International Journal of Science and Research (IJSR)
ISSN: 2319-7064
Index Copernicus Value (2016): 79.57 | Impact Factor (2017): 7.296

A Study on Landuse/Land Cover change Detection and its Impacts on the Soil Quality of Nilachal (Kamakhya) Hills, Guwahati, Assam

Tanvi Hussain[1], Dulal C Goswami[2]

[1, 2]Department of Environmental Science, Gauhati University, Guwahati 781014, Assam, India

Abstract: ***The landuse/landcover (LULC) pattern of a region is an outcome of natural and socio-economic factor and their utilization by man in time and space. Remote sensing has become an important tool for identification and mapping of the global bio-geophysical process affecting the earth. Nilachal Hills located in the middle of Guwahati city of Assam, India is a famous holy place and a site of natural heritage. The study aims at detecting the LULC changes between 2000 to 2015 using Landsat image and understanding the impacts of LULC change on soil quality and also to study the environmental awareness of the inhabitants of the area. LULC map of the study area is prepared by visual image interpretation techniques. The study area has witnessed a decline of in forest cover from 202.38 ha in 2000 to 195.55 ha in 2006, 181.73 ha in 2011 & 153.09 ha 2015. Most prominent changes have been observed in the built up area from 29.93% to 32.30%, 37.08%, & 47% in 2000, 2006, 2011 & 2015 respectively. This study evaluated the influence of LULC in physico-chemical properties of soil which is critical for the unique ecology of Nilachal Hill. In order to reduce the impact of the excessive pressure on the natural ecosystem of the hill proper environmental management plan is suggested such as restoration of the forest cover of the area and checking on deforestation, building a township in the near vicinity of the area for temporary rehabilitation of devotees during Ambubachi Mela.***

Keywords: Nilachal Hills, LULC change detection, forest, soil quality, environment management plan

1. Introduction

Man's presence on the Earth and his use of land has a profound effect upon natural environment resulting in observable pattern of landuse/landcover change (LULCC) over time. Land, an area on the Earth's surface, is an important resource [1]. The landuse/landcover pattern of a region is an outcome of natural and socio-economic factors and their utilization by man in time and space. Land is becoming a scarce resource due to immense demographic pressure [2]. Demographic pressure and competition for land induces structural changes in modern societies and have modified not only the rural/urban equilibrium, but also the existing landuse pattern. Due to urbanization and industrialization, ever increasing amounts of arable and forest lands in and around sub-urban areas are being transformed into building plots, industrial zones, infrastructure projects and recreational values [3].

Landcover information is required for various policy, scientific, management purpose, forest inventories [4], planning as well as other biophysical resource inventories [5], modeling of vegetation-atmosphere interactions [6] and hydrological models [7]. Conventional methods of mapping stand alone and had several limitations, to name a few they are not spatially explicit, time consuming and involves lots of difficulty in revising those observations. But satellite remote sensing technology has overcome these hurdles and it is considered one of the potential complimentary tools for conventional ground assessment. Remote sensing derives synoptic and periodic information of the Earth's surface. The temporal revisits of the satellites have made it possible to assess and analyze changed scenario with better accuracy and precision [8]. Remote sensed imagery provides accurate understanding and comprehensive way of modeling and projecting land change [9]. Landcover mapping is a product of the development of remote sensing [10].

The conversion of natural forest to other forms of landuse can provoke soil erosion and leads to reduction in soil organic content, loss of soil quality and modification of soil structure [11] [12]. Soil is a complex system in which physical, chemical and biological factors occur in dynamic equilibrium [13]. It sustains the forest and provides raw materials for its life by recycling fallen leaves, woody debris and dead animals [14].

Guwahati, the gateway to North-East India and centre of attraction is characterized by a phenomenal change in urbanization in the last few years. The population of Guwahati has increased from 809,895 in 2001 to 963,429 in 2011 with an increase in population density from 3736 persons per sq. km. to 4445 persons per sq. km. respectively (Census of India, 2011). The rapid rate of urbanization has its effect on the vegetation cover and thus to the atmosphere in the city [15]. Nilachal Hills is a natural heritage of Guwahati city has a unique ecology with the temple at the top of the hill and covered by dense vegetation. It is of great historical and mythological interest and *Ambubachi mela* is an important festival of the country. It has also witnessed rapid development during the past years in terms of urbanization and substantially increasing population. Thus, a study on the hills has been taken up with the following objectives: (i) to detect change in the landuse/landcover pattern of the area within the Guwahati metropolitan region. (ii) to analyze the growing human impacts on its environment through soil analysis in those area where changes have taken place. (iii) to examine the status of environmental awareness among the inhabitants of the hills and the quality of their habitat.

2. Study Area

Nilachal Hill located in the middle of Guwahati city between 91.689° E & 26.167° N to 91.718°E & 26.167°N at an altitude of 293 m from the mean sea level covers an area of 288.83 ha i.e. 2.88 sq km. It is a legendary holy place for devotees of Goddess Kamakhya, hence, also known as Kamakhya Hill and a natural heritage site of great eminence. It is thronged by lakhs of devotees from all over the country during Ambubachi Mela which takes place in mid June every year.

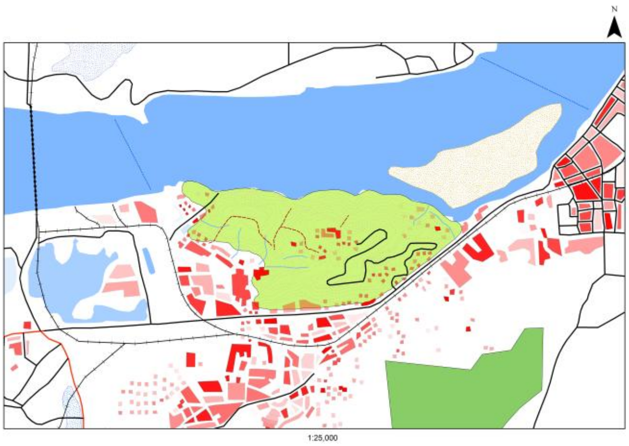


Figure 1: Base map of the study area

3. Methodology

The study is carried out using remote sensing and GIS techniques as well as conventional field survey. In the present study satellite data of Landsat 7 and Landsat ETM+ data of 2000, 2006, 2011 & 2015 were used to understand the dynamics of landuse/landcover change. Cloud free images between the month of October and November were selected for the study since trees of the study area are known be in full foliage in this season. Visual image interpretation of a satellite is a complex process. It includes the meaning of the image content; it requires the analyst's knowledge of the study area and spectral response. The boundary of the study area was obtained from Survey of India topographic map of 1:50,000 scale and the same was digitized and stored in GIS database. The LULC layer of the year 2000, 2006, 2011 & 2015 were prepared visually based on tone, texture, shape, size, pattern, site and association. Landuse/landcover of the area has classified into two broad classes forest land built up land [16]. The forest class was further divided into closed forest, open forest and scrub forest.

In this phase of the study, to observe the growing human impact on the physico-chemical properties of soil, four different locations within the study area were identified and composite soil samples for each sampling site from a depth of 20 cm is collected on March 2013. Soil parameters such as temperature, moisture, bulk density, water holding capacity, pH, conductivity, chloride, sulphate, nitrate, and phosphate were analyzed. The preparation and analysis of the soil samples were carried out following standard methods [17]. Further a socio-economic survey was carried out from 40 out of 4000 households following systematic sampling technique based on questionnaire especially designed for the study.

4. Results & Discussions

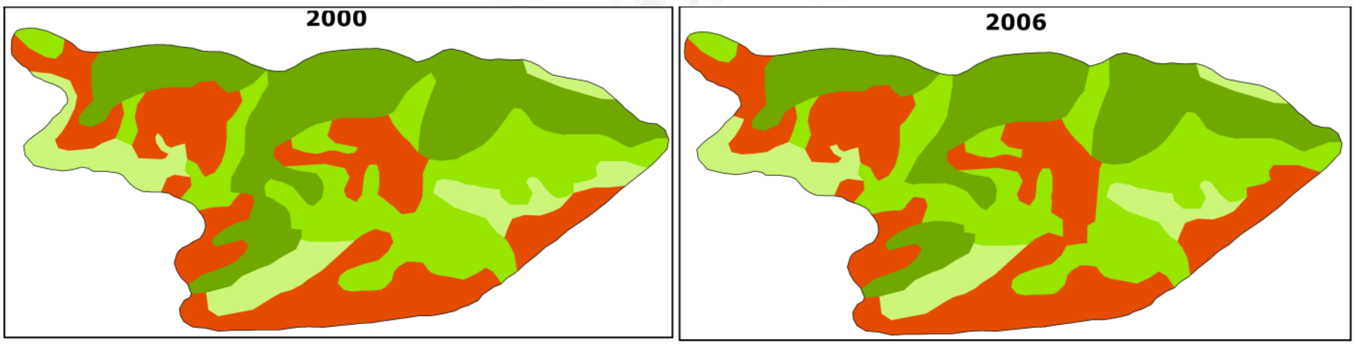
Temporal datasets used in the present study yielded the following comparison with respect to landuse/landcover change shown in Table1.

Table 1: LULC Statistics of the study area from 2000 to 2015

LULCC	2000	2006	2011	2013
CF	90.56	84.09	66.37	48.44
OF	75.81	79.78	42.43	37.07
SF	36.01	31.68	72.93	67.58
BL	86.45	93.28	107.10	135.74
TOTAL	288.83	288.83	288.83	288.83

CF = *Closed Forest* **OF** = *Open Forest* **SF** = *Scrub Forest*
BL = *Built up*

From the analysis it has been observed that there is considerable reduction of forest area from 202.38 ha in 2000 to 195.55 ha, 181.73 ha & 153.09 ha in 2006, 2011 & 2015 respectively.



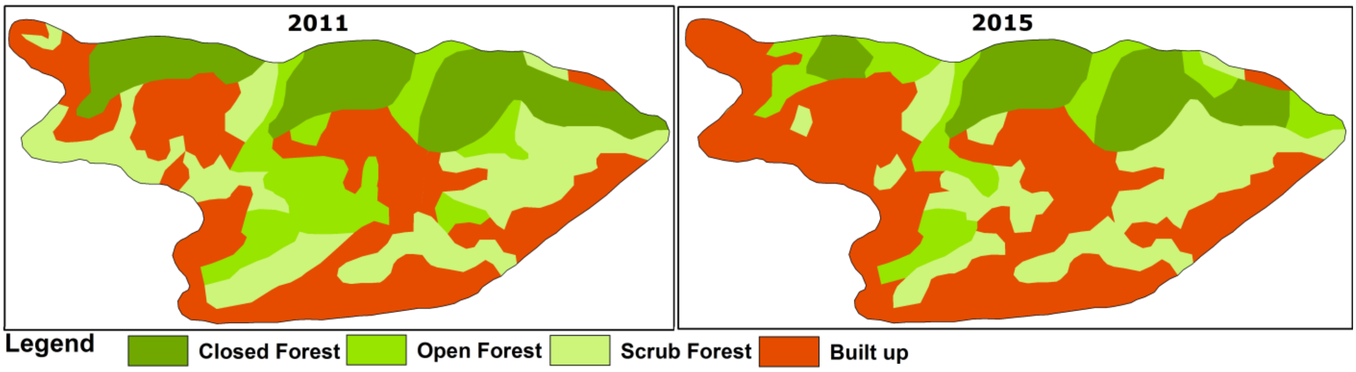


Figure 3: LULC change maps of the study area from 2000 – 2015

Most prominent changes of LULC have been observed in the built up area from 29.93% to 32.30%, 37.08%, & 47% in 2000, 2006, 2011 & 2015 respectively. Simultaneously, area of scrub forest has increased from 12.47% in 2000 to 23.40% in 2015. It has also been observed that closed forest has declined from 31.35% in 2000 to 16.77% in 2015. It was 29.11% in 2006 and 22.98% in 2011. But open forest increased from 26.25% in 2000 to 27.62% in 2006 declining gradually from 14.69% to 12.83% between 2011 and 2015 respectively and the gradual conversion of scrub forest to settlement.

Table 2: Analysis of physico-chemical characteristics of soil in the study area

Sample Code	Sampling Location	Temperature (°C)	Moisture (%)	Bulk Density (g/cm3)	WHC (%)	p^H	Conductivity (µS/cm)	Cl^- (mg/l)	SO_4^- (mg/l)	NO_3^- (mg/l)	PO_4^{3-} (mg/l)
S1	CF	2.4	33	1.33	41	6.32	2.103	106.58	38	1.08	11.23
S2	OF	2.5	24	1.3	38	6.79	2.19	117.62	42	1.26	20.19
S3	SF	2.7	13	1.11	33	7.01	2.291	121.46	49	0.98	47.18
S4	BL	3.4	3	1.26	29	8.04	2.309	181.23	58	2.18	51.06

Temperature of soil greatly affects the physical, biological and chemical processes occurring in soils. It regenerates absorption and transport of water and nutrients in higher plants [18]. Maximum value of soil temperature recorded was 3.4°C in S4 and minimum 2.4°C at S1. Mobility of soil depends on moisture content, soil become mobile and prone to erosion when moisture content is low. Soil moisture values ranges from 3% to 33% and it is evident from the result that closed forest (S1) retain the highest soil moisture and built up (S4) the least i.e. 3%. Bulk density of soil is indicative to the compactness of soil and it's defined as mass per unit volume which includes pore space occupied by solids [19]. Maximum bulk density 1.33 g/cm3 was found in S1 and minimum 1.11 g/cm3 at S3 which implies that scrub forest area has less organic content as compared to closed forest and built up area (S4) has bulk density of 1.26 g/cm3 which indicates that there may be addition of organic matter by human activity. Highest value to water holding capacity (WHC) 41% was found in soil sample of closed forest (S1) and lowest 29% in built up area sample (S4). Good WHC shows good physical condition of soil [20]. pH of soil is one of the most important physico-chemical parameter which affects mineral nutrient, soil quality and micro-organism activity [21]. It was observed to range from 6.32 to 8.05. S1 was found to be acidic i.e. 6.32 which go with acidic trend of the soil of Assam but S3 and S4 were found to be basic which implies presence of metal ions in the soil. The measurement of electrical conductivity is to measure the current that gives a clear idea of soluble salt present in the soil. Conductivity value ranges from 2.103 µS/cm to 2.306 µS/cm. Conductivity of S1 is less i.e. 2.103 µS/cm as compared to S2, S3 and highest at S4 i.e. 2.309 µS/cm which implies human impact on soil quality. Though soil testing for chloride (Cl^-) is not a common practice and little data exists for interpretation of test results. Man and other animal excreta accounts for higher quantities of Cl^- together with other nitrogenous compounds. Cl^- has been found to be highest in S4 i.e. 181.23 mg/l and lowest at S1 106.58 mg/l. Significant factors influence sulphate (SO_4^-) amounts in soil like precipitation [22], soil depth [23], composition of surface humus layer [24], atmospheric sulphur deposition [25], altitude [26] and physical and chemical properties of forest soil. The variability of SO_4^- was found lowest 38 mg/l in S1 and highest 58 mg/l in S4. The concentration of nitrate varies from 0.98 mg/l to 2.18 mg/l. it is well established that higher nitrate concentration gives lower p^H value which is due to effect of nitrification of NO_3^-. Phosphate comes from weathering of rocks and is responsible for eutrophication. Domestic waste and synthetic fertilizers are the major sources of nitrate and phosphate in soil [27]. Maximum concentration of nitrate and phosphate was obtained in S4 which is indicative of human activity and lowest in S1.

The outcome of the socio-economic survey is that, of the 40 houses survey, 27 households were found to be living in a joint family system while 3 households had a nuclear family. Majority of the houses had an RCC (33) structure while only 7 houses were of Assam type (slanting roofs). Maximum households i.e. 34 were directly dependent on the temple for their means of livelihood. The households presented a mixed literacy with members of 17 houses having low literacy (under HSLC) while 19 medium (under graduate) literacy and only 4 houses with higher (graduation & above) literacy. During the *Ambubachi mela*, 28 houses arrange accommodation for the pilgrims in their houses. Overall the waste disposal system practiced by the houses i.e. 29 was unscientific as they simply dump the litter in their backyard. Only 11 houses buried the waste in a landfill. Majority of the houses faced inconvenience in their daily living due to influx of pilgrims during the *mela*. It hampers their day to day activities during the period.

Change analysis of landuse/landcover of the study area derived from Landsat imagery has highlighted pattern of changes during the study period. The analysis has revealed that maximum changes have occurred between periods of 2011 to 2015. Landuse activities are more towards sprawling of built up area at the foothills and it has also expanded centrifugally from the temple complex at the cost of forest cover. It was also observed that physico-chemical properties of soil are in their natural state in the forested areas. Conversion of forest land to other landuse basically built up has a profound impact on soil characteristics. Besides, the inhabitants of the hill are not aware of the degrading environmental condition of their habitat.

5. Conclusion

Change analysis of landuse/landcover of the study area derived from Landsat imagery has highlighted pattern of changes during the study period. The analysis has revealed that maximum changes have occurred between periods of 2011 to 2015. Landuse activities are more towards sprawling of built up area at the foothills and it has also expanded centrifugally from the temple complex at the cost of forest cover. It was also observed that physico-chemical properties of soil are in their natural state in the forested areas. Conversion of forest land to other landuse basically built up has a profound impact on soil characteristics. Besides, the inhabitants of the hill are not aware of the degrading environmental condition of their habitat. Thus, a proper environmental management plan should be made for maintenance of the natural ecosystem and to reduce the impact of sudden influx of pilgrims during the mela in the study area. A township should be built in the near vicinity of the study area for temporary rehabilitation of the pilgrims and to utilize it as a destination point for outstation devotees visiting the temple round the year and a plan for eco-housing complex should be undertaken. Proper waste disposal system and recycling of waste methods should be implemented. Landcover is a critical variable linking human and his environment intimately and calling one another for integrated planning and sustainable development.

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Author Profile

Tanvi Hussain received M.Sc degree in Environmental Science from Gauhati University in 2013. The research paper is a part of the dissertation work done by her for the fulfillment of the degree. Presently, she is pursuing PhD in Environmental Science from Gauhati University, Assam, India.