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Forest cover dynamics analysis and prediction modeling using logistic regression model

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ABSTRACT

Forest cover conversion and depletion are of global concern due to their role in global warming. The present study attempted to study the forest cover dynamics and prediction modeling in Bhanupratappur Forest Division of Kanker district in Chhattisgarh province of India. The study aims to examine and analyze the various explanatory variables associated with forest conversion process and predict forest cover change using logistic regression model (LRM). The forest cover for the periods 1990 and 2000, derived from Landsat TM satellite imagery, was used to predict the forest cover for 2010. The predictive performance of the model was assessed by comparing the model-predicted forest cover with the actual forest cover for 2010. To explain the effects of anthropogenic pressure on forest, this study considered three distance variables viz., distance from forest edge, roads and settlements, and slope position classes as explanatory variables of forest change. The highest regression coefficient ($\beta = -26.892$) was noticed in case of distance from forest edge, which signifies the higher probability of forest change in areas that are closer to the forest edges. The analysis showed that forest cover has undergone continuous change between 1990 and 2010, leading to the loss of 107.2 km^2 of forest area. The LRM successfully predicted the forest cover for the period 2010 with reasonably high accuracy (ROC = 87%).

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1. Introduction

The change in forest cover is of global concern as forest is an indispensable natural resource that provides not only a wide variety of ecosystem goods and services but also plays a vital role in atmospheric carbon balance and thus climate change. Carbon emissions from deforestation and forest degradation are the second largest source of anthropogenic carbon emission (Le Quéré et al., 2009; van der Werf et al., 2009). Although, landscape conversion varies significantly throughout the world, its ultimate outcome is mostly the same: extraction of natural resources for immediate human needs, often accompanied by biophysical degradation (Foley et al., 2005). Hence, assessing the conversion of a forested landscape may help us to understand the way the natural resources extraction occurs, and consequently the human influences on the forest ecosystem services. For better understanding of the impact of forest cover change, factors affecting it must be fully studied. With rapid increases in population and continuing expectations of improvement in the standard of living, pressure on natural resource use has become intense (Eastman, 2001). The consequences of an ever-increasing pressure of human development have resulted in changes of vegetation cover or depletion (Becek and Odihi, 2008; Kushwaha et al., 2011), degradation and fragmentation of habitats (Sun and Southworth, 2013), loss of wildlife corridors (Nandy et al., 2007) and an increased human–animal conflict (Gubbi, 2012).

Forest cover dynamics is actually the rate, pattern, spatial distribution, quantity of change in the forest cover to other land cover or land use due to different natural or human induced causes. The constant interplay of various human-induced disturbances along with topographic and climatic factors can gradually degrade a healthy forest cover or change it to other land use/land cover category. Understanding of the causes of land use change has moved from simplistic representations of two or three driving forces to a much more profound understanding that involves situation-specific interactions among a large number of factors at different spatial and temporal scales.

Studies related to forest cover change using satellite-derived information help in understanding the phenomena like carbon dynamics, climate change and threat to biodiversity. Estimation of forest cover change and deforestation rate is a major challenge without the use of satellite imagery, mainly in remote inaccessible areas. Satellite remote sensing in combination with ground reconnaissance plays a vital role in determining the loss of forest cover. Many studies have used remote sensing and geographic

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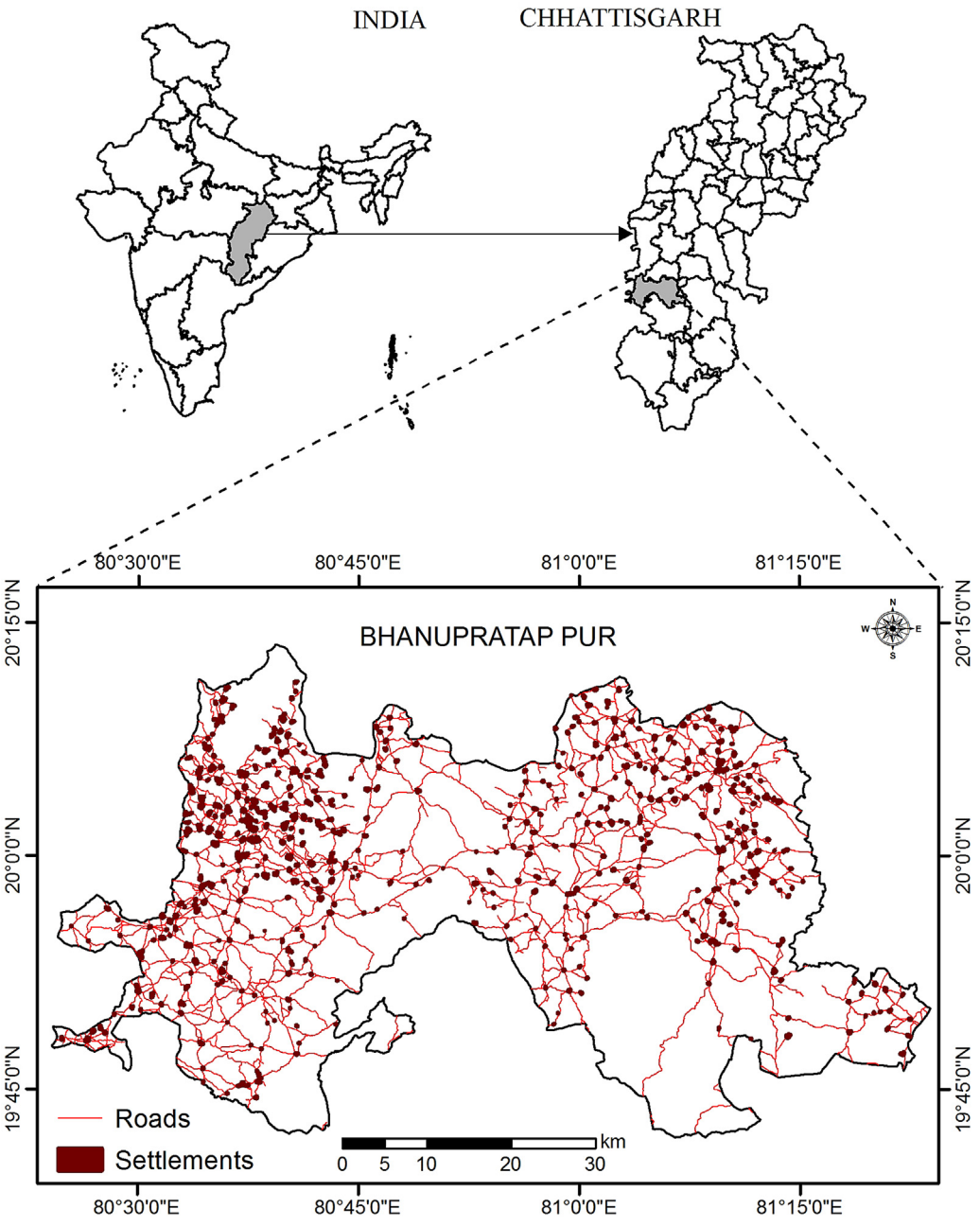

Fig. 1. Location of study area in India.

information system (GIS) for effective forest cover monitoring (FSI, 2011; Kushwaha, 1990; Kushwaha and Hazarika, 2004; Nandy et al., 2007; NRSA, 1983; Singh, 1989; Srivastava et al., 2002). Recent advancement in remote sensing and GIS methods also enable researchers to model and predict land use/land cover more efficiently than ever-before. Several approaches have also been developed to model and predict the dynamics of land use/land cover (Arekhi, 2011; Houet and Hubert-Moy, 2006; Jenerette and Wu, 2001; Lett et al., 1999; Ozah et al., 2010; Pontius and Schneider, 2001; Pontius and Malanson, 2005; Siles, 2009). Temporal forest cover analysis linked with geospatial modeling help in generation of future forest cover scenarios. Spatial modeling could be an immensely useful activity to understand the future of the forests, which are undergoing continuous changes such as those brought about by deforestation, logging, diversion of forests for non-forestry purposes etc., provided such factors are operative in future too.

The present study aims to examine and analyze explanatory variables associated with forest conversion process and to model the forest cover change using logistic regression model (LRM). Loza (2004) studied land cover change and closed forest fragmentation, and established a logistic model to find out the causes of forest conversion in Bolivia. For logistic modeling, the effects of five independent variables *viz*., distance from roads and settlements, land tenure, soil texture and topography on forest conversion were studied. The best model of forest conversion (ROC = 71.5%) was predicted by land tenure, distance from roads and settlements. Siles (2009) modeled forest conversion in Bolivia by considering change in forest areas as a categorical dependent variable and distance from forest edge, roads, and settlements, landscape position and type of settlement as explanatory variables. Logistic regression was used for assessing the relative significance of explanatory variables on forest change and for predicting the probability of forest change.

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