Ecological Indicators 85 (2018) 21–36

Contents lists available at ScienceDirect

Ecological Indicators

journal homepage: www.elsevier.com/locate/ecolind

Original Article

# Long-term land use and land cover changes (1920–2015) in Eastern Ghats, India: Pattern of dynamics and challenges in plant species conservation

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ARTICLE INFO

*Keywords:*
Land use and land cover change
Fragmentation
Habitat suitability
RET and endemic species
Eastern Ghats
Conservation

ABSTRACT

Natural resources are experiencing unprecedented pressures due to land use and land cover (LULC) changes. Such changes in LULC have significantly affected the extent and condition of forests in the Eastern Ghats of India causing a decline in the forest cover as well as disturbing the habitats of several rare, endangered, threatened (RET) and endemic species. The current study attempts to determine the habitat suitability and threat of a selected group of plants viz, RET and endemic species. This is realized in light of LULC change and forest fragmentation over a period of ~100 years to understand the possible conservation strategies in the study area. Historical maps and satellite images from 1920 to 2015 were used to develop the LULC and fragmentation maps. MaxEnt species distribution model were used to simulate the distribution of RET and endemic species. Our study reveals that, by and large, the Eastern Ghats have lost 15.83% of its forest area over a span of ~100 years. For the study period from 1920 to 2015, it is estimated that about 7.92% of forest area was converted into agriculture, and up to 3.80% into scrub/grassland respectively. Also, it was found that the total number of forest patches have been increased from 1509 in 1920–9457 in 2015, core area has declined from 93461.05 sq.km in 1920–61262.11 sq.km in 2015, and edge length has increased to 2.20 sq.km in 2015 as compared to 0.82 sq.km in 1920. Best suitable habitats of RET and endemic species have reduced by 0.08% and 0.22% respectively. Habitat reduction has mainly occurred in the districts of Gajapati (Odisha state), Mahbubnagar (Telangana state) and also in Nallamalai and Kolli hill ranges. The species mostly spread across and the suitable habitats was found outside the rages of protected areas. From the present study we recommend that appropriate conservation strategies should be initiated on these threatened areas to prevent further decline in the extent and habitat quality of the RET and endemic species in Eastern Ghats.

## 1. Introduction

The unprecedented land use and land cover (LULC) change over the last century has resulted in the loss of many habitats and important species (MEA, 2005; McGill, 2015). It is estimated that ~75% of the natural forest area around the world has been affected by human activities since the last ice age (Ellis and Ramankutty, 2008). The ever increasing population, their food demands, need of settlement and exploitation of economic resources are the major factors responsible for the degradation of forest cover and biodiversity across the globe (Foley et al., 2005; Lambin and Meyfroidt, 2011; Newbold et al., 2015; FAO, 2016). Globally, ~40 percent of deforestation has occurred in the tropics and subtropics due to large-scale commercial agriculture (FAO, 2016).

Forest ecosystems are one of the primary focuses of land conversions. Indiscriminate removal of forests has resulted in the shrinkage of species habitats, fragmentation, edge changes and changes in community structure and composition; thereby, distressing the species distribution in many areas (Brearley, 2011). Local richness, rarefied richness, and total abundance are being strongly influenced by land usage patterns and its intensities (Drummond and Loveland, 2010; Ramankutty and Foley, 1999). Forest fragmentation, in which the forest is reduced to patches, can have a marked negative impact on biodiversity (Uddin et al., 2015). Among others, it can result in homogenization (Lôbo et al., 2011), human-wild life conflicts (Acharya et al., 2017), reduction in habitat quality for forest-interior species (Arroyo-Rodríguez and Mandujano, 2006), loss of forest health due to changes in microclimate (Ewers and Banks-Leite, 2013) and increased

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http://dx.doi.org/10.1016/j.ecolind.2017.10.012
Received 29 March 2017; Received in revised form 7 October 2017; Accepted 7 October 2017

susceptibility to predators, parasites, and invasive species (Thuiller et al., 2008). Thus the changes in landscape patterns would certainly influence the ecological process and the existence of species at greater extents (Pătru-Stupariu et al., 2017).

India is experiencing major LULC changes due to expansion of agriculture, urbanization and economic exploitation of natural resources (Goldewijk and Ramankutty, 2004; Tian et al., 2014). Haddad et al. (2015) have reported that the LULC change caused by anthropogenic activities have the capacity to alter even the rainfall and temperature patterns. Therefore, mapping long term changes in LULC is important to study the linkage between habitats, climate, and species. Also effective quantification of loss in biodiversity is necessary to identifying large-scale conservation priorities (Skidmore et al., 2015). However, acquiring detailed information of the species distribution based on ground truth is often laborious and limited. In such a scenario, long term global coverage of satellite remote sensing data could provide useful and vital information on a wide range of scales in a consistent, borderless and repeatable manner. Satellite remote sensing technology has provided a new dimension to build the land change processes in varying temporal intervals at different resolutions (Singh et al., 2010). Furthermore, the Geographic Information System (GIS) provides an indispensable platform for data management, data integration, data visualization, data analysis, and retrieval of remote sensing data in a wide canvas (Goodchild, 2009). Land cover maps derived from remote sensing data could yield meaningful information on global/regional/local spatial assessments of vegetation distribution (FRA, 2000; Lambin et al., 2003; Potapov et al., 2008; Gómez et al., 2016).

With this background, we analyzed the LULC change pattern of the Eastern Ghats and its consequences on the habitats of rare, endangered, threatened (RET) and endemic species. The monitoring and mapping of distribution and habitat patterns of species play an important role in proposing new areas for conservation. In this study, the analysis was done to assess the intensity of habitat destruction of a selected group of RET and endemic species due to LULC change and habitat fragmentation. The Eastern Ghats are most rapidly changing frontier in India, most of its forests are already on the edge of extinction and very small area of forests remain contiguous (Jayakumar et al., 2002). The Forests of Eastern Ghats are largely deforested landscape, cleared for agriculture, dam construction, settlement, transportation, mining and logging for timber for more than ten decades (Jayakumar and Arockiasamy, 2003). We have used remote sensing and GIS technologies together with a modeling strategy to find out the LULC change and habitat characteristics. The present study aims to address the following research questions: LULC change for the past ~100 years; landscape and habitat level changes for a group of RET and endemic species; and, identification of conservation areas for plant species in the Eastern Ghats.

## 2. Materials and methods

### 2.1. Study area

The Eastern Ghats of India are located between 11° 30′ and 22° 0′ N latitudes and 76° 50′ and 86° 30′ E longitudes (Fig. 1). It is a habitat of more than 2600 plant species; most of which are traditionally used for medicinal/other economic purposes. These species were heavily altered by anthropogenic activities in the past century (Chittibabu and Parthasarathy, 2000). The Eastern Ghats are broadly divided into Northern and Southern Eastern Ghats. Due to broken chain like topography and ease of forest accessibility, the hilly terrain and the surrounding plains of Eastern Ghats are densely populated. No systematic studies are reported so far in Eastern Ghats to show how the species have been affected in the light of LULC change, increasing temperature and changing rainfall pattern.

Significant loss of forest cover in parts of Eastern Ghats (Patnaik et al., 2011; Ramesh and Kaplana, 2015; Saranya et al., 2016) has exerted tremendous pressure on the sustenance of biodiversity (Rawat, 1997). Many sensitive species are likely to be vanished from the forests or might be facing extinction because of the habitat loss, fragmentation and climate change (Nemésio et al., 2016). The recent threats faced by the Eastern Ghats include deforestation and fragmentation due to hydropower projects and mining (Jayakumar and Arockiasamy, 2003). The massive impoundments that dams and their reservoirs have formed between the Andhra Pradesh and Odisha borders have submerged thousands of hectares of forest land (MoEF and Kalpavriksh, 2004). The plant inventories and surveys are carried out in parts of Eastern Ghats to study the distribution and pattern of floral diversity (Rao et al., 2013; Pullaiah and Rao, 2002; Muthumperumal and Parthasarathy, 2013). Babar et al. (2012) used ecological Niche modeling for understanding the distribution patterns of *Pterocarpus santalinus* in Eastern Ghats. Little is known about the biodiversity of Eastern Ghats as no comprehensive studies on spatial change and species diversity was conducted so far (NRSA, 2007).

### 2.2. Data products

The analysis was carried out with the help of historical maps (1920, 1940 and 1960) and multi-date multi-temporal Landsat images from the sensors viz; Multispectral Scanner System (MSS) (1975 and 1985), Thematic Mapper (TM) (1995 and 2005), Enhanced Thematic Mapper (ETM+) (2005) and Operational Land Imager (OLI) (2015). The standard Level 1 images of 1975, 1985, 1995, 2005 and 2015 were downloaded as orthorectified form from the earth explorer website (https://earthexplorer.usgs.gov/) of United States Geological Survey (USGS).The detailed descriptions of historical maps and satellite images used in the present study are given in Table S1 (a–c). We have used the data for three seasons, viz. winter (January to March); pre-monsoon (April to May) and post-monsoon (October to December).The satellite images were selected in such a way that all the scenes was free from (less than 3%) cloud cover. The ancillary data, such as vegetation type map of India for the year 2005 (Roy et al., 2015a), LULC maps for the years 1985, 1995 and 2005 (Roy et al., 2015b), and High resolution Google Earth images were also used in the study. Field sample points to the tune of 2971 were collected from the national-level project 'Biodiversity Characterization at Landscape Level' (Roy et al., 2012; Roy et al., 2015a). The Shuttle Radar Topography Mission Digital Elevation Model (SRTM DEM) 30 m data (https://earthexplorer.usgs.gov/), WorldClim Version 1 current bioclimatic data (http://www.worldclim.org/), Protected Area (PA) map from Wild Life Institute of India were used in the modeling to analyse the habitat suitability through Maximum Entropy (MaxEnt) algorithm.

### 2.3. Data preparation

Pre-processing of historical maps and satellite images were carried out prior to image classification in order to bring the images to a standard projection. The standard data preparation methodology is shown in Fig. 2a, b. The historical maps were geometrically corrected with the help of geometric correction tool available with ERDAS Imagine 2015 software. Prior to image interpretation, Level 1 (https://landsat.usgs.gov/landsat-processing-details) satellite images were pre-processed for suppressing the effects of the atmosphere (Chavez, 1996) and noise (Lillesand et al., 2015). The study area then extracted from the multiple sensor scenes for each year by sub setting. Finally all the subset images were mosaicked to obtain a single image of the study area. The satellite images and historical maps were brought into the projection WGS 84 Universal Transverse Mercator (UTM) Zone 44. The satellite images for the year 1975 and 1985 were then re-sampled using nearest neighborhood algorithm to a common resolution of 30 m.