect and physiography for characterization and mapping of soils in the cluster village Lalaguda, Block – Bastanar, Dist. – Bastar (Chhattisgarh) under NAIP-3 project. The revenue maps of 1:4000 scale was digitized and converted to vector shape file with attributes of field details like owners name & caste and coverage area, perimeter etc. This revenue map was overlapped to the FCC of mosaic satellite data for retrieving the true land characterization of the project area. Five farming situations were characterized and mapped as per the local names of the agro climatic zone viz. *Badi, Marhan, Tikra, Mal* and *Gabhar.* Additional water resources in the shape of shallow dug well and farm ponds were constructed following the drainage line of the area. Site specific land use have been suggested and demonstrated with suitable soil and water conservation measures for sustainable land resource management.**

***Keywords: Cadastral mapping, farming situations, geospatial, GIS, remote sensing.***

## I. INTRODUCTION

Land resources are under intense pressure due to ever increasing human and livestock population as well as over exploitation, resulting in acceleration of soil degradation [1]. The per capita land availability is reducing and by the end of 2025, only 0.1 hectare per capita land will be available [2]. Statistics on water budget indicates that our country gets about 400 Mha.m of precipitation annually, out of which 200 Mha.m are lost in evapotranspiration. About 135 Mha.m is available on the surface and remaining portion of precipitation joins groundwater through percolation [3]. The soils and farming situations differ in their morphology, physic-chemical characteristics, inherent productivity and fertility and their response to management practices vary accordingly. Thus, it is imperative to study the soils and farming situations of a particular area for sustainable land use. Due to their influence on many of the environmental issues both direct and indirect, such as loss of biodiversity, changes in hydrological, carbon and nitrogen cycles, and climate change [4,5], it is important that the areas under different land use land cover (LULC) be categorized for adapting suitable management strategies. Improper practices of LULC including deforestation, uncontrolled and excessive grazing, expansion of agriculture, and infrastructure development are deteriorating watershed conditions [6], at various temporal and spatial scales [7]. The spatial variability of fields is generally overlooked while preparing the natural resource management plan of any region, which questions the adaptability and suitability of the proposed management plan. To make any developmental programme successful, site specific management plan has to be generated and implemented depending on the need of the field. Cadastral level plan, based on the farming situations of the field need to be prepared for site specific sustainable natural resource management using geospatial technologies.

Remote sensing technologies have emerged as a powerful and efficient technology for mapping and monitoring of natural resources of earth surface environment. Several workers have utilized this technology for characterization of land resources on different conditions at different scales [8] and on watershed basis [9, 10]. It also provides adequate information in terms of landform, terrain, vegetation as well as characteristics of soils which can be utilised for land resources management and development [11].

The present study was undertaken with a specific objective of developing site specific land and water resource management plan at cadastral/ field level for providing management plan to individual farmer, looking to the availability of natural resources at their disposal.

## II. MATERIALS AND METHODS

### A. Study Area

Bastanar cluster village under National Innovation Agriculture Project, sub component III, comprises village Lalaguda along with two other villages. The villages comes under Block – Bastanar, District – Bastar (Chhattisgarh) and is located between 81°33’ and 81°37’ E longitudes and 19°1’ and 19°4’ N latitudes with an area of 1005 ha. The project was implemented during 2008 – 2012 with the objective of improving and providing sustainable livelihood to the tribal farmers of the region.

### B. Climate

The climate of Chhattisgarh state in general is sub-humid type with an average rainfall of about 1200 mm. The day time temperatures during peak summer season are usually very high in the entire area varying to 38°C at Jagdalpur in the second-fortnight of May. The monsoon sets in around 10th June in the southernmost tip of Bastar district and finally extends over the entire area by 25th June. Rainfall during July and August is high (about 350-400 mm) at all places. It is assured and stable till mid September. The major crops grown in the area are paddy, maize, small millets, niger, horse gram in *kharif* and chickpea, lentil, pea, lytharus in *rabi* on residual moisture.

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## III. METHODOLOGY

Multispectral satellite data of IRS P6, LISS IV sensor with 5.8 m spatial resolution and panchromatic satellite data of Cartosat-1 with 2.5 m spatial resolution was acquired of the project area under National Agriculture Innovation Project (NAIP) sub component-3 (sustainable livelihood security), and were merged to get high resolution multispectral satellite data of 2.5 m spatial resolution. The toposheets on 1:50000 scale from Survey of India was used to prepare the base map and derivation of contour lines for the DEM. The cadastral map of 1:4000 scale was acquired for the Department of Land Revenue, Government of Chhattisgarh, for the field level information of the cluster village. The toposheet and cadastral maps were digitized and georectified. The database of field level information from the land records and cadastral maps was generated to give the clear picture about the land holdings of the inhabitants. Pixel based classification was adopted for the classification of land use/ land cover from the satellite image. Digitized revenue or cadastral map was used to delineate each and every field with the creation of digital database of the land records.

Following resampling and geometrically corrected near-infra red, red and green bands of the merged MX LISS IV + PAN data was used to generate a false color composite (FCC) of the study area. Supervised classification was used to identify the various land cover pattern of the area and delineation of water bodies. Data obtained by GPS (global positioning system) were used for pixel based image classification. Various thematic maps were generated like soil, land use, land cover, drainage network, DEM, slope and aspect map. Soil sampling density of 5 ha was considered to get representation of the five farming situations for analyzing the profile of the study area. Standard image interpretation characteristics such as tone, texture, shape, size, pattern, association along with sufficient ground truth and local knowledge were used to finalize these maps. The soil sample of all the villages were analyzed for giving the field condition of the project area in perspective of farming situation and fertility. The appropriate locations for excavating farm ponds and RCC shallow dug out wells were identified based on the farming situation, slope, aspect, land use and cover maps.

## IV. RESULTS AND DISCUSSION

### *A. Land use/ land cover*

Based on image characteristics, the major land use/ land cover identified (Fig. 1) are agricultural land (705.2 ha), dense forest (113 ha), permanent fallow (99 ha), open land with shrubs (75.3 ha), settlements (12 ha). On analyzing the present land use/ land cover pattern it can be clearly identified that more than 18% of land is still unused and has to be brought under cultivation by adopting suitable and sustainable management plan. Even the region is bounded by mono cropping culture, so suitable management practices were adopted to increase the cropping intensity.

### *B. Slope*

The slope map was generated by the classifying the relief in four classes (Fig. 2) viz. (a) flat (0 – 1% slope) covering an area of 573 ha (b) gently slope (1.1-3.0 % slope) covering an area of 161 ha, (b) moderate gently slope (3.1 – 8.0 % slope) covering an area of 221 ha, (c) moderately steep slope (8.1 – 14 % slope) covering an area of 50 ha. The slope map played the major role in delineating the farming situations for preparation of site specific management plan.

### *C. Soils*

The soil texture of the Bastanar cluster village Lalaguda (Fig. 3) varies from loamy sand to sandy loam with three classes comprising of the least dominance of loamy sand. The dominating soil texture in the project site are sandy loam covering an area of 670 ha followed by sandy clay loam with 242 ha area. The soil depth of the project site varies from 0 to 180 cm with soil depth map generated and classified in seven classes. The soil depth classified played major role in identifying and delineating the farming situation of the Bastar plateau agro climatic zone. The maximum depth was obtained in the low lying area of the cluster whereas the midland and upland comprises of medium and low range of soil depth respectively. Land use was found to be highly correlated with the soil characters.

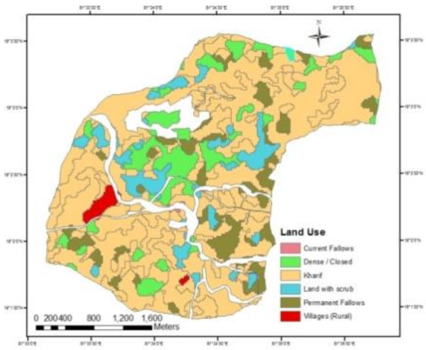


Fig. 1 – Land use map of Village Lalaguda

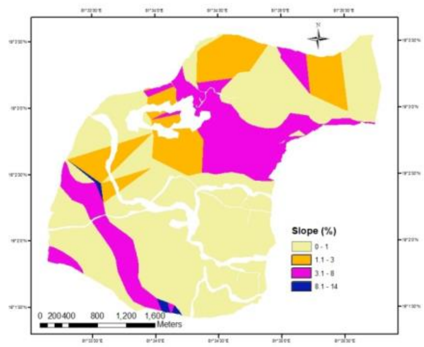


Fig. 2 – Slope map of Village Lalaguda

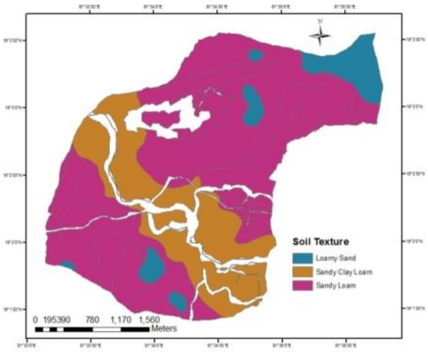


Fig. 3 – Soil texture map of Village Lalaguda

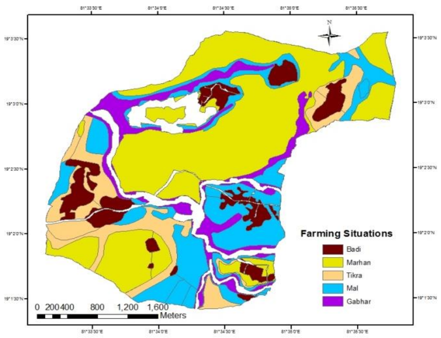


Fig. 4 – Farming situations of the village

### D. *Farming situations*

Based on the visual interpretation and field survey, five farming situations (Fig. 4) viz. *badi, marhan, tikra, mal* and *gabhar* were identified and characterized based on soil morphology, land use, land cover, drainage, slope and aspect. *Badi* is the settlement area of the village, *marhan* and *tikra* are the upper and lower upland respectively, *mal* is the midland and *gabhar* is the low lying area of the region. The *badi* (10.1%) comprises of upland settlement, *marhan* (45.8%) is the upper upland, *tikra* (12.9 %) is the lower upland, *mal* (21.7%) comprises the midland part and *gabhar* (9.5%) is the low lying situation. *Marhan* are un-bunded with steep sloped situation, *Tikr*a is the un-bunded upland entisols with steep slope, *Mal is* the midland and is characterised as Inceptisol, Alfisol, bunded, flat lands whereas *Gabhar* is the lowland, comprises of bunded Alfisol/ Vertisol.

### E. *Land And Water Resource Management*

The integration of physiography, soil, land use, land cover, slope and cadastral maps under GIS environment has brought out the five farming situations of Tahakapal cluster village for implementation under NAIP-3 programme, which leads to identify the areas for alternate land use, resource development and conservation. The topography of the area with *marhan* and *tikra* were identified for upland early maturing variety (*samleshwari, danteshwari, poornima* etc.) of paddy farming, *mal* was identified for cultivation of medium variety of paddy (MTU-1010, IR-64, IR-36, *Karma masuri* etc.) cultivation and *gabhar* farming situation was identified for cultivation of late maturing variety of paddy (MTU-1001, *Swarna* etc.). *Marhan* and *tikra* farming situations were identified for mid *kharif* crops like horse gram (AK-21) and niger (JNC 6) along with finger millets (GPU 28) and Kodo millet (JK 48, JK 41) cultivation. Maize (JM 216) was grown under protected cultivation in *badi* farming situations. Sites on *bad*i were given priority so as to create the water resource on the backyard space of farmer's which in turn will promote the cultivation of *rabi* vegetables by judiciously utilizing the harvested well water through designed gravity operated drip irrigation system. As the protected upland land viz. badi farming situation were deprived of availability of irrigation water, so water resources in the form of shallow dug out RCC well of 30' depth and 6' diameter were designed to be dug out on suitable sites conserving and harvesting more than 26000 ltr of water. *Marhan* and *tikra* farming situations were targeted to excavate farm ponds of appropriate sizes based on the catchment command relationship and on the basis of farm availability. Two check dams were constructed on the drainage line to interrupt and store the runoff water for efficient utilization of the harvested water. These water resources have helped in increasing the production and productivity of the moderately fertile farming situations. Vegetables like tomato, brinjal, chilli, okra etc were grown successfully by the tribal farmers in their small *badi's* and the adjoining area of the nala by lifting water from the nala which occurred as additional source of income and nutrition to sustain their livelihood. The productivity of crops has doubled due to the interventions along with the increased area of production due to the additional harvested water.

## V. CONCLUSIONS

In order to make sustainable management plan, due emphasis was given to utilize geospatial techniques for identifying different farming situation and to enhance its potential be adopting necessary land and water resources developmental measures. Appropriate crops with variety and conservation structures were proposed for various farming situations to utilise their maximum potential. The increase in production and productivity of crops reflects the impact of operational strategy for land and water conservation structures based upon geospatial technologies.

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