INTERNATIONAL GEOGRAPHICAL UNION (IGU) COMMISSION SEMINAR

IGU UGI

LAND USE, BIODIVERSITY AND CLIMATE CHANGE
11th-13th DECEMBER, 2010

E-PROCEEDINGS

ORGANISED BY

DEPARTMENT OF GEOGRAPHY
COTTON COLLEGE, GUWAHATI, ASSAM, INDIA

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Government of India Ministry of Earth Sciences
INDIAN NATIONAL SCIENCES ACADEMY
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Landuse/Land Cover Dynamics in New Shillong Township Area of Meghalaya using Geospatial Tools

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ABSTRACT

Meghalaya is a landlocked state where the progress of industrialization is very slow. Majority of the population (rural) depends on agriculture. Agriculture in the state is carried on in primitive ways with Jhuming prevailing in many parts. This practice is considered destructive as vast forest areas are cleared and burnt. Such areas are used for cultivation and left out. After a gap of few years (2- 3 years as of now and 15-20 years in past the area is revisited for cultivation without allowing rejuvenating. The present work provides a status and trend of Land use land cover dynamics in parts (at watershed level) of Meghalaya. The geospatial tools have been used to assess (a) the changes in land use land cover since 1970s to 2007; (b) patch dynamics for understanding the degree of fragmentation; (c) changes along the terrain topography. New Shillong Township of Meghalaya is taken as experimental area, which is a representative of mid altitudinal watershed particularly in the East Khasi Hills district of Meghalaya. With the help of geospatial tools researcher tries to emphasis the landuse/ land cover dynamics of New Shillong Township area

Keywords: Landuse, Land cover, Human Interference, Dynamics, Meghalaya.

Introduction

Landuse/Land cover change, associated with climate changes have become a focus of the study on the interaction between human activities and natural environment. Land cover change can be regarded as one of the most sensitive indicator that echos this particular interaction (Zhou *et al.*, 2008) Landuse/Land cover changes in mountainous areas are extremely complex due to increasing human interference that is determined by a whole range of factors. Highly diverse human societies living in these natural resource rich areas of the region are facing an accelerated rate of societal changes leading to finer patterns with respect to the processes contributing to the Landuse/Land cover change (LULCC). Temporal changes in most ecosystems are dictated by a combination of natural and human influences, each of which operates at different spatial and temporal scales.

Gradually increasing disturbances in an area due to human interface are a major controlling factor of forest structure. Forest cutting and burning, land clearing and other human disturbances partly mask and minimize the effects of natural disturbances (Chadwick and Larson, 1990). Ecosystem properties which have implications for institutions have been identified as energy and material stocks and flows, the temporal and spatial variability of those resources, and complex and dynamic ways in which the underlying processes relate to one another, with perturbations playing an important role (Pritchard Jr. et al., 1998). Transformation of forest (major component of the ecosystem) takes place in many ways, due to natural event or human activities, which deplete the stand, eventually leading to a lasting transformation of the floristic composition and structure of the forest over a short or long term period (Ramakrishnan et al., 2001).Monitoring Landuse/Land cover that have either undesired or beneficial effects on the environment deserves special attention. Satellite remote sensing provides detailed information regarding extent of the Landuse/Land cover Change (LULCC) in the landscape pattern of any particular region. Remotely sensed data can be collected at multiple

scales and at multiple times, thereby offering the opportunity for analysis of previous phenomenon synoptically from local to global scales throughout the time (Reddy, 2004). Land degradation processes like shifting cultivation, clear felling of trees for timber and mining have altered the virgin natural landscape to a great extent (Roy and Tomar, 2001).

In the present study, an attempt has been made to estimate the Landuse/Land cover change since 1977 to 2007 in a hilly tract of East Khasi hills district of Meghalaya.

Study Area

The New Shillong Township area is located 13 kms at the distance of in eastern direction of the existing Shillong city. The area lies in between 25°34´00´´ N to 26°36'00" N and 91°55'00"E to 92°4´00" E. The study area covers an area of approx 18.44 sq.km. The study area comprises a major part of the eastern part of Wah Shella microwatershed of East Khasi hills district of Meghalaya and lies in the toposheet no 780/14 and 83C/2. The river Wah Shella where most of the parts of our study area lies originate from the north eastern part of present Shillong city. The major portion of the New Shillong area is covered by uncultivable landforms, forests and small fraction of landforms is under cultivable landform. The topography of the area is undulating in nature. Pine forests dominate in most of the places, the extent of shrubs and grass is also high in the study area. The elevation of the study area ranges in between 1090 to 1600m. The study area boundary has been delineated by using toposheets and satellite imagery. The Fig.1 shows the location of the study area in the state of Meghalaya.

Materials and Method

Satellite data used

Satellite images for the period of 1977 -2007 are used to find the temporal changes (Table 1).

Table 1 Satellite data used in the study

Data Type	Path and Row	Date of accusition
Landsat MSS	111/53	8 February 1977
Landsat TM	111/53	21 February 1987
IRS 1B LISS III	111/53	7 March 2004
IRS 1D LISS III	111/53	23 March 2007
IKONOS	Map sheet no: 780/14 and 83C/2	20 Feb 2009

The Landsat satellite data provided by Global Land Cover Facility (GLCF) was radiometrically and geometrically (ortho-rectification with UTM/WGS 84 projection and datum system) corrected. The datasets were with sub-pixel level accuracy. For the IRS P6 LISS-III dataset, the same principle was applied for radiometric and geometric correction using LANDSAT-TM (Thematic Mapper) data.

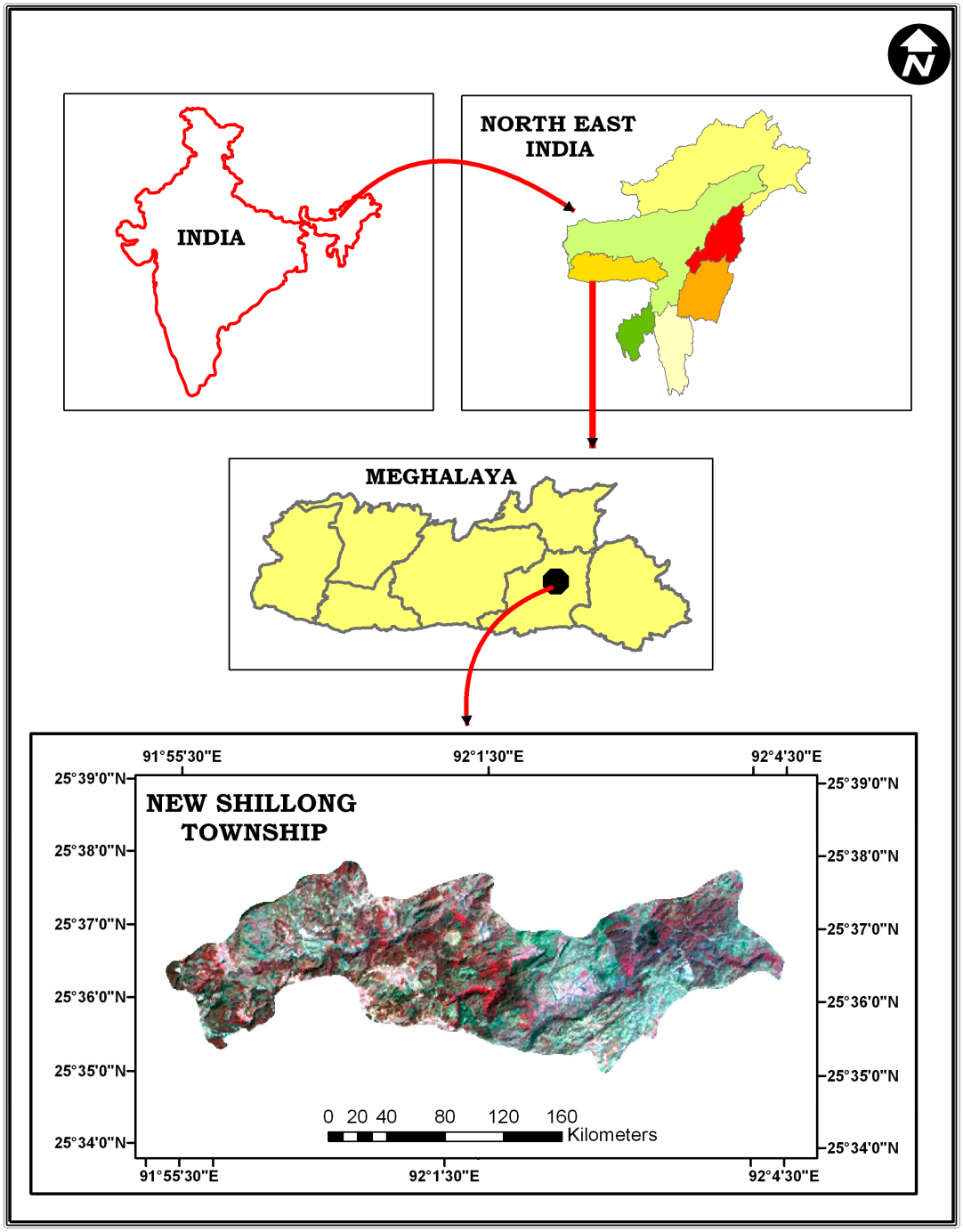

Fig.1 Location Map of New Shillong Township Area

Ground Truth Verification

A pre-field interpretation map was prepared and the confusing areas were verified by ground truth. Ground truth information was collected by using a Garmin E-Trex vista 76 module. Recent satellite data were used during the field survey and the current landuse practices are noted in the field. The past

Landuse/Land cover information was gathered by informal interviews with the local people and concerned state government department. The (Global Positioning System) GPS points were downloaded and overlaid on the imagery and used for refinement of the pre-field interpreted Landuse/Land cover map. The downloaded GPS points which were overlaid on the satellite image has been shown in Fig-2

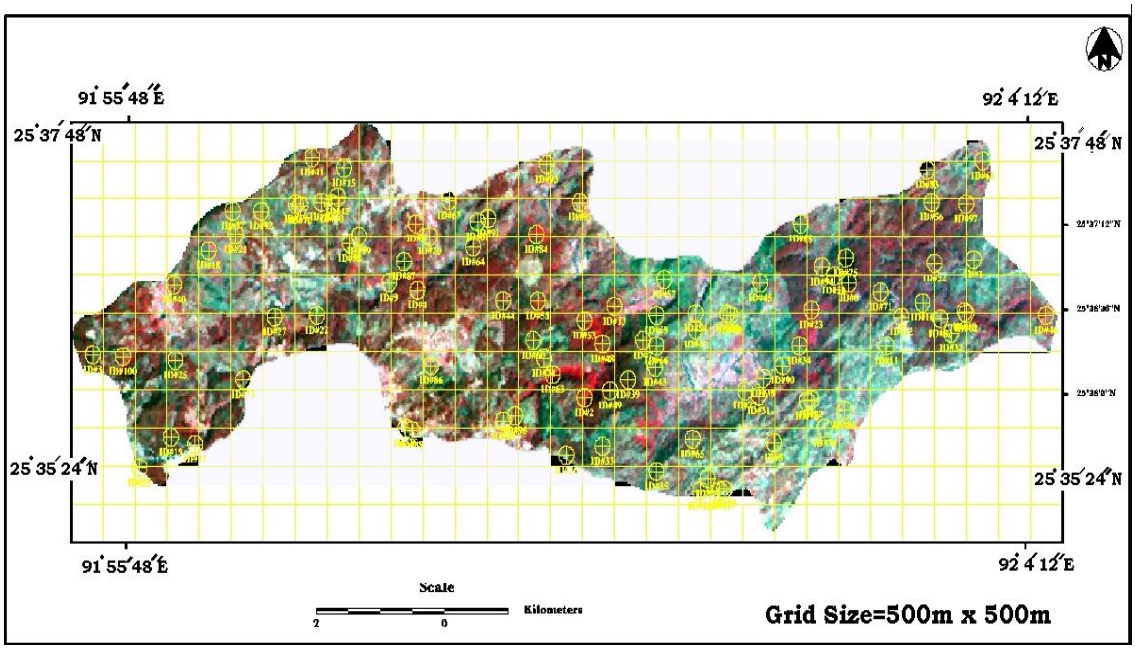

Fig.2 Grid Sample Map of New Shillong Township Area

For the Landuse/Land cover mapping supervised classification method was applied. The Landuse/Land cover maps are generated for the years 1977, 1987, 2004 and 2007. The mapping exercise was carried out first on the datasets of 2007. After that other landuse maps were prepared. As the Landsat MSS satellite image of the year 1977 was merged with the PAN image of higher resolution to get a better result of the Landuse/Land cover classification. Landuse/ Land cover statistics area generated for each year (Table.2)

Change Detection Analysis

The change detection analysis was performed by using the Landuse/Land cover maps of all the time scales. The Landuse/Land cover maps of all the time scales were overlaid upon each other to analyze the change matrix. The changes were analyzed along the topography viz: elevation, slope and aspect. Digital Elevation Model (DEM) was used to derive the slope and aspect condition of the study area.

Table.2 Area statistics of different landuse/land cover classes of the study area

Landuse Class	Area in ha				Net change		
	1977	1987	2004	2007	77-87	87-2004	2004-2007
Pine Forest	976.32	817.52	730.98	409.3	-158.8	-86.54	-321.68
Broadleaved	220.60	332.52	232.83	479.01	111.92	-99.69	246.18
Water Body	148.47	159.77	144.08	161.04	11.3	-15.64	16.96
Cropland	176.08	222.55	366.4	443.72	46.48	143.85	77.32
Settlement	93.57	142.95	159.63	211.5	49.2	16.68	51.87
Barren land	197.82	161.39	168.02	102.16	-36.43	6.63	-65.86

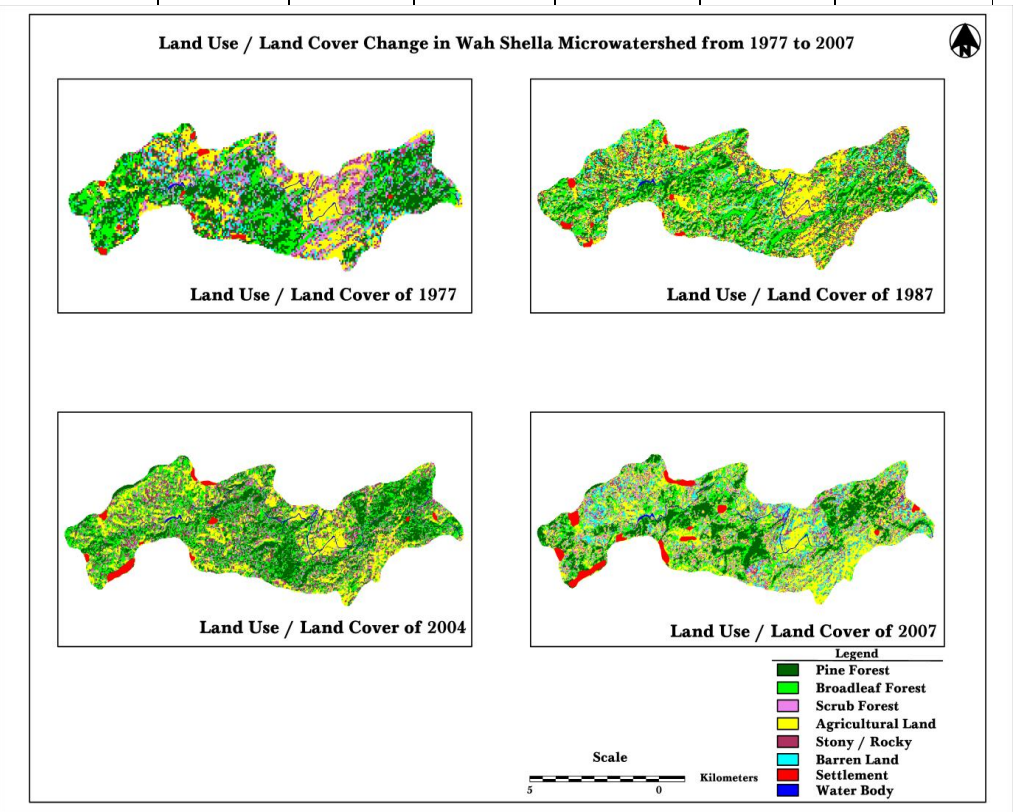

Fig.3 Change Detection Map of New Shillong Township Area

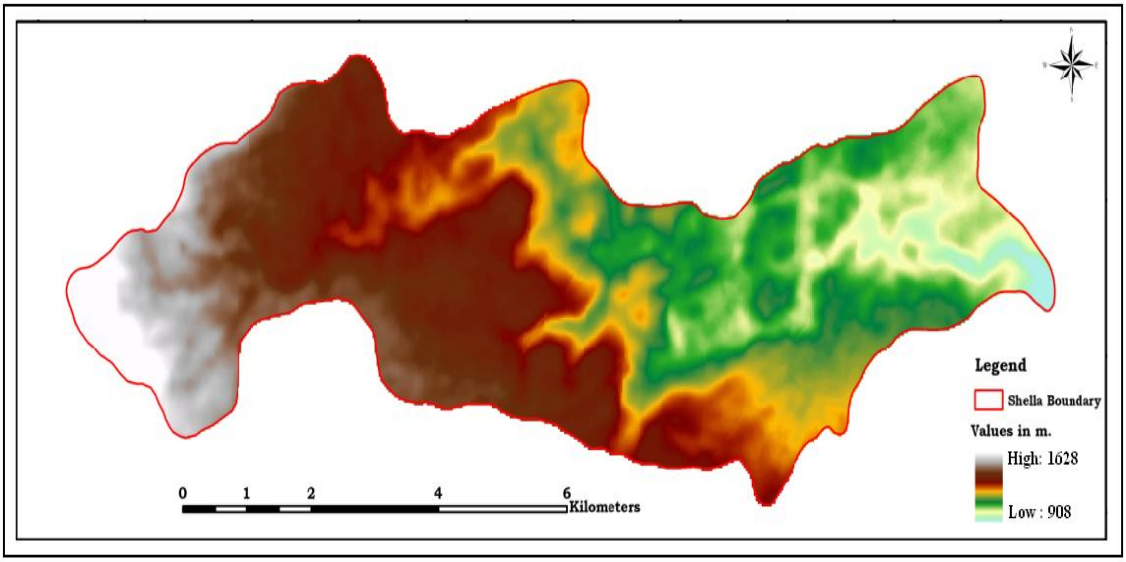

Fig.4: Digital Elevation Model of New Shillong Township

Patch Based Index Analysis

In order to examine landscape pattern, its dynamics and degree of fragmentation the patch-based index with supplementary ecological meaning has been studied. Patch can be described as non-linear surface area differing in appearance from its surroundings. The primary significance of shapes in determining the nature of the patches in a landscape appears to be related to the edge effect. The number of patches shows the porosity in the matrix (a surrounding area that has different species structure or composition). More the number of patches more porous are the ecosystem.

Results and discussion

Landuse/Land cover Mapping

Presently, 409.3 ha of land is under pine forest, which is 22.65 per cent of the total geographical area. The *Pinus kesiya* with sporadic occurrence of a few broad leaved species like *Schima wallichii*, *Quercus griffithii*, *Q. semiserrata*, *Lyonia ovalifolia* etc.are noticeable. The shrub layers, varies from sparse cover to thick cover and is dominated by *Lantana camera*, *Rubus* spp., *Eupatorium* sp. The ground vegetation is sparse and dominated by grasses. The sparse ground vegetation in pine forest is due to repeated disturbance of annual fire. And it is located mostly in the south-western part of the study area.

Broadleaved forests are restricted to certain small pockets in inaccessible areas and near rivers and in scattering in every direction of the study area. However, the native flora of the area has been disturbed to a great extent and the broad leaved forest patches in most of area represents secondary successional stages with mostly pole size trees. All the trees were more or less of equal height (average 6 m) that gives these patches a bushy look. The area under this category is 479.01 ha. which is 26.51 per cent of total geographical area. The broadleaved forests are under great anthropogenic pressure along the southern boundary of the study area.

Croplands are concentrated in the areas that are close to the rivers and adjacent plain lands. Areas adjacent to Wah Shella and in Umbah rivers are used for agricultural purposes. Besides this, croplands are also scattered in close proximity of the village settlements. Presently, a total of 443.72 ha area is under the different crop cultivation which is 24.55 per cent of total geographical area. Agriculture is the main source of livelihood of the inhabitants of the area. More than

70 per cent people are engaged in agriculture for their livelihood.

The settlement pattern of the New Shillong Township shows a clumped distribution. Settlement units are concentrated in general at flat lands, which are spread over southern, northern and mid-eastern directions. Southern part is thickly populated as compared to the middle area. However, settlement occupies an area of 211.5 ha; it is 11.70 per cent of total geographical area. There are eight villages in the study area.

The Barren lands are the land which remained unused throughout the year. These fallow lands are mainly found in the areas adjacent to rivers and rivulets. Those stretches of lands which were earlier used for the purpose of shifting cultivation but are currently barren, are also included in the category of fallow land. River banks which are seasonally submerged by overflow of water and cannot be use for any purposes are also kept under this category. In the study area barren land occupies an area of 102.16 ha. which is 5.65 per cent of total geographical area.

The New Shillong Township has been criss-crossed by numerous small rills and gullies. But the prominent water bodies in the area are river Wah Shella, Umroh and some small tributaries of river Wah Tamdong. Besides, these in some places seasonal wetlands are recorded. The water bodies cover an area of 161.04 ha, which is 8.91 per cent area of the total land. The water bodies are mostly flowing towards the eastern direction.

A total of 6 Landuse/Land cover classes were observed in the New Shillong Township site during our field survey period, these are- Pine forest, Broadleaved forest, Cropland, Barren land, Built-up area and Water body (Table.2).

Major portion of the Landuse/Land cover classes in the study area has been covered by Pine forest and broadleaved forest blanket. Cropland practices include settled agriculture fields with potato and cabbage as a major crop. Bamboos are found to occur as a secondary growth in disturbed areas. Agriculture practice is seen to remain stable throughout the year. Barren land area places which are devoid of vegetation cover and characterized by stony/rocky patches. The gradual decrease of pine forested land areas can be attributed to the cause of increase of croplands and built-up or settlement areas. Areas under settlement or built-up have increased continuously since 1977 onwards. It is found that after 1977 the major forest blanks are occupied by increasing cropland areas and somewhere come under the impact of increasing human occupancies for other purposes. The reduction in barren land can be attributed to the increase in the areas in cropland, broadleaved forest and built-up classes. Some areas under cropland adjacent to the river bed have been converted from cropland to barren land.

Land cover Dynamics

The DEM (Digital Elevation Model) of the study area has been classified into altitudinal ranges to find out the changes at different height levels. Majority of area in the study area falls in the altitude range of 1254-1350m (Fig.4). The most active zone for the human activities is found to be at a height of 1350-1628m. Although changes are found to be occur at the lower altitude also but there appears a trend of increasing human activities at the higher altitudinal ranges in the recent years. The changes in the various slope categories were found out by overlaying the change detection map with the slope map. The maximum changes in all the years were found to occur in 0-30 per cent slope category and in the southern aspect of the study area.

Patch Characteristics of New Shillong Township Area

The marked changes in the landscape pattern of the New Shillong Township area ultimately affect the patch characteristics (shape, size, association and number etc.). Patch characteristics of the landscape

usually provides valuable information on the phenomena of conversion of the ecosystem cycle. The number of broadleaved patches has been increased over the time period. But as seen during the year 2004 the patch number has reduced as compared to 1987 but the area remains almost same in the year 1977 and 2004. The pine forest patches show decrease in the number of patches over the time and reduced area; thus imply that the many of the pine patches have disappeared during this period. The patchiness of the degraded pine and its area show that certain areas are converted to broadleaved, owing to the high fast growing and regeneration of the broadleaved forests. Both the pine and broadleaved forests show high level of disturbances as indicated by unstable numbers of patches. The changes in landscape pattern affect the patch characteristics (shape, size and association etc.). The patch characteristics of the landscape provide valuable information on the process of alteration of the landscape. Patches are non-linear surface area differing in appearance from its surrounding. Human activities are the main causes of fluctuating nature of patchiness in an ecosystem. The primary significance of shape in determining the nature of the patches in a landscape appears to be related to the edege effect. Shape Index(SI) attains minimum value when the shape of the patch is completely regular, such as circle, and usually increases when the patch turns to be more complex (Schumaker, 1996; O'Neil *et al*., 1999; Fuller 2001)

Conclusion

Landuse/ Land cover change have either undesired or beneficial effects on the environment deserve special attention. Remote sensing and GIS is a vital tool for measuring the landscape dynamics of any particular area. It immensely contributes in detecting the type of change, location of the change, quantifying the changes taking place in an ecosystem. The present study is a case study which was conducted in a mid-altitudinal area in the state of Meghalaya showing the dynamics of LULC classes will help in assessing the health status of the ecosystem. The gradually increasing areas under cropland and associated landuse pattern are causing disturbances in the study area. The barren lands occurring in the region are the result of repeated deforestation and disturbances causing by anthropogenic pressure. In the span of time some of the barren lands have been converted to cropland and settlement area. Presently, there occurs a trend of Landuse/Land cover change moving towards the higher altitudes, which may be due to the high resource utilization in the lower altitude and high resource availability in the higher altitude. The patch based analysis indicates prevailing disturbances in the study area. The level of disturbance is not so severe in the broadleaved forest area. But on the contrary it is severe in the pine forest covered areas.

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