The expansion and impact of cement manufacturing units and mining areas in Lumshnong, Jaintia hills, Meghalaya

Kasturi Chakraborty* and S. Sudhakar

North Eastern Space Applications Centre, Umiam 793 103, India

With the rapid developmental process taking place across the globe, there are several pockets widespread in North East Region of India which are becoming hotspots of land-use change. Industrial expansion is one of the main reasons for conversion of land-use/land-cover classes, particularly from forest to non-forest. This study focuses on the impact of the cement industrial and mining activities leading to the loss of forest cover in Jaintia hills district, Meghalaya, NE India. The region owing to its large natural resource store is becoming the zone of forest to non-forest conversion at a much faster rate. In this study, remote sensing has been used as a tool to observe the extent of land-use change using an automatic change detection software, DeltaCue to map the expansion of the cement industrial units and their impact on the vegetation in the immediate vicinity. The present study highlights the spread of the industrial units from 2005 to 2011 and the loss of vegetation.

Keywords: Cement industry, land-use change, loss of vegetation, mining activities, remote sensing.

MEGHALAYA in North East India is endowed with rich natural resources. Physical, biological and geochemical resources play a crucial role in the interactive action as they form the base of the production system on which the indigenous society depends for its sustenance and survival. Forest wealth of Meghalaya has been well documented in several studies carried out in this region. Various factors like increase in population, and jhumming have often been the cause of rapid deforestation in Meghalaya along with many other places in India and also globally. Planning plays a pivotal role towards attaining the objectives of development. The hill specificities of Meghalaya and richness of natural resources in its diverse agro-ecological setting demand integrated resource planning with a holistic approach towards natural resource management[1]. However, the recent trend of developmental processes in this region is leading to rapid deforestation. Mining activities in Meghalaya have increased by leaps and bounds. Indiscriminate mining has disastrous effect leading to deforestation, destroying good soil ingredients and loss of wildlife.

Coal is a premier export commodity. Mining has extended over a vast area in Jaintia and Garo hills of Meghalaya. Jaintia hills is contributing to the industrial extension for supply of cement to various places[2]. Being rich in minerals, particularly limestone, coal, shale, bauxite, laterite, etc. the Jaintia hills district of Meghalaya has become a boon to the cement industry. The setting up of such industry exploits natural resources of the area, degrades the environment and can lead to imbalance in the ecosystem. According to the IPCC special report[3] from 1850 to 1998, approximately 270(+30) GT carbon has been emitted as CO_2 into the atmosphere from fossil-fuel burning and cement production. Remote sensing has been universally recognized as a highly effective and extremely versatile technology for identification of natural resources, including forest resource[4]. This study has been carried out to observe the growth of cement industries in Lumshnong, Jaintia hills district, which is leading to change in land use/land cover from forest to non-forest categories. The study attempts to automatically extract the areas of change taking advantage of the change detection software.

The study area (Figure 1) extends between 92°16″9.7′–92°28″10.8′ and 25°06″10.3′–25°16″59.5′. There are several cement manufacturing units located in the area.

Figure 2 shows the satellite data used in the study. The satellite images of IRS P6 LISS III 111/54 Nov 2005, IRS P6 LISS III 111/54 Jan 2009 and IRS P6 LISS III 111/54 Dec 2011 have been used in the change detection study. The satellite images were registered carefully using AutoSync, an automated image registration tool in ERDAS Imagine software. The satellite data of 2005 was classified to understand the existing forest in the study area. The 2005 image was classified by supervised classification technique into forest and non-forest classes. The classified map has forest area divided into three categories, viz. less dense forest, medium forest and very dense forest, and other non-forest classes. The expansion of the manufacturing units, establishment units and the mining areas of the cement factories in Lumshnong was observed from 2005 to 2009, 2009 to 2011 and overall change from 2005 to 2011 within a buffer of 10 and 5 km from a central location of the manufacturing plants. For automatic and efficient change detection, the ERDAS Imagine change detection software, DeltaCue has been used. This software implements an automated procedure for image-to-image normalization that forces the mean and standard deviation of the time-2 image to match the same statistics of the time-1 image. The primary colour difference algorithm has been used in the change detection process. The redness difference algorithm could pick up the regions of forest to non-forest conversion. The primary colour difference algorithm requires a colour threshold value. This value is a per cent threshold on the cosine of the spectral angle. Any cosine values lower than this threshold are not considered in the difference. The total expansion of the cement industrial units was observed from 2005 to 2011. The removal of the forest due to industrial expansion was

*For correspondence. (e-mail: kasturi.nesac@gmail.com)

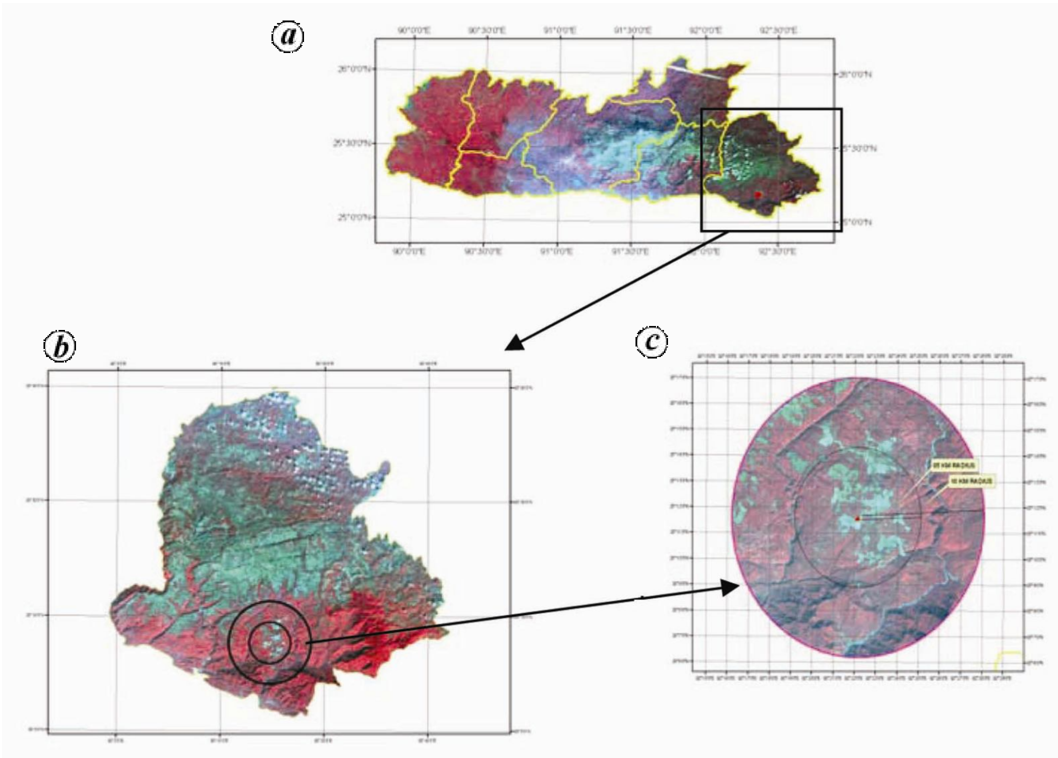

Figure 1. FCC images showing location of the study area. ***a***, Meghalaya with district boundary; ***b***, Jaintia hills district; ***c***, Study area with buffer of 5 and 10 km radius.

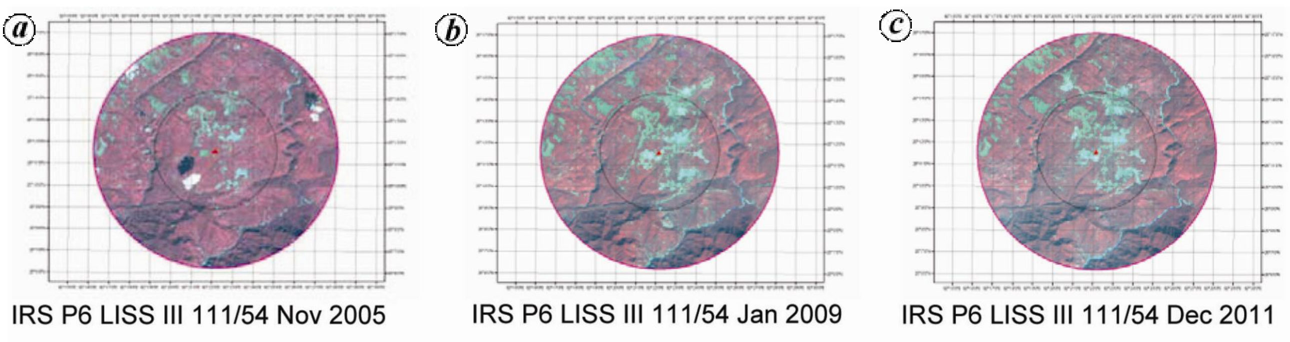

Figure 2. Study area – satellite image of 2005 (***a***), 2009 (***b***) and 2011 (***c***) with buffer area of 5 and 10 km radius.

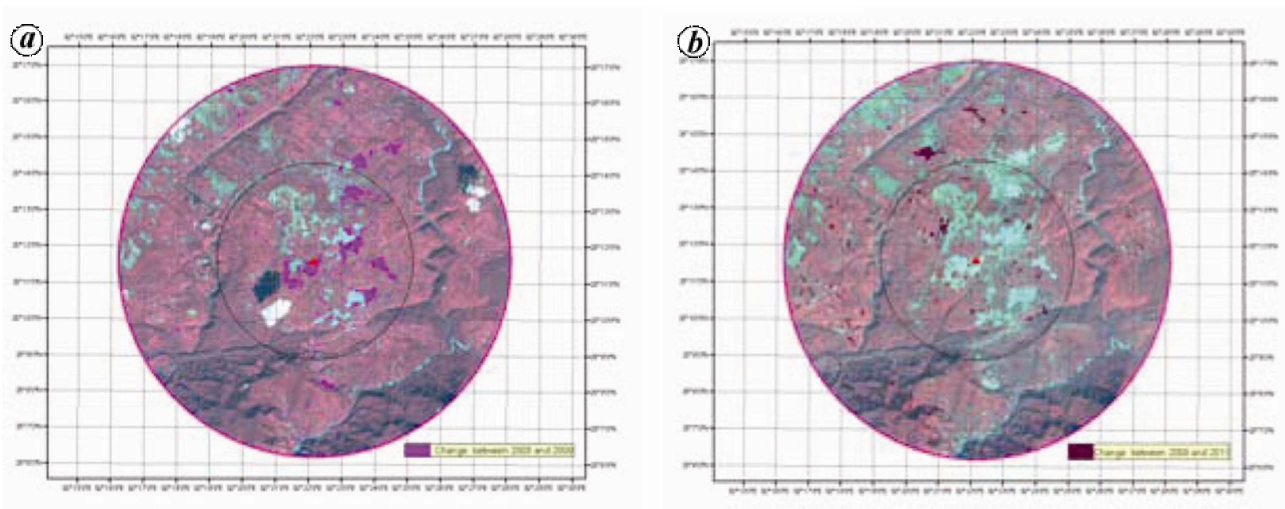

Figure 3. Expansion of area between 2005 to 2009 (***a***) and 2009 to 2011 (***b***).

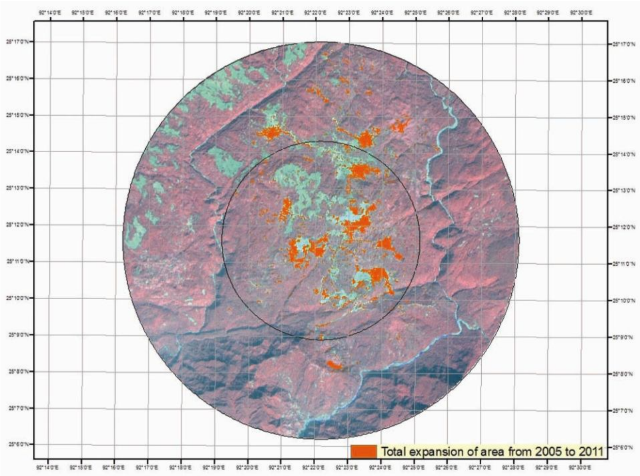

Figure 4. Total expansion of area between 2005 and 2011.

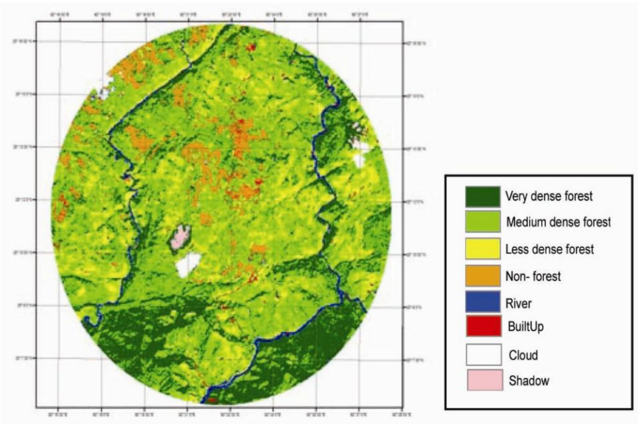

Figure 5. Classified image showing the existing forest and non-forest classes during 2005.

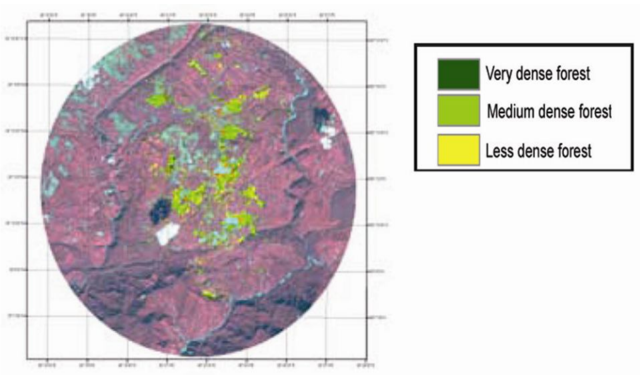

Figure 6. FCC image of forest areas removed due to expansion of industrial area between 2005 to 2011.

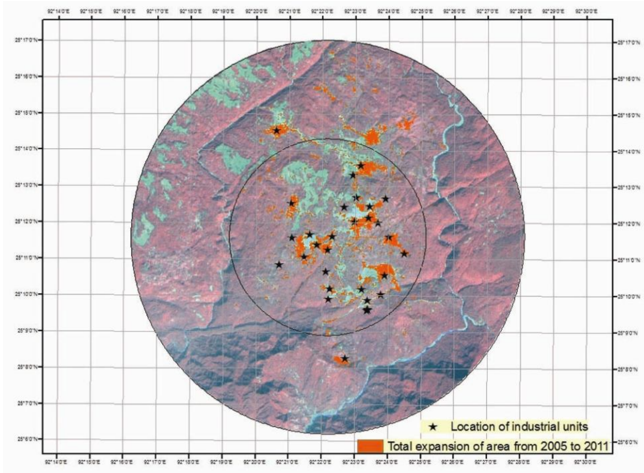

Figure 7. Location of the cement manufacturing units on the ground compared with the results obtained by change detection shown on the FCC image.

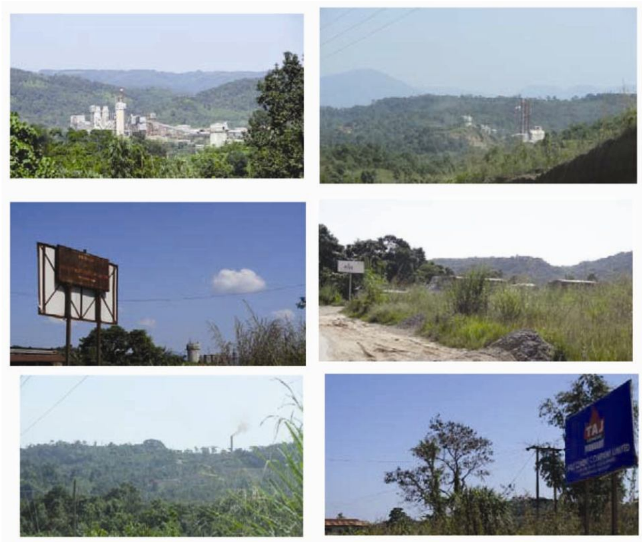

Figure 8. Ground photographs of the industrial units located in the area.

Table 1. Loss of existing forest area (ha) from 2005 to 2011

Classified forest class	Total forest area	Remaining forest after establish-ment of units	Loss of forest
Less dense forest	5,111.37	4,859.72	–251.65
Medium dense forest	13,295.9	12,528.9	–767.00
Very dense forest	9,145.32	8,898.62	–246.70
Total			–1,265.35

quantified by comparing with the existing forest in the area and the total change of the industrial units detected in the study area.

The land-use/land-cover change from forest to non-forest area has been observed from 2005 to 2011. Figure 3 *a* and *b* shows the change between the years 2005 to 2009 and 2009 to 2011 respectively. It was found that the expansion of the non-forest area attributed to the cement manufacturing units amounted to 554.69 ha during 2005–2009 and 291.86 ha during 2009–2011. Figure 4 shows total expansion of the industrial units from 2005 to 2011.

Figure 5 is a classified image of 2005 showing the distribution of the existing forest. The vegetation removed from the study area due to industrial expansion can be observed from Figure 6. Removal of the forest area was observed by comparing the classified image and the zones of expansion of industrial units extracted by the change detection from 2005 to 2011. Table 1 compares the loss of the existing forests in different categories. The total loss of forest in the area was found to be around 1265.36 ha from 2005 to 2011, with maximum expansion during 2005–2009 and within 5 km radius.

The zones of industrial expansion were verified on the ground (Figure 7) and the locations were found to match with the results extracted by change detection. It was found that large areas are being converted to non-forests due to industrial expansion. Figure 8 shows the ground photographs of some industrial units. The names of all the units are not been mentioned but the location of each unit as shown in Figure 7 constitutes the manufacturing unit, the mining area, etc. of several cement industries.

The present study has been carried out in a small area of radius 5 and 10 km to understand the ongoing changes in the immediate vicinity of the cement manufacturing units. It is observed that the changes are occurring in the immediate surroundings, particularly within the radius of 5 km, which is perhaps due to the expansion of the manufacturing units. Major changes are noticed from 2005 to 2009, while the expansion continued during 2009–2011. The expansion has been occurring in the forested region. The total loss of forest within a short span is found to be 1265.36 ha, which is supported and validated with the ground information. This study attempts to observe and extract the forest–non-forest conversion using automated software like DeltaCue and also indicates the ongoing deforestation taking place due to the establishment of such industrial units in the region. At the same time there is increase in mining activity where good forest areas existed in the past. On the ground, it is found that a conglomeration of the manufacturing unit exists in this region. Therefore, it is important to take the immediate necessary steps to control further expansion leading to change from forest to non-forest land-use categories.

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Hydrogeochemical assessment of groundwater in karst environments, Bringi watershed, Kashmir Himalayas, India

Nadeem A. Bhat[1,*], Gh. Jeelani[1] and M. Yaseen Bhat[2]

[1]Department of Earth Sciences, University of Kashmir, Srinagar 190 006, India
[2]Directorate of Geology and Mining, Srinagar 190 015, India

Hydrogeochemical assessment of precipitation, streams and springs of Bringi watershed, SE Kashmir has revealed that Ca and HCO_3 are the dominant ions, making up more than 50% of the total ions, which indicates carbonate lithology as the dominant source of ionic species. However, increased Na in some samples, particularly Kongamnag, indicates the impact of silicate weathering on water chemistry. The dominant order of cations and anions in the water samples is Ca > Mg > Na > K and HCO_3 > SO_4 > Cl respectively. In both streams and springs, electrical conductivity, total dissolved solids (TDS), Ca, HCO_3 are high during winter when the discharge is low and low during summer when the discharge is high. However, Kokernag and Achabalnag springs also show higher concentrations during July, resulting from piston effect. The springs show a significant variability of TDS, with highest value of 180 mg/l observed at Achabalnag followed by Kokernag (130 mg/l) and Kongamnag (90 mg/l). The high variability of TDS indicates rapid and strong reaction of Achabalnag to hydrological events followed by Kokernag and Kongamnag.

Keywords: Bringi watershed, hydrogeochemistry, Karst springs, Kashmir Himalayas.

NATURE has bestowed the Kashmir Valley with ample freshwater resources in the form of snow and glaciers, surface water and groundwater. Towards SE Kashmir, numerous freshwater springs are concentrated in Anantnag district[1] ('Anant' in Sanskrit language means countless and 'Nag' in the local language means springs), occurring along the foothills of Pir-Panjal range, controlled by limestone lithology[2]. Besides being of historical importance for decades, the spring water has been majorly used for domestic and agriculture purposes since prehistoric times.

As a result of chemical reaction between groundwater and carbonate minerals, the chemistry of groundwater changes from low mineralized to highly mineralized[3], particularly HCO_3, Ca and Mg (ref. 4) until a quasi-chemical equilibrium is reached[5]. The highly mineralized groundwater emerges at the surface in the form of a karst

*For correspondence. (e-mail: mnadeem83@gmail.com)