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Distribution pattern of *Dendrocalamus strictus* in Kangra district of Himachal Pradesh, India

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Abstract: Recognizing the multiple utilities of bamboo, mapping of bamboo resources has been done in many bamboo growing countries including India. In India, such type of work has been confined to North-eastern States and Western Ghats. Little information is available on the distribution pattern of bamboo in Western Himalaya. Therefore, present work was carried out to understand the prospects of remote sensing and Geographic Information System (GIS) in extracting bamboo related information in the Kangra district of Himachal Pradesh using IRS LISS III satellite image. The results showed that 302.64 ha of the study area was occupied by *Dendrocalamus strictus*, while its extent of occurrence was 572.51 ha. The difference between area of occupancy and extent of occurrence of *D. strictus* is a result of opening up of bamboo canopies. The area of occupancy of *D. strictus* was highest in Indora tehsil of the study area followed by Nurpur, Jaisinghpur and Dera Gopipur tehsils. Its extent of occurrence was highest in Nurpur followed by Jaisinghpur, Indora and Dera Gopipur tehsils. It was concluded that there is a need of proper conservation and sustainable utilization of the bamboo resources in the region.

Key words: Dendrocalamus strictus, area of occupancy, extent of occurrence, Western Himalaya, remote sensing, GIS.

INTRODUCTION

Bamboos cover an area of 6.3 million km^2 in the Asia Pacific region (Bystriakova *et al.*, 2003). In India, area under bamboo is 8.96 million hectares (FSI, 2003). Of these 66 per cent of the bamboo growing stock is in the North-eastern States, and remaining 34 per cent in rest of the country (Rai and Chauhan, 1998). More than 83 per cent of these growing stocks comprise of *Dendrocalamus strictus*, *Bambusa bambos* and *Melocanna baccifera* (Adkoli, 2002). The bamboo in Himacal Pradesh (HP) occupies 100 km^2 areas and occurs in small patches (Shanmughalvel *et al.*, 2002).

As in the other parts of the country, *D. strictus* is the most common and widely distributed species in Kangra district of HP (Negi and Naithani, 1994). It is generally

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up to 15 m in height and its diameter ranges from 6 to 10 cm (NMBA, 2005). It generally occurs in semi-dry and dry zone along plains and hilly tracts (Shanmughavel and Francis, 2001) and often forms pure patches.

Deforestation, land-use changes and unending exploitation of bamboo have taken a heavy toll on limited bamboo resources in the State. Thus, strategy for conservation and rejuvenation of bamboo resources becomes imperative at this point of time. To combat such adverse situation, resource mapping of bamboo becomes imperative. Presently, this information is mainly derived from intensive field surveys deploying large number of field staff using conventional methods. The advanced tools such as Remote Sensing (RS) and Geographic Information System (GIS) are quite useful in generating action plan for conservation and management of bamboo resource. As compared to traditional methods of locating and mapping bamboo bearing areas, RS technology provides timely and accurate information on spatial pattern of distribution of bamboo. Globally, this method is being widely used for gathering first hand information on various aspects of bamboo resource management (Khali *et al.*, 1996). RS/GIS have been efficiently used in mapping of bamboo in North-eastern and Southern India (Menon and Nair, 1998; Bhardwaj *et al.*, 2003). Such studies are of immediate concern in Western Himalayan region such as HP which supports good bamboo diversity.

Study Area

The Kangra district of Himachal Pradesh located between 31°41′0″ N to 32°28′5″ N latitude and 75°35′34″ to 77°4′46″ E longitude, which is a part of Western Himalayas, was chosen for the present study. The geographical area of the district is 5739 km^2 out of which *ca.* 41 per cent area comes under recorded forests (Anonymous, 1991). The Kangra district has been further sub-divided in to 11 administrative boundaries known as talukas namely Baijnath, Baroh, Dera Gopipur, Dharmshala, Jaisinghpur, Jaswan, Jawali, Indora, Kangra, Nurpur and Palampur. The Kangra district comprises of four distinct regions *viz.*, High hills wet sub-temperate region, Valley region, Chanital region, and Shiwalik foot-hill region, based on precipitation, ambient temperature, topography, irrigation facilities, soil, *etc.* The slope in the district varies from flat to highly steep. This varied topography has resulted in a diversity of forest communities/ types starting from scrub forests at lower elevations to alpine pastures at higher altitudes. In the mid altitudinal area, forests of chir, ban oak, mixed conifers (kail, spruce) and Kharsu oak dominate the vegetation. The district is mainly drained by Beas and Chakki rivers with little area under Ravi. The annual rainfall in the study area varies from 1500 to 1800 mm.

Inputs and Software Used

The IRS P6 LISS III multispectral satellite images (Fig. 1), having scene id path 94

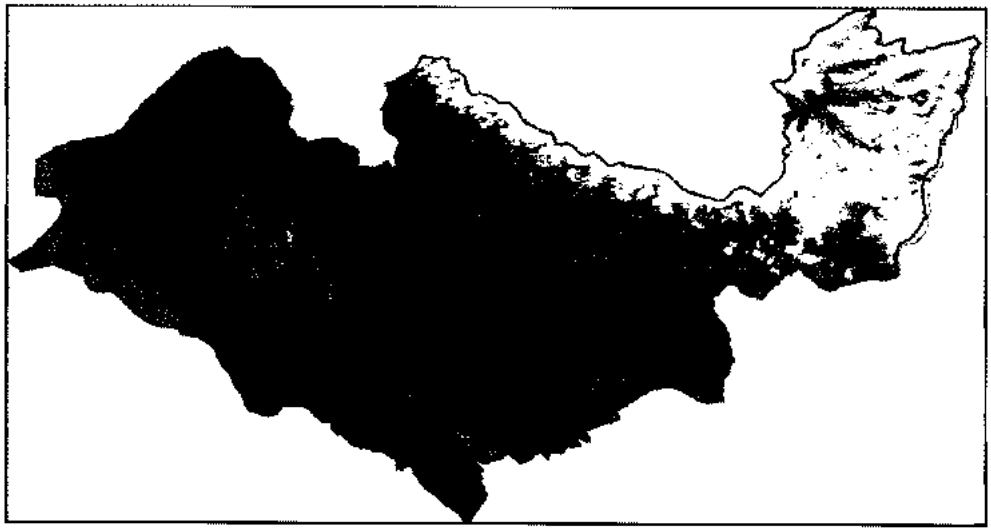

Figure 1. IRS P6 LiSS III MX image of the study area.

row 48 of January 28, 2007, acquired from National Remote Sensing Centre (NRSC), Hyderabad was used for the present study. The image is suitable for mapping the bamboo resources as its spatial resolution, which is 23.5 m and its swath of 141 km is suitable for having a good synoptic view of the ground. In addition, toposheets on 1:50000 scales, procured from Survey of India (SOI), Dehradun, were used for georeferencing the satellite images as well as for ground information. The digitized administrative boundaries from Survey of India, Dehradun were used to delineate boundaries of the study area. The classification of bamboo bearing areas was done using Erdas Imagine 8.6 digital image processing software. The ArcGIS 8.3 and ArcView GIS 3.3 GIS softwares were used for overlay analyses for acreage estimation and map compositions. The geographical co-ordinates recorded using GPS handset was downloaded and exported to GIS software with the help of Map source 4.09 software.

METHODOLOGY

Field surveys in the study area were conducted to understand the patterns and characteristics of bamboo distribution and to collect training sites of *D. strictus* so that they can be used to train the pixels in the satellite image during supervised image classification process to get an accurate classified image for bamboo distribution in the study area. In addition, local people were also interviewed and forest history files from the State Forest Department were also consulted to know the general occurrences of bamboo species in the study area.

The satellite images of the study area, which were procured from NRSC, Hyderabad, were geometrically corrected (Rees, 2004) in reference to SOI toposheets using 38

evenly distributed ground control points, which were taken mainly from intersections like road network ignoring intersection of natural features such as rivers. The image was then resampled to 23.5 m by Nearest neighbour resampling method using 2nd degree of polynomial transformation resulting 1.51 root mean square error. The images were projected in Universal Transverse Mercator (Datum WGS 84 & Zone 43) projection systems. The image was later enhanced by contrast adjustment so as to increase the visibility of the features. The satellite image of the study area was clipped by overlaying district and tehsil boundaries over the above-mentioned georeferenced and enhanced image.

For extracting the bamboo bearing areas from the satellite image, 'Hybrid classification' approach was followed (Lillesand and Keifer, 2000). Initially, satellite image was classified using 'ISODATA' algorithm of unsupervised classification (Tso and Mather, 2001). This classified image was further grouped into vegetation pixels and non-vegetation pixels. The vegetation pixels were identified based on their color as they appear in shades of red in a color infrared composite image, where infrared, red and green bands of the image were displayed using red, green and blue image planes in the computer (Kumar *et al.*, 2007). The pixels displaying color other than red were grouped as non-vegetation class. The vegetation class thus obtained represented pixels of various sub-classes of vegetations such as forest, agriculture, shrubland/ grassland, which are the major categories of the area. Since, the objective was to extract only bamboo, the non-vegetation class was excluded from further analysis as they represented features like habitations, open areas, water bodies, *etc*. The masking operation was performed using vegetation class so as to get image corresponding to vegetation pixels (Singh *et al.*, 2002). During masking, classified image served as area of interest and pixels outside the area were excluded. The pixels falling within the area of interest were extracted from the satellite image of the study area and image corresponding to vegetation pixels was produced. This was later reclassified into above mentioned sub-classes of vegetations with Maximum likelihood algorithm of supervised classification using signatures of those classes. These signatures were generated from the representative training areas obtained for sub-classes of vegetation from various locations during field survey. Again from the vegetation classified image, only forest class was masked leaving other two classes such as agriculture and shrubland/grassland. The forest class was further classified using signature generated from training sites collected for the *D. strictus* from the field, so as to get final map showing its distribution in the study area.

The accuracy assessment of the above classification was done using 52 reference points. These reference points were randomly generated throughout the study area and verified during ground truthing. The accuracy assessment performed on the above bamboo classification showed over all accuracy of 88.4 per cent. The misclassified pixels were masked and replaced with their accurate classes by local editing of pixels with the aid of ground data and field checks during post-classification editing. The

area of *D. strictus* thus obtained from the above classified image, provided its area of occupancy and when a boundary encompassing all the classified pixels of *D. strictus* provided its extent of occurrence (IUCN, 2000).

RESULTS AND DISCUSSION

The present study has revealed that in the Kangra district, of the total area, 302.64 ha is occupied by *D. strictus*. It was mainly found distributed in the forested landscapes. The results showed that the distribution of *D. strictus* was mainly confined to Jaisinghpur, Dehra Gopipur, Indora and Nurpur tehsils of the Kangra district. The *D. strictus* dominated patches were observed near Ashapuri area in Jaisinghpur, Barwara area in Dera Gopipur tehsils, and near Damtal area on the boundary of Nurpur and Indora tehsils. The total area occupied by *D. strictus* in Dera Gopipur, Jaisinghpur, Indora and Nurpur tehsils is 22.30 ha, 68 ha, 109.41 ha and 102.94 ha, respectively. The distribution pattern of *D. strictus* was studied in the image and as also observed in the field showed that, at places bamboo canopy has gaps (Fig. 2). It is assumed that these gaps might have been occupied by *D. strictus* in the past. If these open areas are added to the area of occupancy of *D. strictus* then its actual extent of occurrence becomes approximately 572.51 ha that includes 138.92 ha in Dera Gopipur, 144.76 ha in Jaisinghpur, 139.78 ha in Indora and 149.05 ha in Nurpur tehsils.

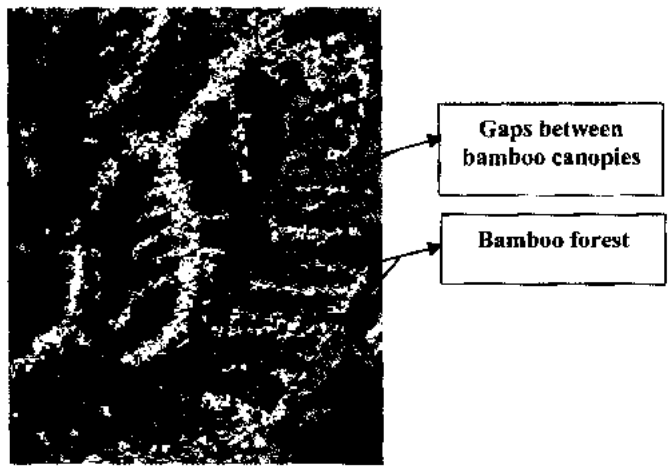

Figure 2. Image showing gaps in the bamboo forest

The difference between area of occupancy and actual extent of occurrence of *D. strictus* was highest in Dera Gopipur followed by Jaisinghpur, Nurpur and Indora. These values indicate fragmentation of *D. strictus* forest in the Kangra district. The maximum fragmentations was observed in Dera Gopipur tehsil followed by Jaisinghpur, Nurpur and Indora.

CONCLUSION

The present study reveals that in the terms of area of occupancy, Kangra district has a very small area under *D. strictus* as compared to other bamboo bearing areas of the country. These bamboo bearing areas are under tremendous pressure and showing signs of fragmentation. Therefore, there is an immediate need of sustainable utilization of bamboos to conserve the limited bamboo resources. The study also demonstrates the applicability of RS and GIS in extracting information on bamboo in the Western Himalaya.

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