Land Use and Land Cover Mapping for Catchment Area Afforestation

A case study of East Khasi Hills District

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Abstract: ***The aim of this study is to produce a land use and land cover map for accessing the catchment area for afforestation purposes using remote sensing data and geographic information system. In this study, land use land cover in East Khasi Hills District was carried out to map the forest cover, other land use land cover classes and potential afforestation sites. IRS LISS IV data and Google Earth high resolution images have been used and visual image analysis technique has been employed to do the land use land cover mapping. The study area covers 2813.05 sq. km and consists of mosaic of land use and land cover features. These are classified into eight categories: settlements, water bodies, agricultural land, barren land, grassland, culturable waste land or scrub land, open forest, dense forest. Therefore culturable barren land has been identified as the potential area for afforestation in the catchments. It has been assessed that area under culturable barren land which may be potential afforestation sites is 124.93 sq km which is 4.44% of the total geographical area of the district.***

Keywords: **L**and Use Land Cover (LULC), **i**nterpretation key, **a**fforestation, catchment

1. Introduction

Land use land cover is important spatial information in understanding interactions of human activities with the environment and thus it is necessary to monitor and detect the changes to maintain a sustainable environment. Land use change is defined as the alteration of land use due to human intervention for various purposes, such as for agriculture, settlement, transportation, infrastructure and manufacturing, mining and fishery. In contrast, land cover change refers to the conversion of land cover from one category of land cover to another and/or the modifications of conditions within a category [1]. The knowledge of land use and land cover is important for many planning and management activities as it is considered as an essential element for modeling and understanding the earth's features. Though the district falls in high rainfall area, increasing pressure on forest due to degradation leading to high run-off, soil erosion and land slide has taken place. Climate change has further added up to this problem whereby many streams are drying up adversely affecting the livelihood of the people. As such, to address this problem, catchment area afforestation has been taken up as a strategy to rejuvenate the streams & springs to supplement this lost. The present study is expected to provide an important input in planning afforestation in the catchment areas.

2. Methodology

A. Study Area

This study has been conducted in East Khasi Hills District, Meghalaya which is located between 25° 07' to 25° 41' N latitude and 91° 21' to 92° 09' E longitude and elevation from 220m to *1,966*m above sea level. The average temperature in the district is 28ºC in the summer and 3.8ºC in winter and average annual rainfall is 12,000 mm respectively. Agriculture is the major economic activity which is characterized by rain-fed and predominantly subsistence nature. The district is largely inhabited by the Khasi Tribe.

B. Data Collection

Multi-spectral satellite imageries Landsat 7 ETM 2016 imagery and IRS P6 LISS VI of 2014 has been used in the study. Interpretation of the Satellite data for identifying land use and land cover classes has been done by on-screen visual analysis after collecting adequate signature from ground for each class. The interpretation of IRS P6 LISS IV data was done on the scale of 1:12,500. LANSAT ETM 2016 data was also used in classification to improve accuracy of classification. Field observations and ground truthing were conducted to verify the interpreted area with the real world. Geo-tagged photos have been used for referencing the features in the satellite images related to the ground. A LULC map on a scale 1:12,500 was prepared for digitization and ground verification.

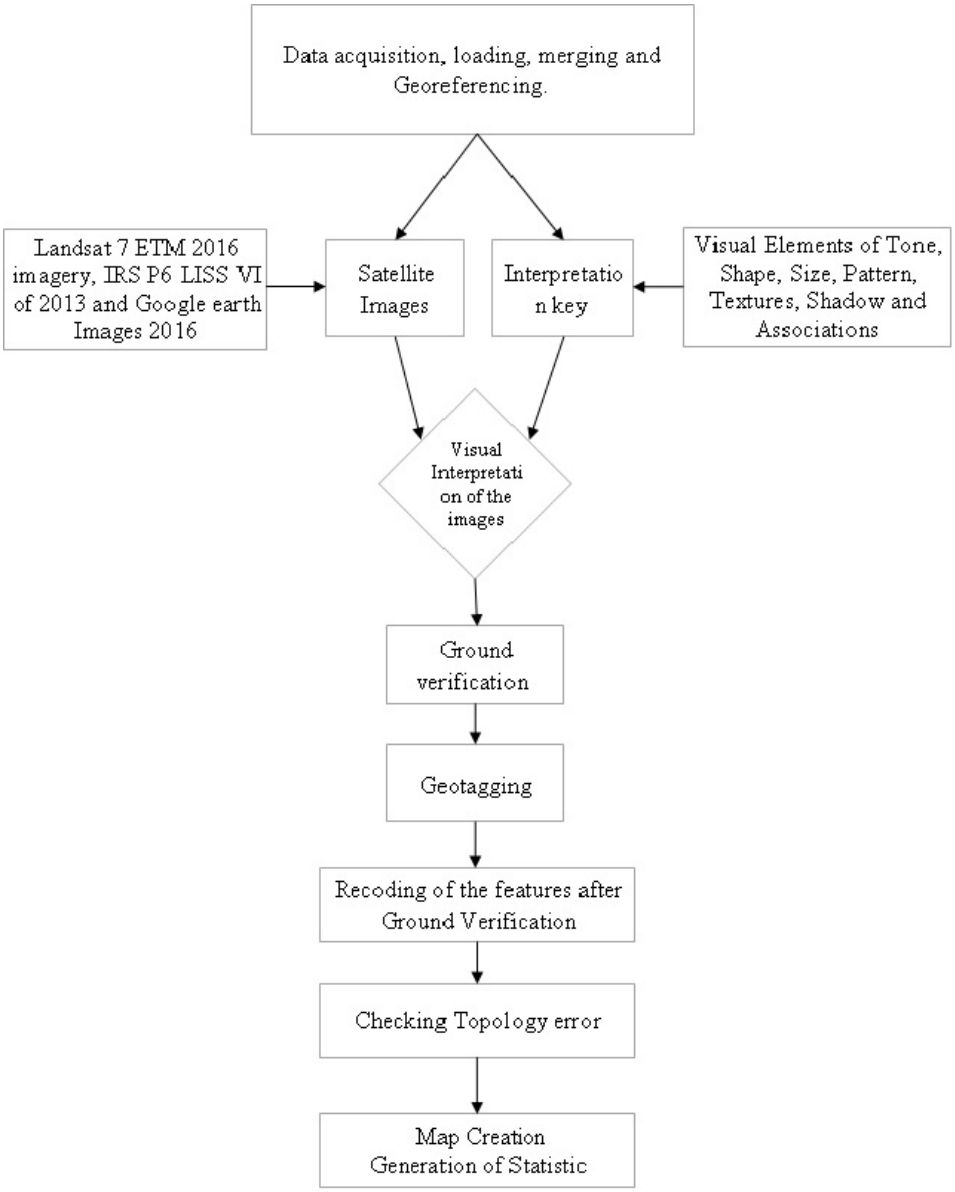

Figure 1: Methodology Flow Diagram.

I. **TABLE 1:** INTERPRETATION KEYS

Codes	LULC Class	LISS IV Images	Ground Photos from parts of East Khasi Hills District
1	Settlement		
2	Waterbodies		
3	Agricultural Land		
4	Barren Land		
5	Grassland		
6	Culturable Waste Land/Scrub Land		
7	Open Forest: 10-40% canopy density		
8	Dense Forest: 40% above canopy density		

C. Image Interpretation Methods

Image Interpretation was undertaken using Multi-spectral satellite imageries Landsat 7 ETM 2016 imagery, IRS P6 LISS VI of 2014 and Google earth Images 2016 for reference in visual image interpretation method. Visual image interpretation method was chosen because it improves the accuracy and efficiency of the classification which involves feature identification through both spectral and spatial pattern recognition, using the interpretation key (Table I) based on the relationships between ground features and image elements like texture, tone, shape, location and pattern. The LULC classes include settlements, water bodies, agricultural land, barren land, grassland, culturable waste land or scrub land, open forest, dense forest. ArcGIS 10.3 software was used for visual image interpretation. The flow diagram (Figure 1.) shows the sequence of steps of Methodology.

LULC map of East Khasi Hills District created from this study is presented as Fig 3. The eight classes mapped in the LULC map along with the area figures are shown in Table I.

3. Results And Discussion

The result of this study shows that Open forest area are well distributed throughout the study area and it covers 1082.68 sq.km which occupies 38.49% of the total geographical area and followed by Grassland which occupies 663.41 sq. km and sharing about 23.58%. Dense forest occupies 427.57 sq. km which is 15.20%. Agricultural land occupies 347.61 sq. km which is 12.36%. Culturable waste land/scrub land occupies 124.93 sq. km which is 4.44%. Settlements occupy 114.42 sq. km which is 4.07%. Water bodies occupy 39.87 sq. km 1.42% and Barren land occupies 12.55 sq. km 0.45% (Table II). It can be observed from ground verification that most of the grassland and barren land are sandy and rocky composition and it is not suitable for planting and cultivating. As per the result it has been observed that the categories belonging to grassland and barren land cannot support afforestation due to intense soil degradation, whereas, on the other hand, culturable waste land/scrub land (Fig 4.), has been taken up as potential area for afforestation, small vegetations are seen in this class which has helped in preservation of soil and moisture conservation. It has been observed while ground truthing that such areas can support tree and bamboo plantations.

A further analysis has been undertaken to study distribution of culturable barren land patches (polygons) in different altitude zones in the district. The distribution as observed after analysis in GIS is presented in Table III. It is seen that maximum culturable barren land is available in the altitude zone 1000m to 1500m. This is the zone where Pinus kesiya grows naturally in the district. Map showing distribution of culturable barren lands in different altitude zones will be particularly helpful in planning different species for afforestation on such lands in different altitude zones.

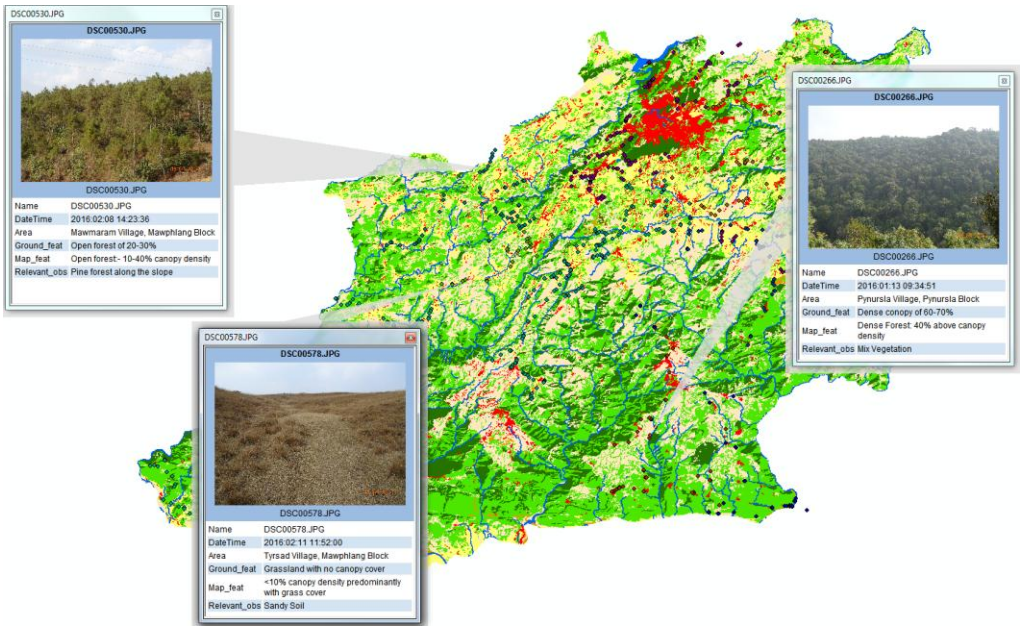

Figure 2: Ground truth points with geo-tagged images.

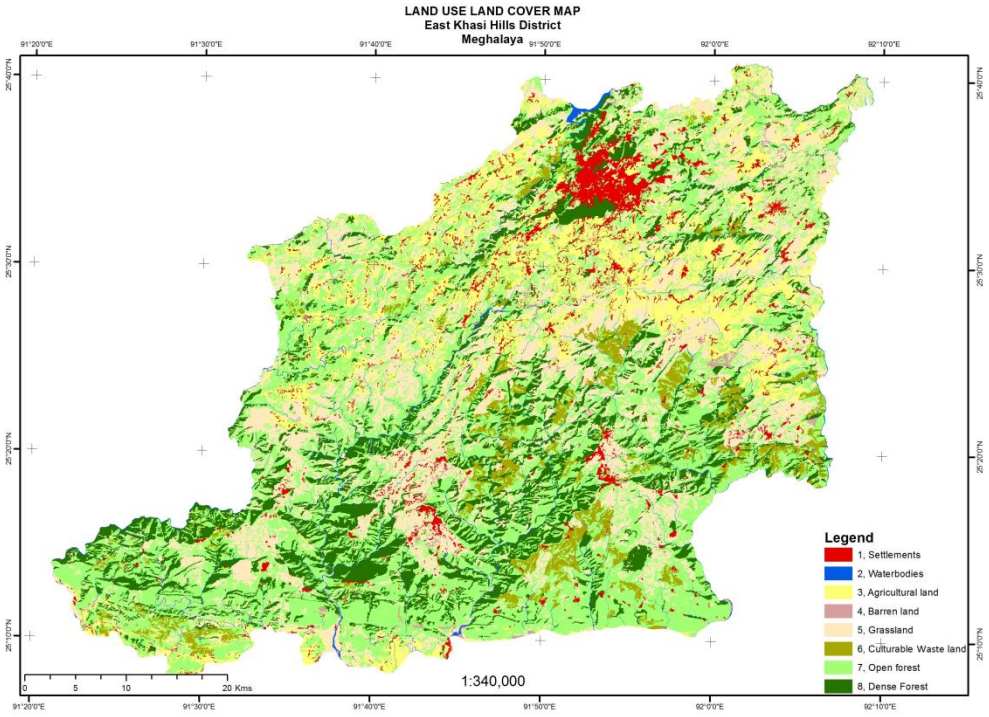

Figure 3: LULC map of East Khasi Hills District.

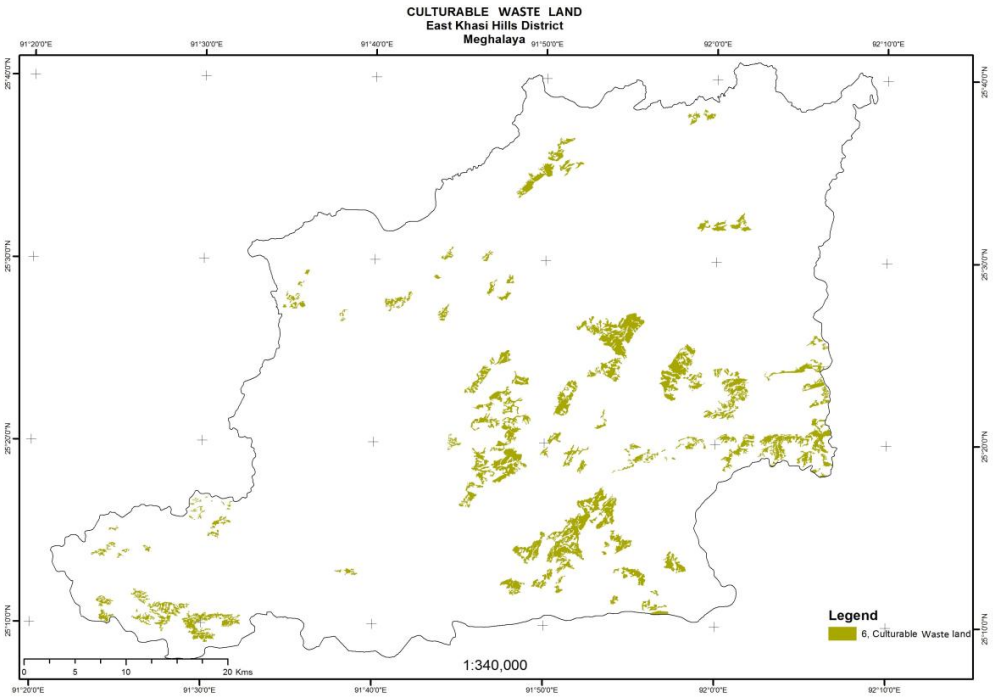

Figure 4: Potential Catchment Area Afforestation Sites in East Khasi Hills District.

II. **TABLE II:** LULC DESCRIPTION AND AREA MEASUREMENT

Code	Description	Area in sq. km	Percentage
1	Settlements	114.42	4.07
2	Waterbodies	39.87	1.42
3	Agricultural Land	347.61	12.36
4	Barren Land	12.55	0.45
5	Grassland	663.41	23.58
6	Culturable Waste Land/Scrub Land	124.93	4.44
7	Open Forest: 10-40% canopy density	1082.68	38.49
8	Dense Forest: 40% above canopy density	427.57	15.20
	Grand Total	**2813.05**	**100.00**

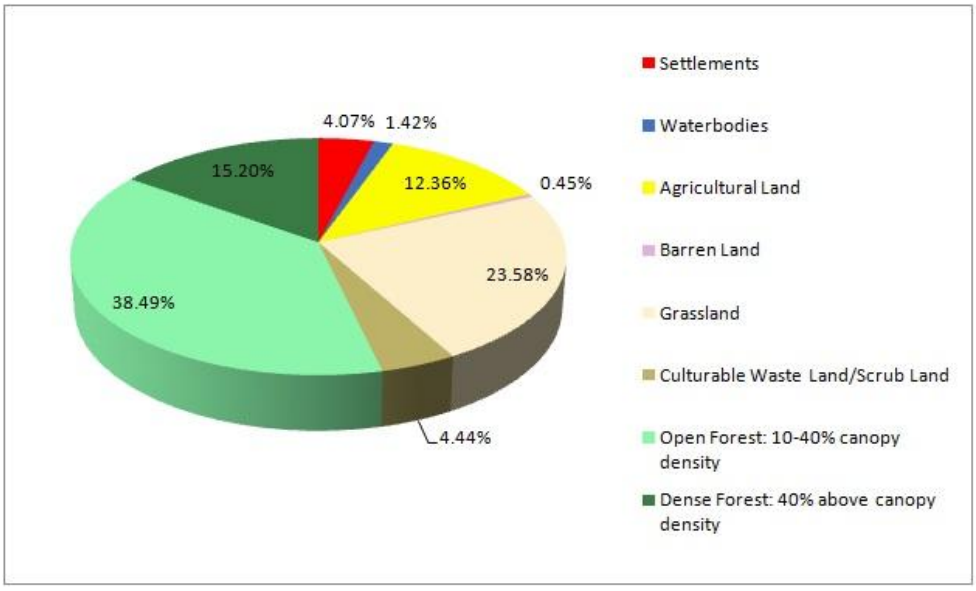

Figure 5: Pie chart of different LULC.

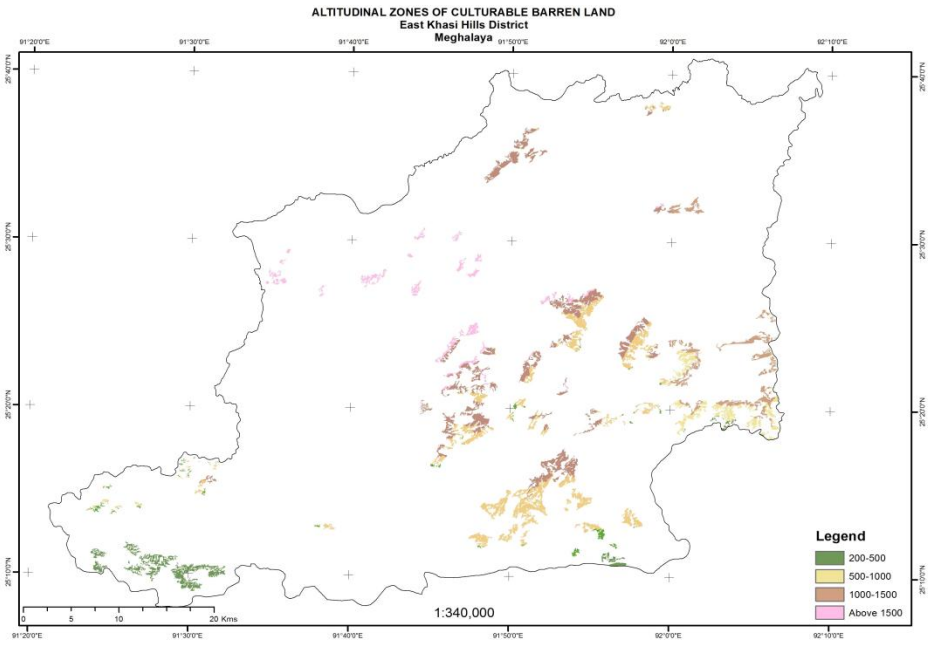

Figure 6: Altitudinal Zones of Culturable Waste Land/Scrub Land.

III. **TABLE III:** ALTITUDE ZONES AND AREA MEASUREMENT OF CULTURABLE WASTE LAND/SCRUB LAND

Altitude (in meters)	200-500		500-1000		1000-1500		Above 1500	
Total Area=124.93 sq. Km	Area in sq. Km	Percentage	Area in sq. Km	Percentag	Area in sq. Km	Percentage	Area in sq. Km	Percentage
Culturable Waste Land/Scrub Land	15.42	12.34	48.66	38.95	50.05	40.06	10.80	8.64

4. Conclusion

The present study demonstrates effective use of satellite remote sensing in mapping land use land cover and potential catchment afforestation sites occurring over an area. The information on location and spatial extent of forests and wastelands is an essential prerequisite for management of forest and wastelands. From the result culturable waste land/scrub land occupied 4.44% of the total area. Afforestation and regeneration of the area is of critical importance in order to restore the degraded forests for overall improvement of ecology in the district and particularly rejuvenating the impaired streams and water springs where water flow has significantly reduced over the areas. LULC maps also help in proper land use planning in the district and in developing strategies to restock the degraded forests and strengthen forest management in general. The scientific approaches of natural resource management and environment management have assumed high significance in the face of adverse impacts of climate change.

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