Assessing impact of industrialization in terms of LULC in a dry tropical region (Chhattisgarh), India using remote sensing data and GIS over a period of 30 years

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Abstract The main focus of the paper is to assess the land use/land cover (LULC) change in northern Chhattisgarh due to industrialization using remote sensing and Geographical Information System (GIS). The impact was assessed using an information extraction method applied to temporal satellite data (LANDSAT and IRS scenes) in GIS domain. For assessing the impact on natural resources, the classification scheme was restricted to (1) Forest patches ((a) completely cleared, (b) partially cleared, (c) least affected), (2) Non-Forest ((d) completely changed, (e) least changed), (3) Industrial/Mining area, and (4) River. Over the three decades 22.22% of forests have been completely cleared and converted to industrial setup. Another 25% is completely cleared and 10% is degraded. Around 4% of agricultural area is totally affected due to industrial activity. Random assessment of plant distribution (Trees, Shrubs and Herbs) indicates significant changes in the herb distribution directly related to distance gradient from the industrial/mining setup. Visual recording, socio-economic survey and satellite data also helped in delineation of extent of environmental pollution in forest and non-forest areas. The paper presents methodology for the environmental impact assessment.

Keywords GIS · Industrialization · LULC · Remote sensing · Tropical forest

Introduction

Minerals are a primary source of energy and plays vital role in an energy-intensive economy such as India. Chhattisgarh is one of the states with vast potential of underground minerals, industries and lust tropical forest. The industrial development activity in the forested landscape results in permanent destruction of indigenous forests and woodlands to provide
infrastructure for the setup. Moreover, the changes in the land cover, particularly the tropical deforestation, have attracted worldwide attention because of their potential effects on soil erosion, run-off and carbon dioxide level. The crucial issue is not one of reducing industrialization rather developing an understanding of environmental degradation phenomena and minimizing its impact. In this context, it is very important to investigate impact of industrialization in its environs and evaluate the available tools.

Generating an environmental database for carrying out environmental impact assessment in regional context and to understand deforestation in spatial and temporal domain is a difficult task by conventional methods. Today, remote sensing data, which is synoptic, repetitive and multi temporal in nature has efficiently filled this gap. Kindred with Geographical Information System (GIS), the technique has a distinct advantage over conventional methods/approaches to map and monitor the evolution of degraded areas. It has become a versatile tool for assessing and monitoring environmental impacts as a result of natural and man made activities (Hill et al. 1983; Wang et al. 2001; Zha et al. 2007). The technique has proved its usefulness in assessing the environmental degradation with reference to land, water, air and vegetation. It provides an excellent overview of the status of industrial areas and their impact. Earlier works have demonstrated its potential in various facets of industrial activity viz., land use change detection (Ghosh and Ghosh 1991; Prakash and Gupta 1998; Joshi et al. 2006), environmental impact (Ghosh 1989; SAC 1990; Rathore and Wright 1993; Chatterjee et al. 1994), coal fires assessment (Mansor et al. 1994) etc. Few of the earlier workers have also used satellite data processing for assessing the mining areas (Mamula 1978; Parks and Peterson 1987; Rathore and Wright 1993; Schmidt and Glaeser 1998).

The present study focuses on a representative area (Raigarh district) in the industrial landscapes of tropical forest of Central India to quantify the process of land use/land cover changes using multi-temporal remotely sensing data and GIS. This quantification was made possible through interpretation of remote sensing data, ground verification and socio-economic survey. Such knowledge is essential to establish a harmonic relationship between industrialization and the land use practices.

**Study area**

Raigarh coalfields are having a deposit of nearly 100MT, which is the second largest reserve of coal in India. Two coal blocks (Chhal and Kurumkel) have already been developed/working in the district. Another block (Gare Pelma) is under private mining. In addition to this, these are well known for industrial setup on the map of India. The coal extraction has immensely affected the landscape in terms of deforestation, degradation of arable land and pollution in different ecosystems. Therefore, it would be very interesting to study, research and document the impact of industrialization/mining activities in the region, which is well known in the international industrial scenario. The area has ample opportunities of minerals and industries and hence provides an opportunity to study the impact of mining on land cover status with special emphasis on the vegetation/forest distribution which is surrogate of biodiversity and socio-economic relevance in the environs.

**Materials and methods**

The techniques used for assessing impact of industrialization in the Raigarh include satellite data preprocessing, visual interpretation and change detection analysis. Random assessment of plant distribution (Trees, Shrubs and Herbs) was carried out around the industrial sites. A socio-economic survey with visual recording in field and satellite was used to delineate the extent of environmental pollution in forest and non-forest areas. Landsat MSS, TM, ETM and IRS P6 LISS III digital data pertaining to December 1972, November 1990, November 1999 and February 2004, respectively were used to evaluate the changes. Survey of India (SOI) toposheet at 1:50 000 scale and Forest Survey of India (FSI) reports were also used as legacy data. The Landsat satellite data provided by Global Land Cover Network (GLCN) was radiometrically and geometrically (ortho-rectification with UTM/WGS 84 projection) corrected. The datasets were with sub pixel level accuracy. For the IRS P6 LISS III data same principle was applied for radiometric and geometric correction. Detailed ground truth was collected with the help of 1:50,000 scale toposheet, base maps, Global Positioning System (GPS) and on-site investigation. A uniform