

Full Length Research Paper

Spatio-temporal changes in land uses and land cover due to human interference in Meghalaya, India: A case study of Wah Shella microwatershed

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Impact of human interference on the degradation of natural forests in the last three decades in Wah Shella microwatershed in Meghalaya (India), a hilly state of North-Eastern India has been reported. Remote Sensing and GIS data were applied to highlight spatial and temporal changes in land use and land cover. The present study is an excellent example of human induced land use changes and later the measures for ecorestoration were suggested.

Key words: Human interference, forest degradation, spatio-temporal changes in land uses and land cover, Wah Shella microwatershed, Meghalaya, ecorestoration.

INTRODUCTION

Degradation of natural resources has been a global problem. Accelerated conversion of forest land, due to rapid urbanization and industrialization, intensive agriculture practices, over-exploitation, over-grazing, mining and other anthropogenic activities have resulted to changes in land-use and land cover pattern. Significant land-use/land cover changes have been reported during the last century both on spatial and temporal scale, mainly due to economic development and population growth (Mitch and Gosselink, 1993; Sarmah et al., 2011). Although, information on land use/land cover in the form of maps and statistical data is very essential for spatial planning, management and utilization of land for agriculture, forestry, pasture, urban industrial, environmental studies and economic production etc, (Chopra et al., 1997). Anthropogenic changes in land use and land cover being increasingly recognized as a critical factor influencing global change (Nagendra et al., 2003). Currently with the growing population pressure, changing human population-land ratio and increasing land degradation, the need for optimum utilization of land assumes much greater relevance. Remote sensing integrated with Geographic Information System (GIS), provides an effective tool for analysis of land use and land cover

changes at macro, meso and micro level which could potentially enhance management of critical habitats of entire human society. The geospatial technology that combines the technology of remote sensing and GIS holds the potential for timely and accurate determination of pace of land degradation due to various anthropogenic and natural phenomena. These sorts of techniques have been used in the tropics for generating valuable information on vegetation cover, vegetation types and land use changes (Foreman, 1995).

The north-eastern region of India is globally recognized as a mega biodiversity area because it supports the richest genetic diversity of plants, animals and microbes. The state of Meghalaya is one of the seven sister states of north-eastern India and is recognized in the world due to highest rainfall zone of the world. The natural resources of Meghalaya state is under serious threat due to extensive felling of trees for shifting cultivation and to meet the demand of timber and fuel for internal consumption. The massive deforestation due to human interference has caused conversion of forested land into wasteland. This has resulted in vast changes in land cover and land uses in Meghalaya state. Thus, in order to examine and validate the truth, a pilot study has been carried out in Wah Shella microwatershed a representative area of Meghalaya to regulate and control the anthropogenic pressure through a proper eco-restoration plan.

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Table 1. Dataset used.

Data type	Path and row	Date of acquisition
Landsat MSS	111/53	8 February 1977
Landsat-TM	111/53	21 February 1987
IRS P6 LISS III	111/53	7 March 2004
IRS P6 LISS III	111/53	23 March 2007
Survey of India toposheets	Scale 1: 50,000	1973
MUDA Map	1:50,000	1996

Study region

The Wah Shella microwatershed is located at 25°34'0" to 25°39'0"N latitude to 91°55'0" to 92°4'0"E longitude in the north-eastern most boundary of East Khasi hills district of Meghalaya. It is about 15 km north-east from the capital city of Shillong. It occupies a total area of 18.78 sq.km. The study area comes under Central Upland zone of Meghalaya state with altitudinal ranges from 1100 to 1600 m amsl. The climate of the area is warm and wet during rainy seasons (June to August) and cold and dry during winter season (December to February). The average maximum temperature in the area is 25°C during the month of July and August and the mean minimum is 10°C during January. The area receives an average annual rainfall of 2500 mm. About 90% of the rainfall occurs during the period between May to October. Physiologically, the area is undulating in nature.

MATERIALS AND METHODS

To analyze the landuse/landcover change dynamics of Wah Shella microwatershed multi date satellite imageries were used. Besides the Survey of India topographical sheet no 78 O/14 and 83 C/2 at 1:50,000 scale and also maps available with the Meghalaya Urban Development Authority (MUDA) were used for delineation of microwatershed boundary and to generate baseline information from the study area. The details of the datasets used in the study area are given in Table 1. Satellite imagery of 1977 Landsat MSS of 1987 Landsat-TM and IRS P6 LISS III image of 2004 and 2007 were used to analyze the landuse/landcover change dynamics in the Wah Shella microwatershed area (Figure 2). The open source Landsat MSS and TM were downloaded from NASA's Global Land Cover Facilitator's (GLCF) website (www.glcfc.edu.org) and satellite imagery of 2004 and 2007 were procured from NRSC, Hyderabad. The imageries were projected to UTM-WGS 84 projection system using Landsat-ETM images as reference. Sub-pixel image to image accuracy was achieved through repeated attempts. Radiometric corrections of all the images were done using dark pixel subtraction technique (Lillesand et al., 2004; Erdas field guide, 2008). Resampling of IRS P6 LISS III imageries were carried out through at 30 m pixel size as the other imageries (Landsat MSS and Landsat TM) at 30 m resolution.

Subset operation of satellite imageries of 1977, 1987, 2004 and 2007 were carried out by creating an area of interest (AOI) layer of the vector layer of the microwatershed boundary, which was digitized from the published map of MUDA, Government of Meghalaya at 1:50,000 scale. After subsetting, the images of the

study area were processed through spectral enhancement technique using Erdas Imagine 9.1 software package. Principal Component Analysis (PCA) was carried out to all the images. All the images were converted to three principal components. PCA is often used as a method of data compression. It allows redundant data to be compacted into fewer bands that is the dimensionality of the data reduced. The bands of the PCA data are non-correlated and independent, and are often more interpretable than the source data (Jensen, 1996). After generating the hybrid PCA images for all the years, a supervised classification technique was used using maximum likelihood algorithm to assess the land cover change dynamics in Wah Shella microwatershed since 1977 to 2007. Supervised classification is a process where the image analyst supervised the pixel categorization process by specifying to the computer algorithm, numerical descriptors of the various land cover types present in the scene (Lillesand et al., 2004). Ground verification was conducted using an e-trex Global Positioning System 76 (GPS) receiver. A total of 86 points were collected from the different parts of the microwatershed to know the proper representation of different land use classes.

RESULTS AND DISCUSSION

The entire Wah Shella microwatershed area (Figure 1) was classified using supervised classification technique into six landuse/landcover types based upon field knowledge and collected training sets of vegetation types. The six different land cover types are as follows:

- (a) Pine forest
- (b) Broadleaved forest
- (c) Agricultural land
- (d) Settlement area
- (e) Abandoned fallow land and
- (f) Water bodies.

The composition and distribution of land use/land cover types are as follows:

Pine forest

Presently, 409.3 ha of land is under pine forest, which is 22.65% of the total geographical area. The *Pinus kesiya* with sporadic occurrence of a few broad leaved species like *Schima wallichii*, *Quercus griffithii*, *Quercus semiserrata*, *Lyonia ovalifolia* etc are noticeable. The shrub layers, varies from sparse cover to thick cover and

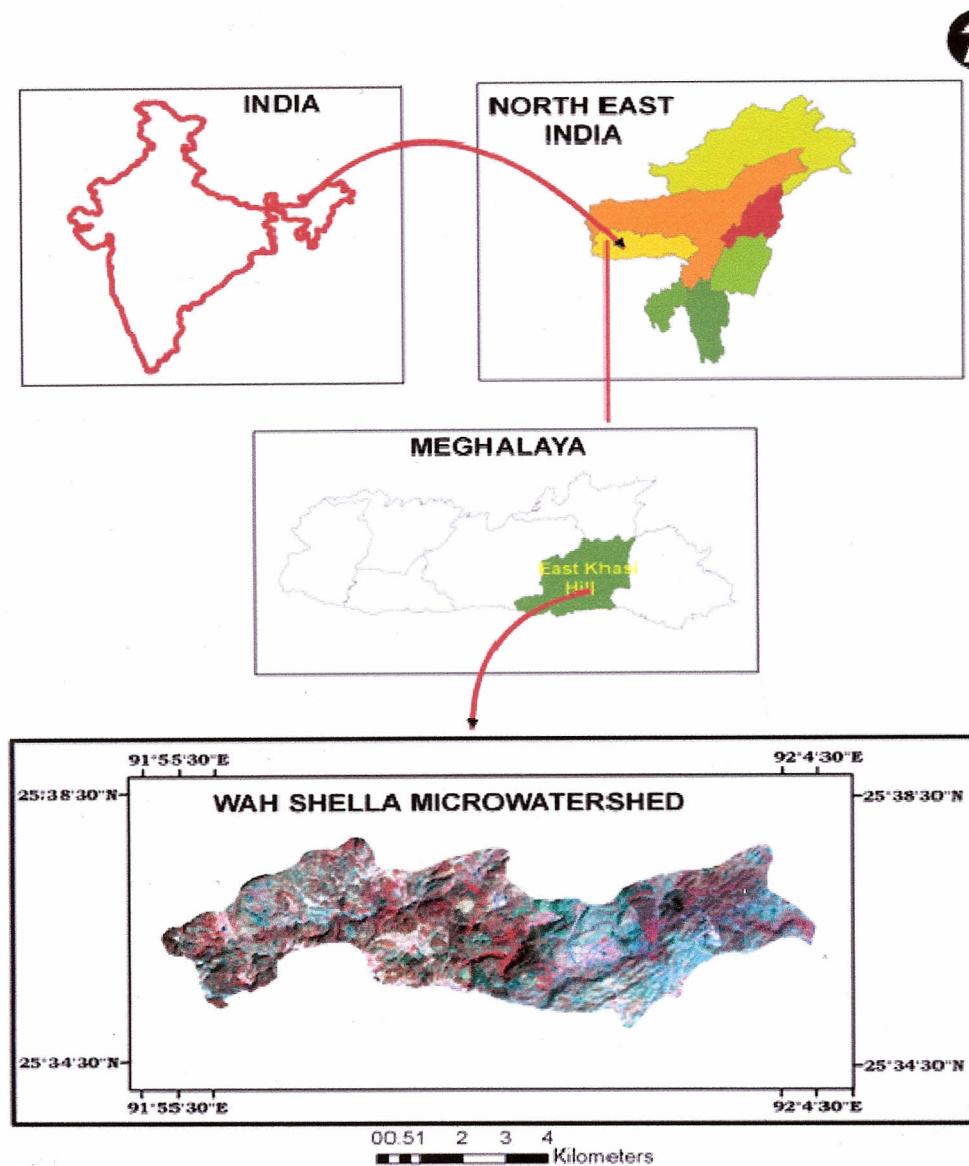


Figure 1. Location Map of Wah Shella microwatershed.

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 due to annual fire and it is located mostly in the south-western part of the micro watershed.

Broadleaved forest

Broadleaved forests are restricted to certain small pockets in inaccessible areas and near rivers. However, the native flora of the area has been disturbed to a great extent and the broad leaved forest patches in most of the

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% of total geographical area. The broadleaved forests are under great anthropogenic pressure along the southern boundary.

Cropland

Croplands are concentrated in the areas that are close to the rivers and adjacent plain lands. Areas adjacent to the Shella and in Umbah Rivers are used for agricultural purposes. Besides this, croplands are also scattered in

Satellite Imagery of Wah Shella Microwatershed

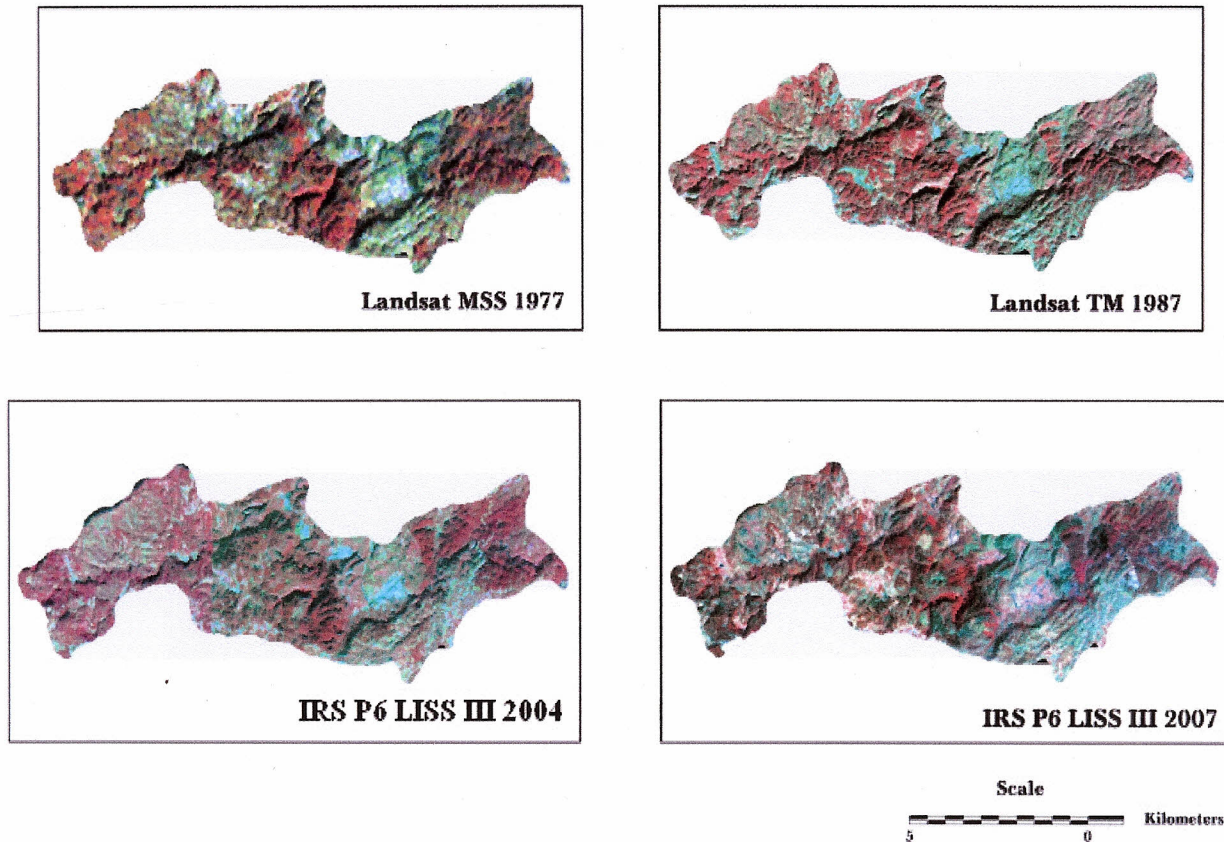


Figure 2. Satellite imageries of Wah Shella microwatershed.

close proximity of the village settlements. Presently, a total of 443.72 ha area is under the different crop cultivation which is 24.55% of the total geographical area. Agriculture is the main source of livelihood of the inhabitants of the area. More than 70% of people are engaged in agriculture for their livelihood.

Settlement area

The settlement pattern of the Wah Shella microwatershed 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% of total geographical area. There are eight villages in the microwatershed.

Abandoned land

The abandoned or fallow lands are the land which

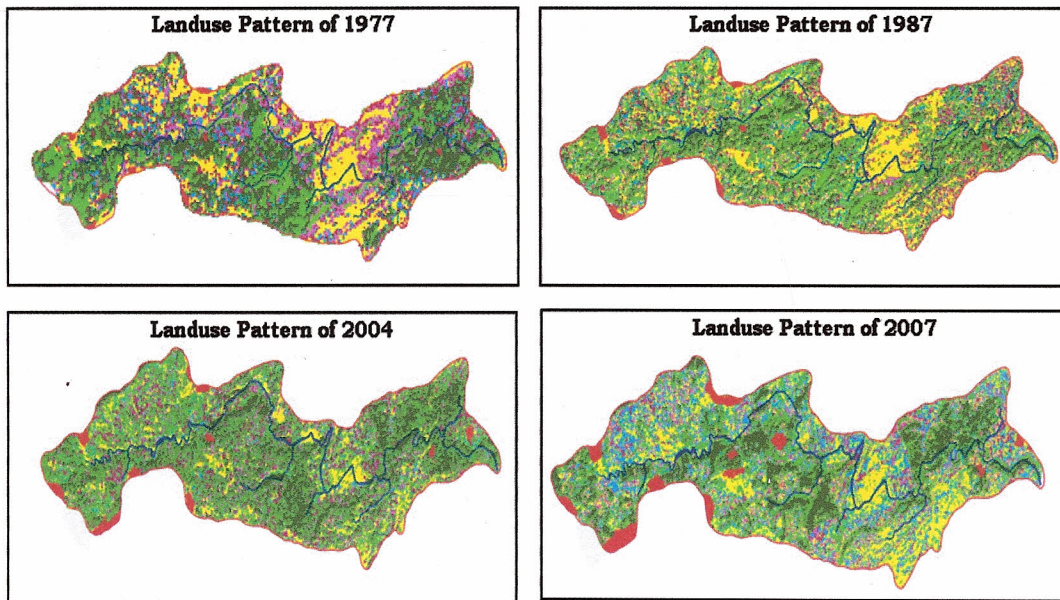
remained unused throughout the year. These fallow lands are mainly found in the areas adjacent to rivers and rivulets. Those stretches of lands which were earlier used for the purpose of shifting cultivation but are currently fallow, are also included in the category of fallow land. River banks which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

Water bodies

Wah Shella microwatershed has been criss-crossed by numerous small rills and gullies but the prominent water bodies are River Wah Shella, Umroh and some small tributaries of Wah Tamdong River. Besides, this in some places some seasonal wetlands are recorded. The water bodies cover an area of 161.04 ha, which is 8.91% area of the total land. The water bodies are mostly flowing towards the eastern direction.

Table 2. Land cover/Land use changes in Wah Shella microwatershed.

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
Abandoned land	197.82	161.39	168.02	102.16	-36.43	6.63	-65.86

**Figure 3.** Change dynamics of Landuse/Landcover pattern of Wah Shella microwatershed.

Land cover and land use changes

The analysis and elaboration of the satellite imageries for the years 1977, 1987, 2004 and 2007 had provided the land use/ cover types and changes there in within three decades. The most prominent estimated change of Wah Shella micro-watershed during three decades (1977 to 2007) was the decrease of Pine forest area. The pine forest area reduced from its initial extent of 976.32 ha in 1977 to 409.3 ha in 2007 (Table 2 and Figure 3). Almost 321.68 ha of pine forested area had been lost in these three decades. The area under Broadleaved forest shows increasing trend that is 332.52 ha with reference to 1977 that is 220.60 ha. Again, decline in broadleaved cover recorded in 2004, that is 232.83 ha and same increased more than double in 2007, that is 479.01 ha. Pooled data on forest cover under pine and broadleaved species showed forest cover 1150.04, 963.81 and 888.31 in 1977, 1987, 2004, and 2007 respectively (Table 2).

This shows decline in overall forest cover. It is also gradually losing its share to settlement or built up area. From the aforesaid analysis, it is evident that a major chunk of land has been deforested and most of these areas are in the south-east direction. Initially, the inhabitants of the area were only collecting minor forest produce for their livelihood. Gradually with the passing of time, the Pine and Broadleaved species were felled to a great extent and the cleared area used for the purpose of settlement and farming practices. Over the period covered (1977 to 2007), the area under the water bodies shows increasing trend. In the year 1977, water bodies were covering an area of 148.41 ha which increased to 161.04 ha in 2007 (Table 2). The present study gives an excellent example of human induced land use change; it becomes clear with the steady increase of cropland area. In 1977, the area under cropland was 176.08 ha but same has climbed up to 443.72 ha in 2007 (Table 2). Almost 267.64 ha of forest land has been converted to

cropland. Over 70% of people of the microwatershed area are engaged in agricultural activity. The change in people's economic activity and increase in income level has also influenced the settlement modes to a great extent. As a result, presently 211.5 ha is under settlement area, which is 117.93 ha more than the year 1977 (Table 2).

Measures for eco-restoration

The eco-restoration of the study area is essential and need specific treatment for environmental conservation. The Wah Shella microwatershed in particular and state of Meghalaya in general is in the grip of heavy deforestation. The area under pine forest declined severely in the last three decades. This can be restored by implementation of suitable afforestation practices and filling the gaps by indigenous broadleaved or *P. kesiya* species. The distribution of broadleaved species are restricted in the riverine belt, thus to minimize the siltation of gaps which need to be filled by indigenous tree species. The abandoned fallow land should be brought under social forestry programme and same can be revegetated by involving villagers. In the study area, land having slope percent of more than 50° are also under cultivation. Although, the area under this category is very little. Land having more than 50% slope should be put under agroforestry system such as Tree-Green hedge, crop farming system to control biophysical problems such as soil, moisture and nutrient loss (Jha, 2001).

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