Conservation Priority Hotspot for Forests of Nirmal District, Telangana using Geospatial Techniques: A Case Study

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Abstract

Increasing population and anthropogenic activities are ultimately leading to exploitation of the natural resources. It is of utmost importance to develop the forest conservation regulation and policies time to time to strengthen the forest resources. This paper in focused on study the assessment of the forest ecosystem and to generate the spatial information of various threat factors such as deforestation, fragmentation and forest fire in forests of Nirmal District, Telangana. This study has found the deforestation between 2005 and 2015 is reduced by 14.04% and the fragmentation study identifies approximately 32% reduction in large core areas over the 2005-2015. Study help to analyse the pattern of forest burnt areas across the past 11 years. Present study reveals the conservation priority hotspots involving the deforestation, forest fire & fragmentation threats which will be a significant contributor for the formulation of policies and plans to take conservation measures.

Keywords — *Remote sensing, Forest, Deforestation, Fragmentation, Forest Fire, Conservation Hotspot*

I. INTRODUCTION

An understanding of anthropogenic influence in tropical forest dynamics is thus critical to understand the global climate change and the conservation of forests [16]. Tropical dry forests are among the most threatened and over looked forest formation in the world [1] and conversion to pasture and agriculture are major threats, reflecting a long history of human occupation attracted by fertile soils, flat landscapes, timber extraction and favourable climatic conditions for agriculture. The national data aggregates all forest types into one category; therefore, they obscure the fact that deforestation in regions dominated by tropical dry forests has advanced faster than for regions dominated by other forest types [15]. The studies in India have found large scale deforestation in the regions where dry deciduous forests are dominant [7, 12]. The environment has been modified by anthropogenic activities to an extent where it is evident from the landscape pattern that shows mosaic of human settlements, agricultural land and scattered fragments of ecosystems [5]. Forest is defined as 'land area covers more than 1 ha, dominated with tree species with the canopy cover greater than 10%' which is not initially utilized for agricultural or other anthropogenic activities. IUCN Red List criteria for ecosystems, version 2.0, broadly considers five criteria, i.e. reduction in geographic distribution, restricted geographic distribution, environmental degradation, disruption of biotic processes/ interactions and quantitative analysis that estimates the probability of ecosystem collapse ([3]; http://www.iucnredlistofecosystems.org/). There is an increasing scientific consensus that most of the biodiversity is experiencing extinction risk due to ecological disturbances driven by deforestation, habitat fragmentation and forest fires. Five conservation categories (i.e. Critically Endangered, Endangered, Vulnerable, Near Threatened, Least Concern) of International Union for Conservation of Nature (IUCN) have been successfully adopted for the forest ecosystems of Odisha State by integration of forest loss, degradation, fires, fragmentation and invasive species abundance data [10]. Reddy et al (2015) [11] classified the conservation priority hotspots by integration of deforestation, forest fires and fragmentation in Telangana State, India. Grid cell wise fire frequency, forest type wise burnt area and influence of topography, climate, roads and settlements on forest fires was analysed by Satish and Reddy, 2015 [13] in Silent Valley National Park, Nilgiri Biosphere Reserve, Western Ghats. The knowledge transfer between remote sensing and ecological communities can shape out the actual picture on ongoing changes and ecological processes of the global biodiversity patterns [6]. It requires the understanding of the elements of biodiversity through rapidly increasing a wide array of tools and techniques from remote sensing. Remote sensing enables directly observing vast coverage of landscapes and ecosystems. This can track the change drivers of global biodiversity loss [6].

In the present study, we have attempted to prepare a spatial database of Nirmal District, Telangana state, India, to evaluate the status of forest ecosystems and its affecting factors as well as conservation priority zone formulation.

II. STUDY AREA

Nirmal District is located in northern region Telangana state of India. It is a newly formed district in the year 2016, prior to which it was a part of Adilabad District. It lies on the deccan plateau between North latitudes 18° 845' and 19° 34' and East longitudes 77° 758' and 77° 95'. The District is land locked sharing boundaries with Adilabad, Komaram Bheem Asifabad, Mancherial, Jagital, Nizamabad of Telangana state and Nanded of Maharashtra state. Godavari River flows in the south of the district. This region represents very warm and dry condition during the summer (March–May) and continues to be warm in other months of the year, but for December and January, the temperature drops during nights. The maximum and minimum temperatures have been recorded as 45°C and 16 °C, respectively. The forests of Telangana can be broadly grouped into two main forest types, i.e. tropical moist deciduous and tropical dry deciduous [11]. The pictorial representation is given in Fig. 1.

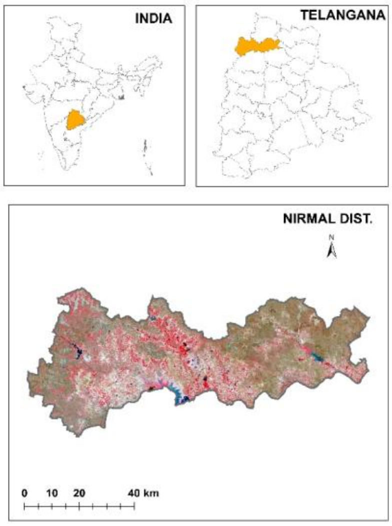

Fig. 1: Study Area

III. METHODOLOGY

In present study various factors has been studied to identify the conservation priority zones. A grid cell of 1 km x 1 km size has been prepared to understand the threats. The conservation terminology by IUCN has been adopted [2] (IUCN 2010), but the criteria for each category of threatened ecosystem have been developed following Reddy et al. [9]. Ecosystems are considered as least concern if no threat is identified as per the selected parameters (Table I). Flow chart of methodology has been presented in Fig. 2.

TABLE I
Quantitative Parameters followed in present study

Category	**Deforestation in ha**	**Fragmentation Index Recurrence**	**Forest Fire Area Recurrence**
Extinct	1-10	NA	NA
Critically endangered	10-25	>6	>9
Endangered	25-50	4-6	6-9
Vulnerable	50-75	3-4	3-6
Near Threatened	>75	1-3	1-3

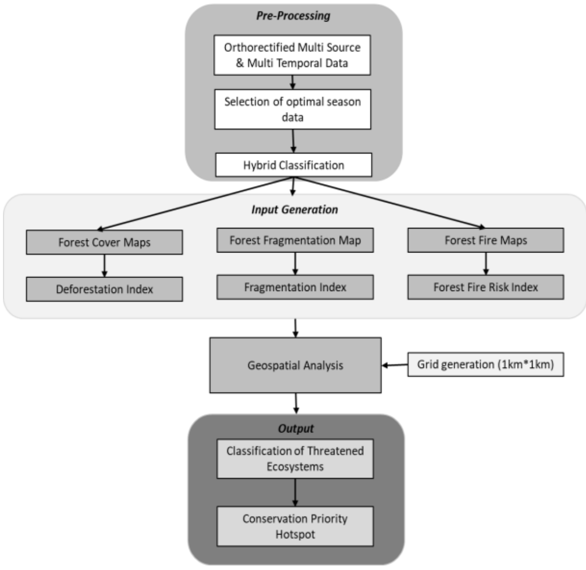

Fig. 2: Workflow of Methodology

A. *Forest Cover Mapping*

Forest cover map of 2015 was generated using Orthorectified Landsat 8 OLI image and IRS P6 LISS III. The forest cover map of 2005 was prepared using IRS P6 LISS III data and satellite data procured from NRSC. The survey of India topographical maps (1:250,000 scale) prepared by Army Map Service, U.S. Army, Washington was only earliest available source for historical forest cover information (http://www.lib.utexas.edu /maps/ams/india/). Hybrid classification techniques in combination of supervised classification and visual interpretation were used to map forest cover.

A random sampling technique using 300 random pixels was used to validate the accuracy of forest cover map for 2015. An error matrix was used to calculate the overall accuracy of the classification [4].

A grid cell of 1 km x 1 km was generated for time series analysis to understand the patterns in the spatial distribution of forest cover (2005, 2015, 2025 and changes). The spatial extent of change was categorized across the five classes i.e. <10 ha, 10-25 ha, 25-50 ha, >50-75 ha and >75 ha as per IUCN terminology nomenclature.

B. *Forest Fragmentation Mapping*

The Landscape Fragmentation Tool (LFT) is utilized for the analysis of fragmentation pattern of forest as well as Land use/Land cover developed by Clark lab. The LFT is add-in extension which can be downloadable and incorporate with ARCGIS Versions. In this study, the forest cover map is classified into four main categories - patch, edge, perforated and core - based on a specified edge width i.e. 100 meters.

The core pixels are outside the "edge effect" and thus are not degraded by fragmentation. Core pixels are sub-classified into 3 categories based on the area of a given core patch - small core (< 101 ha), medium core between (101 ha to 202 ha), and large core (>202 ha). Edge and perforated pixels occur along the periphery of tract (boundary) containing core pixels. Edge pixels comprise the exterior peripheries of the tracts whereas perforated pixels are the interior edges along small gaps in the tracts. Patch forest are within a small forest fragment that are completely degraded by edge forest. The fragmentation categories shown in Fig. 3

The Forest Fragmentation of 2015 was used to identify the trend of change using a grid cell of 1 km x 1 km. The fragmentation index has been generated using fragmentation map.

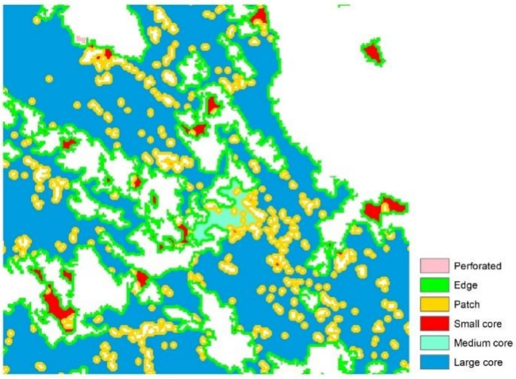

Fig. 3: Fragmentation Categories

C. Forest Fire Mapping

No more than 3 levels of Least cloud coverage AWiFS and Landsat OLI satellite from 2005 to 2015 data was used in the study of forest fire monitoring. The AWiFS satellite imageries were geometrically co-registered with orthorectified Landsat OLI data as master image using ERDAS IMAGINE. Supervised maximum likelihood classifier was used for extraction of burnt areas [14]. In the first step, all the non-forest classes were masked out from the satellite imagery using classified forest cover data of 2015. Post-classification smoothening was carried out with a 3 x 3 matrix.

Forest fire maps are analysed with 1 km x 1 km grid to generate the forest fire risk index. There are four fire hotspot classes obtained from this analysis.

D. Conservation Priority Hotspots

The analysis here focuses on ecosystems which are undergoing multiple threats. Threat valuation from deforestation, fragmentation and forest fires are used to assign the conservation status of ecosystems. The highest threat value in the range of 14-17 represents the Conservation priority hotspot-I followed by conservation priority hotspot-II with a threat value of 9-13 and a threat value of 6-8 as conservation priority hotspot-III.

IV. RESULT AND DISCUSSIONS

A. Deforestation Index

In this study, the forest cover map of 2005 and 2015 were generated shown in Fig. 4. The classified map of 2005 and 2015 indicate the forest cover, accounting to an area of 943.48 km^2 (24.54%) and 810.98 km^2 (21.01%) of Total Geographical Area respectively. The forest cover loss was estimated as 132.49 (14.04%) from 2005 to 2015.

B. Fragmentation Index

For the computation of forest fragmentation input should have to reclassify into two classes viz., forest and non-forest resulting in a new spatial data layer. The classified map of 2005 and 2015 were used for fragmentation analysis shown in Fig. 5. The significant increase in patch and perforated area is observed. The fragmentation study identifies approximately 32% reduction in large core areas over the 2005-2015. Fragmentation statistics are given in Table. II.

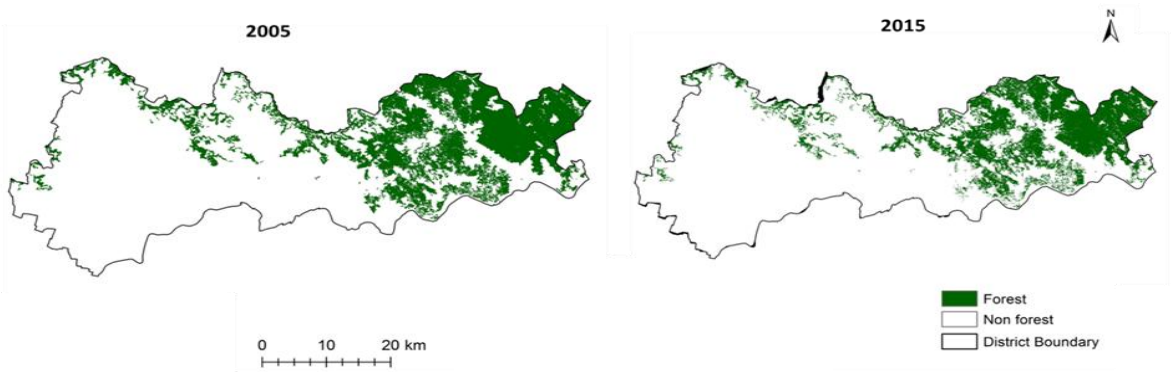

Fig. 4: Forest Cover Map

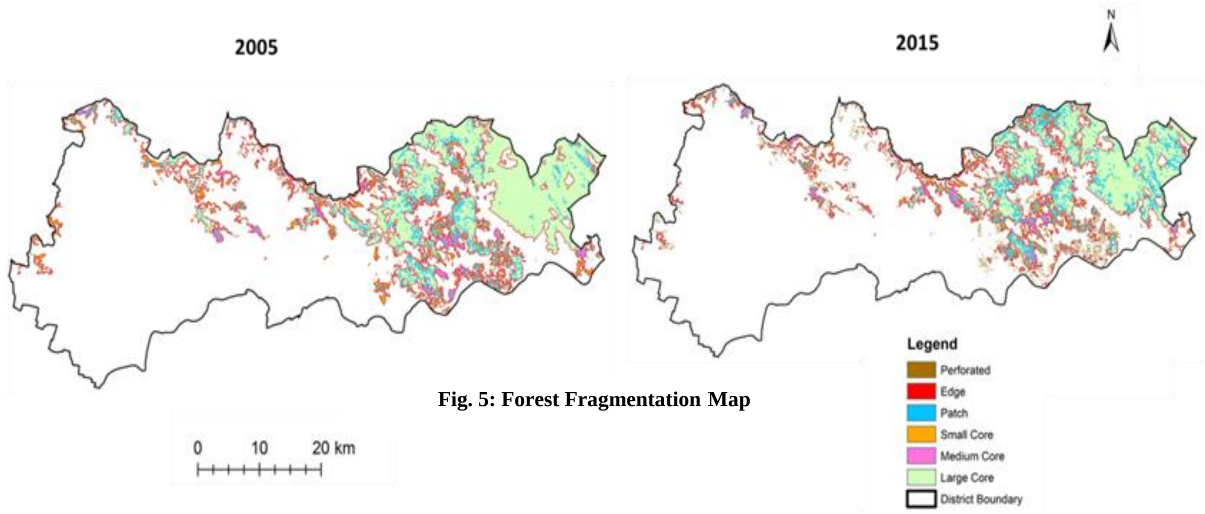

Fig. 5: Forest Fragmentation Map

TABLE III
Fragmentation Statistics

		Area in sq. km.	
S. No.	**Category**	**2005**	**2015**
1	Perforated	8.0	49.9
2	Edge	229.3	208.2
3	Patch	109.6	139.6
4	Small Core	57.6	46.1
5	Medium Core	21.3	14.8
6	Large Core	517.6	352.3
	Total Core	**596.5**	**413.2**
	Total	**943.5**	**811.0**

C. Forest Fire Risk Index

The forest fire statistics generated for each year is based on multi-temporal data of Landsat and AWiFS imagery. During the transition period the total area affected under forest fire along with percent-wise is shown in Table III. The 2007 and 2013 shows highest area has been exposed to the forest fire. It was observed that forest fires are mainly due to anthropogenic activities and increasing population. The forest fire maps are shown in Fig. 6.

TABLE IIIII
Percent-wise statistics of forest fire area

S. No.	**Year**	**Area in sq. km.**	**Percent**
1	2005	125	6.0
2	2006	67	3.1
3	2007	234	14.0
4	2008	258	6.4
5	2009	316	7.7
6	2010	204	8.6
7	2011	72	2.3
8	2012	117	6.5
9	2013	460	12.4
10	2014	71	5.6
11	2015	120	8.6

The results of the study indicate loss of biodiversity at the ecosystem level in Nirmal Dist., Telangana forests. The considerable losses were summarized by listing ecosystems as critically endangered, endangered and vulnerable. Total grid-wise statistics given in Table IV.

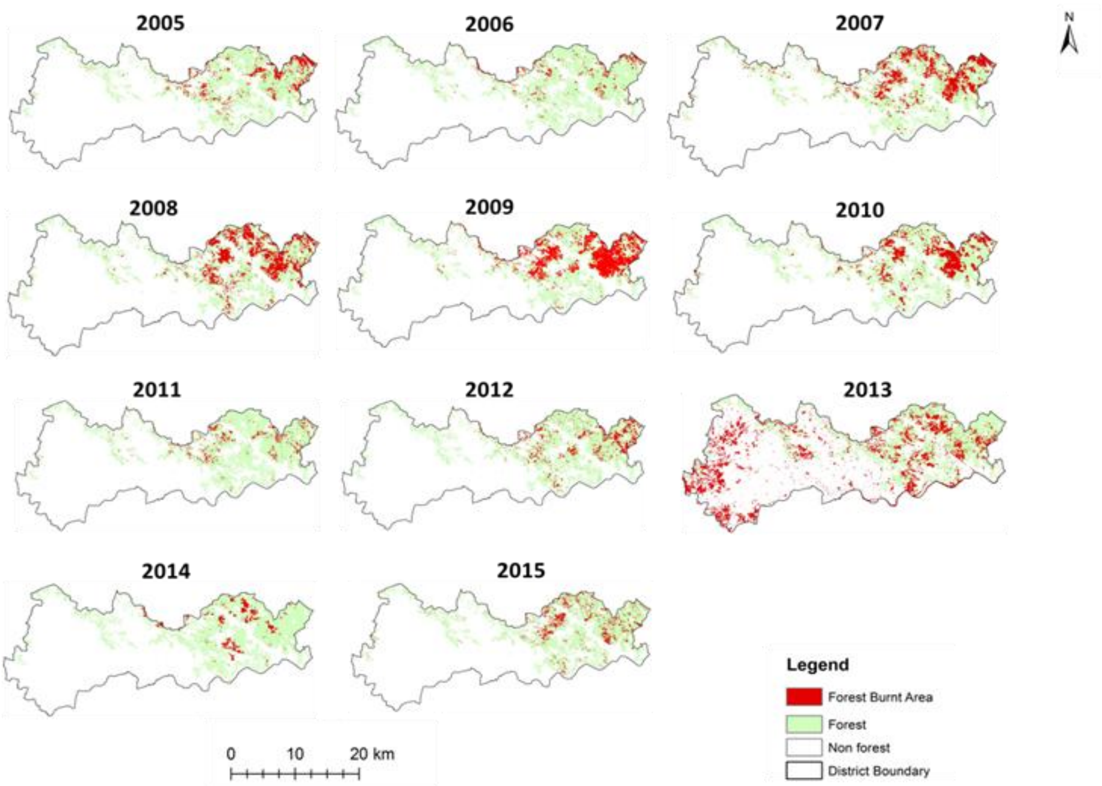

Fig. 6: Forest Fire Map

TABLE IVV
Grid-wise statistics

Ecosystem	Deforestation Hotspot		Fragmentation Hotspot		Forest Hotspot	
	Grids	% of grid	Grids	% of grid	Grids	% of grid
Extinct	997	25.01	0	0	0	0
Critically endangered	378	9.48	4	0.10	413	10.36
Endangered	115	2.89	327	8.20	433	10.86
Vulnerable	8	0.20	772	19.37	385	9.66
Near Threatened	0	0	651	16.33	1478	37.08
Non-forest	2488	62.42	2232	56.00	1277	32.04
Total	3986	100	3986	100	3986	100

D. Deforestation Hotspot

As shown in Table IV the study has identified grids 997 extinct, 378 critically endangered, 115 endangered and 8 vulnerable. Within the district, the losses of forest ecosystems are prominent shown in Fig. 7. Coupled with the urbanization and infrastructure development, demand for cultivation land has led to deforestation in Nirmal Dist., Telangana.

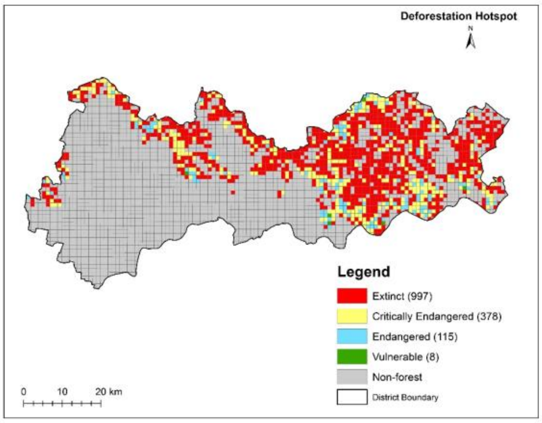

Fig. 7: Deforestation Hotspot

E. Fragmentation Hotspot

The geospatial analysis has identified a pattern of fragmentation across the whole Nirmal District. There are 4 grids which are identified under very high fragmentation index and categorized as critically endangered with 327 endangered and 772 vulnerable grids (Fig. 8). 651 grids are identified as low-fragmented areas and classified as near threatened. The study has found highly fragmented forests in Nirmal districts, while national-level analysis for India has reported a moderate level of fragmentation in Deccan biogeographic zone [8].

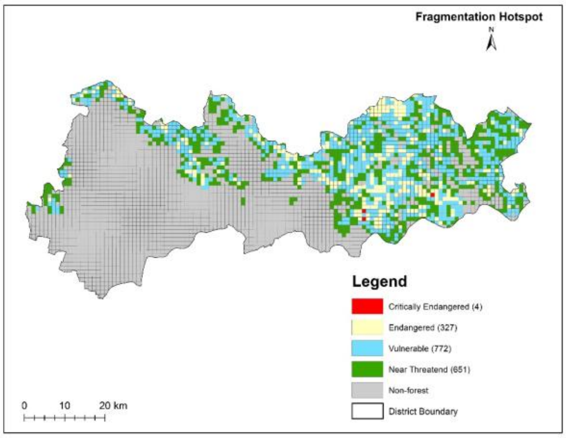

Fig. 8: Fragmentation Hotspot

F. Forest fires Hotspot

Analysis shows that forest fires are scattered all over the state (Fig. 9). Geospatial analysis indicates 413 grids are critically endangered category infer very high risk of forest fires as well as 433 grids in endangered and 385 in vulnerable grids.

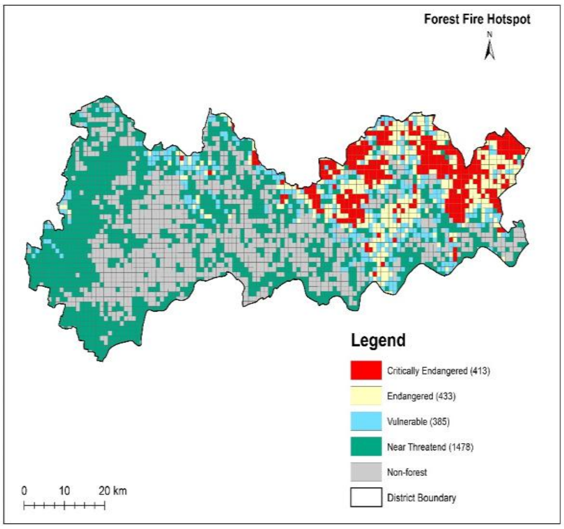

Fig. 9: Forest Fire Hotspot

G. Conservation priority hotspots

This analysis complements an assessment of the threatened ecosystems undergoing multiple threats. of existing forest, 5.57% (222 grids) had severe ecosystem collapse and had been included under the category of conservation priority hotspot-I, followed by 19.47% (776 grids) in conservation priority hotspot-II and 13.67% (545 grids) in conservation priority hotspot-III (Fig. 10). Thus, understanding the hotspot ecosystems helps in effective conservation programmes. The conservation measure helps to protect the floral and faunal diversity of the ecosystems. In the present study, we have analysed the data using geospatial techniques which will encourage the decision making to prioritize the ecosystem and its developmental activities. Spatial database on ecosystems need to be developed to facilitate similar types of studies at the national level which would in turn help in the conservation of the ecosystem.

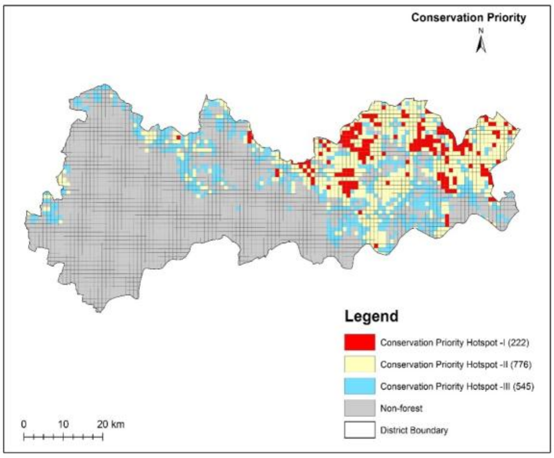

Fig. 10: Conservation Priority Hotspot

V. CONCLUSION

Current study has been facilitated by geospatial techniques to classify threatened ecosystems. It has helped in identifying critically endangered, endangered & vulnerable ecosystems which is a result of deforestation, anthropogenic activities, fragmentation & forest fires. Integration of different spatial data in cohesion with the survey maps were used in the current study to derive at the conservation prioritization of ecosystems which would facilitate the red listing of ecosystems in Nirmal District of Telangana state, India.

Thus, understanding the hotspot ecosystems helps in effective conservation programmes. The conservation measure helps to protect the floral and faunal diversity of the ecosystems. In the present study, we have analysed the data using geospatial techniques which will encourage the decision making to prioritize the ecosystem and its developmental activities. Spatial database on ecosystems need to be developed to facilitate similar types of studies at the national level which would in turn help in the conservation of the ecosystem.

ACKNOWLEDGMENT

The authors are thankful to Director, NRSC, Deputy Director, NRSC, Group Director, Forestry and Ecology Group, NRSC for encouragement and facilities.

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