

ASSESSMENT OF FOREST ENCROACHMENT IN CHIKMAGALUR DISTRICT OF WESTERN GHATS USING RS AND GIS

Hemanjali, A.M, Research Scholar, Department of Environmental Science, Bangalore University, Bangalore, India.
Pramod Kumar, G.R, Research Scholar, Department of Environmental Science, Bangalore University, Bangalore, India
Somashekar, R.K, Professor, Department of Environmental Science, Bangalore University, Bangalore, India
Nagaraja, B.C, Assistant Professor, Department of Environmental Science, Bangalore University, Bangalore, India

Abstract

The Western Ghats, which covers about 60 % of forest area of Karnataka, is recognized as one of the bio-diversity hotspots of the world. These forests are shrinking in recent years due to anthropogenic pressures, especially encroachment of lands for agriculture. It has led to forest fragmentation, loss of habitat and corridor for movement of wild animals, etc. The present study focus on RS and GIS based assessment of forest encroachment scenario over a period of three decades in Chikmagalur district of Karnataka using Landsat TM/MSS of 1990 and 2000, and IRS P6 of 2010. It is observed that the forest encroachment has considerably increased from 0.98 % to 6.63 % between 1975 and 2010 and the majority of encroachment has taken place during 1990 and 2000. Higher encroachments prevailed in moist and dry deciduous forest in the district. The information maps generated out of this study will help will help the frontline forest officials to trace back and recover the encroached forests besides preventing future encroachments.

Keywords

Western Ghats, Hotspots, Encroachment, Zonal classification, Deforestation

Introduction

The forest and tree cover of the country is 78.29 M ha [9], which is 23.81 % of the total geographical area. Forestry is the second-largest land use in India after agriculture, with 27 % of the total population depending on forests for their subsistence and livelihood [6]. Human pressure on land use is increasing in the unprotected landscapes that surround many protected areas across the world [11]. Increasing industrialization and growing population are also responsible for damaging the forestland [8], [22], [23], [1]. Forest degradation is mainly due to over exploitation, excessive grazing, uncontrolled fires, illicit cutting, shifting cultivation and encroachment practices [9], [7], [5], [14], [2], [24].

In the last several decades, forest encroachment, deforestation and biodiversity loss became a common event throughout the globe [4], this phenomenon is much more frequent in developing countries like India. Encroachment of forest land for cultivation and other purposes continues to be the most

pernicious practice endangering forest resources throughout the country [3]. Totally an area of 13.5 lakhs ha is categorized under encroached forest in the country till date and wherein the share of state of Karnataka is 96,230 ha. Many state government and farmers have approached the court informing that the survey done by Forest Department is unscientific.

The Western Ghats, which cover about 60 % of forest area of Karnataka, is recognized as one of the bio-diversity hotspots of the world. The total recorded forest area of the state is 43,356.45 Km², constituting 22.60 % of the geographical area with 29,550.19 Km² of reserved forest, 3,585.22 Km² of protected forests, 49.05 Km² of village forests, 10,117.92 Km² of unclassified forests and 54.07 Km² of private forests. The Western Ghats forests are rich in fauna and flora diversity and are very valuable as both genetic and natural resources [15]. As a result of burgeoning population and consequent landlessness, the pressure on the available land resources has been increasing day by day leading to encroachment of forestland, which has become a major threat to the conservation of forest and its resources [18], [19]. [13], reported deforestation for different regions with annual rate of degradation of 0.8 % and 1.5 % for dense forest and open forest types respectively. [21] Rabindar reported a loss of dense forest at an annual rate of 0.53% in the Western Ghats region of Maharashtra. Also, in Karnataka there are valuable patches of private forests that require protection [10].

Study Area

Chikmagalur district is located on the western ridge occupying 3.8 % of the total area of the Karnataka state (Fig.1). It is located between 12° 54' 42'' and 13° 53' 53'' N latitudes and 75° 04' 46'' and 76° 21' 50'' E longitudes. It covers an area of 7,202 Km² partly in Malnad tract (hilly area) and partly in transition and Mairdan area, (plain area). For administrative convenience and forest management purpose, Chikmagalur district has two territorial forest divisions Chikmagalur and Koppa with seven taluk, 10 towns and 1022 number of inhabited villages, Mullayyanagiri is the highest point which is 1926 m, above MSL. Chikmagalur has a population of 1,18,496 (1,71,861) with a population density of 141 persons / Km² (2011 census). The forest resource of Chikmagalur is 2108.62 Km² of total area of the district. The overall climate is cool and it comprises of large

extent of hilly terrain. April is generally the hottest month with the mean daily maximum temperature at 30.7⁰ C and the mean daily minimum temperature at 19⁰ C. The summer temperature reaches 36⁰ C. Chikmagalur district harbours tropical rain forests at the one end and the dry scrub forest at the other end of the spectrum. It has hill ranges and rolling terrain with coffee and tea plantations. The average rainfall in Chikmagalur district is 1925 mm. It varies from of 595 mm to 2379 mm. The important forest produce are Rose wood, Teak wood, Bamboo, Fire wood, Eucalyptus wood, Honne, and Nandi. The important minor forest produce are Shikakai, Antwala, Cinnamonum leaves, Watehuli, Honey, Bee wax, Halmadi, etc.

age and choosing prominent landmarks. These geo-rectified images were later fine-tuned to account for greater degree of details and information and attributes were labeled separately. Further, the major settlement location was also generated as point coverage from SOI topomap, and the forest encroachment map using ERDAS (version 9.2). The encroached forest area has been categorized into large (> 10 ha), medium (<10 ha) and small (<5 ha). Based on the extent, each taluk in each category, three sample plots were laid for assessing the changes that have taken place during the decades (Fig. 3).

Results and Discussion

The forests of the Chikmagalur district have been classified into five general types: Southern tropical evergreen forests, Southern tropical semi-evergreen forest, Southern moist-deciduous forests, Southern dry-deciduous forests and Scrub forests as described by Champion & Seth 1968 forest classification of South India. The forests of Kalasa, Sringeri, Koppa and Balur State forest ranges are the examples of Southern Tropical evergreen forest covering 715.61 Km² (around 23.6%). The vegetation is typically evergreen to semi-evergreen resulting from the abundance of percolation of water in the soil and the shelter afforded by the high hills all round. The hilltops are covered with grass. The fringes of these grasslands are flanked by Shola forests, which get transformed into dense tropical evergreen forests in the valleys at lower altitudes. In the Semi-evergreen Forests spread over 274.59 Km² (9.1%) edaphic type forms a transition between the tropical evergreen and moist deciduous forests and can be regarded as a sub-type of both. The Sub Deciduous Forests with an area of 884.67 Km² is recognized by the presence of evergreen species 29.17 % in Basavanakote, Devadan Reserve forests and, Sargod and Tatkola State forests. The leaf shedding season is either short or even absent in sheltered ravines. Mixed deciduous forests covering 418.34 Km² (13.79%), the vegetation comprises typically of deciduous species. The dry thorny scrub forests spreads over 126.81 Km² represents 4.18% the area. The vegetation consists of typical dry deciduous and thorny scrubs. Grassland forest followed by Scrub forests cover around 4.2% and other plantations such as Acacia Plantation, Bamboo Plantation, Casuarina Plantation and Eucalyptus Plantation cover about 7%. More than 50% of the plantation is covered by Eucalyptus plantation and the others with 2.2%, 0.2%, 0.2 (0.17) % and 4.5% respectively. The others and the mixed plantation cover merely 0.76% and 0.47% respectively. The rest of the district is occupied by Coffee estates, which are under the canopy of Silver oak trees as well as natural forests (Table 2).

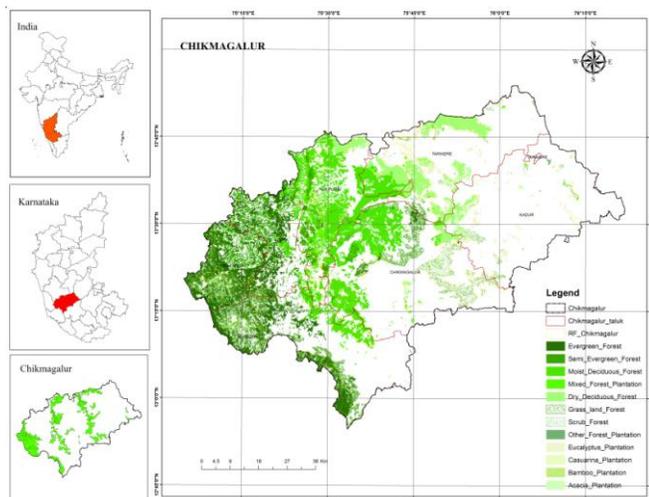


Figure 1: Location map showing Reserve forest Boundary, Taluk Boundary and major Forest types.

Methodology

Forest types were identified and delineated through on-screen visual interpretation and thematic maps were prepared using satellite imageries of 1975, 1990, 2000 and 2010. The Survey of India (SOI) toposheets pertaining to study area were mosaiced and subsetting to aid in further analysis such as geo-referencing of satellite images, creation of cultural features and ground truthing. Further the onscreen interpretation was carried out to prepare (spread and extent) various extraction of administrative boundaries such as reserve forest, district, taluk and villages. The forest administrative boundaries procured from the working plan and wildlife management plan of the Karnataka Forest Department were transferred onto topomaps. This was followed by pre-processing of the acquired geocoded sub-scene of selected study area for 1975, 1990, 2000 and 2010 using ERDAS Imagine (version 9.1). Map to image geo-rectification process was adopted for geometrically correcting the satellite images with polyconic projection parameters using ERDAS (version 9.2), where ground control points (GCP) were obtained from 1:50,000 scaled, geo-referenced, SOI topomaps. Selection of points was done by referring to the im-

Table.2: Vegetation Land Use / Land Cover of Chikmagalur District

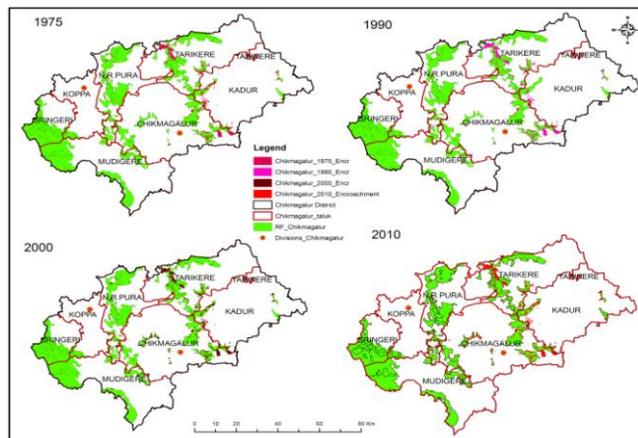
Land Use /Land Cover Classification	Area (Km ²)	Percentage (%)
Evergreen Forest	715.61	23.59
Semi Evergreen Forest	274.59	9.05
Moist Deciduous Forest	884.67	29.17
Dry Deciduous Forest	418.34	13.79
Grass land	360.66	11.89
Scrub-Forest	126.81	4.18
Acacia Plantation	67.29	2.21
Bamboo Plantation	4.62	0.15
Casuarina Plantation	5.39	0.17
Eucalyptus Plantation	137.28	4.52
Other Forest Plantation	14.28	0.47
Mixed Plantation	23.16	0.76
Total	3032.71	100

Around 48.4% of the evergreen forests have more than 40-70 % canopy density whereas Semi evergreen forest has more than 25-40 % canopy density. The deciduous forests have more than 40-70 % canopy density. Dry deciduous forests are 41.2% with a canopy density between 10 – 25 % (Table 3).

Table.3: Vegetation Density of Chikmagalur District.

Forest type	Density (%)	Area (Km ²)	Total Area (Km ²)
Evergreen Forest	<10%	42.3944	715.6076
	10-25%	26.1186	
	25-40%	176.2206	
	40-70%	346.2237	
	>70%	124.6503	
Semi Evergreen Forest	<10%	25.23569	274.5923
	10-25%	41.58709	
	25-40%	144.1928	
	40-70%	58.17205	
	>70%	5.404702	
Moist Deciduous	<10%	92.01529	884.66979
	10-25%	162.4735	

Forest	25-40%	171.5648	418.33975
	40-70%	446.3996	
	>70%	12.2166	
Dry Deciduous Forest	<10%	68.42519	418.33975
	10-25%	172.4212	
	25-40%	66.07536	
	40-70%	111.418	
Others		739.496086	
Total			3032.70558


Figure 2: Forest Encroachment Map of Chikmagalur District of the Year 1999, 2000 and 2010.

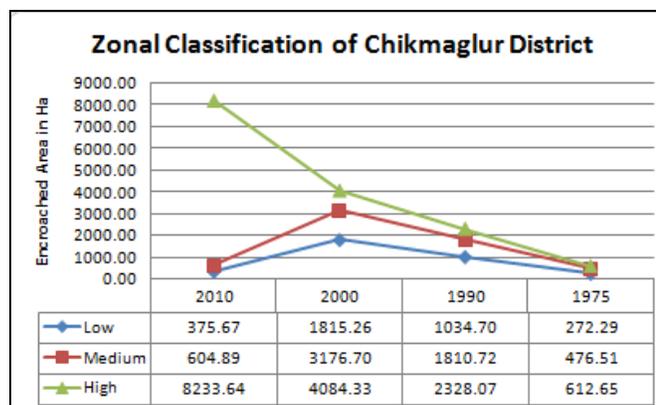
Extent of Encroachment

A total of 6.63 % of reserve forests in Chikmagalur district is encroached as per 2010 satellite data. After overlaying encroached area on the reserve forest map prepared using 1968 SOI topomaps the extent of encroachment was found to be 92.143 Km², 90.762 Km², 51.735 Km² and 13.614 Km² for 2010, 2000, 1990 and 1975 with a variation of 6.63 %, 6.54 %, 3.72 % and 0.98 % respectively (Table 4). The rate of encroachment has considerably increased from 0.98 % to 6.63 % from 1975 to 2010 and the peak period between 1990 and 2000 (Fig. 2) which was ascertained to be the outcome of unauthorized cultivation after felling of trees. The encroachment is more in Chikmagalur, Tarikere and NR Pura taluks in 2010 with a weighted average percentage of 44.76, 34.82 and 15.37 respectively for moist deciduous, thorny scrub and very few trace of semi-evergreen forest with plantations such as Eucalyptus, Acacia, etc. Interestingly in Mudigere taluk with highest reserve forest area average weighted percentage is 3.01. This is because the area represents evergreen forest covered under Kudermukh National Park. In Koppa and Sringeri taluks the encroachment is nil as it is protected area under Kudremukh National Park.

Table 4: Taluk wise Forest Encroachment in 1975, 1990, 2000 and 2010 in Chikmagalur District.

SL. No	Taluk	Forest Type of Encroached Area	Geographical Area (Km ²)	Reserve Forest Area (Km ²)	Encroached Forest Area (Km ²)							
					1975		1990		2000		2010	
					Area	% of Area	Area	% of Area	Area	% of Area	Area	% of Area
1	Tarikere	Scrub Forest	1221.15	244.47	4.765	35	18.107	34.99	31.767	35	32.09	34.82
2	NR pura	Moist Deciduous	802.31	282.87	2.042	14.9	7.76	14.99	13.614	14.99	14.16	15.37
3	Kadur	Scrub Forest	1423.13	54.58	0.272	1.9	1.035	2.03	1.815	1.99	1.87	2.02
4	Chikmagalur	Moist Deciduous	1593.67	231.84	6.127	45	23.281	45	40.843	45	41.25	44.76
5	Mudigere	Evergreen & semi evergreen	1151.93	326.89	0.408	3.52	1.552	2.99	2.723	3	2.78	3.01
6	Koppa	Evergreen & semi evergreen	566.65	28.15	Kudermukh National Park							
7	Sringeri	Evergreen & semi evergreen	443.76	218.94	Kudermukh National Park							
Total			7202.6	1387.74	13.614	100	51.74	100	90.762	100	92.143	100
Percentage (%)					0.98		3.72		6.54		6.63	

It is evident that the ratios of small, medium and larger encroachments have almost increased year after year. In 2010, the encroached area under the three classes is 375.65, 604.89 and 8233.64 ha respectively (Fig. 3).


Figure 3: Zonation Classification of Forest Encroached Area for 2010, 2000, 1990 and 1975.

A very similar kind of encroachment scenario is also reported from Bangladesh where also forest area is depleting mainly due to illegal logging and conversion to non-forestry uses associated with the community socio-economic status, limited land availability and unemployment [12]. Social destabilization as an outcome of ethnic frictions has culminated in shift in resource control by migrants. Hence, locals made an attempt in national park forest of two forest margin village in Sulawesi to re-secure their economic base adopting a strategy of land expansion into ecological buffer zone areas and it is viewed as encroachment [17]. Naturally the forest cover exhibits a great deal of variation in both spatial and temporal context because of climate change. However biotic pressure is hastening up deforestation and change in land use. Over the 30 years encroachment in Chikmagalur district is 3.72 % to 6.63 % which is comparable with the published literature [20]. [18], [19], Pramod et. al. reported that forest

encroachment in two district of Karnataka is about 291.6 ha in Kodagu and in Belgaum it is 29010 ha during 2010 which represent 15.27 % of the under moist and dry deciduous forests whereas in Chikmagalur the encroachment it is 6.63 % in 2010 and the major area under Moist Deciduous and Scrub forests.

Protection is one of the most important activities of the forestry sector to preserve the forest wealth, which have been inherited from many generations. The problems are increasing day by day posing real challenge to the forest department. [25] In Southern Ontario, conducted a long interview among planners, landscape architects, forest managers and law officials aiming at limiting residential encroachment impacts within forest edges. To address the same bylaws are the primary tools. Nonetheless, field studies indicated infrequent enforcement in our case. To overcome the problem boundary-focused structures, such as fences, could be the primary means of preventing encroachment. The field survey brought to light more encroachment alongside nearby villages and towns. Good natural regeneration of seedlings was observed in the abandoned cultivated areas, which can be conveniently encouraged to grow as a good forest in future. As such it is wiser to bring the encroached area again under forest cover.

Acknowledgement

We thank Ministry of Environment & Forests, Government of India for financial assistance, NRSC, Hyderabad for providing satellite imageries and Karnataka Forest Department for granting permission for ground truthing.

References

- [1] ADB. (2002). Country Assistance Plans – Bangladesh: III. Sector Strategies. <http://www.adb.org/documents/caps/ban/0301.asp>.
- [2]. Ali, M., (2003). Scientific forestry and forest land use in Bangladesh: A discourse analysis of people's attitudes. *International Forestry Review*, 3, pp214–222.
- [3]. Armenteras, D., Gast, F., & Villareal, H. (2003). Andean forest fragmentation and the representativeness of protected natural areas in the eastern Andes, Colombia. *Biological Conservation*, 113, pp245–256.
- [4]. Benhin, J., (2006). Agriculture and deforestation in the tropics: a critical theoretical and empirical review, *Ambio*, 35(1), pp9-16.
- [5]. Capistrano, A.D., and Kiker, C.F., (1995). Macro-scale economic influences on tropical forest depletion. *Ecological Economics*.
- [6]. Centre for Science and Environment (CSE). (2012). Media Briefing Forests in India. Publication is supported by Jamsetji Tata Trust.
- [7]. Dwivedi, A. P., (1992). *Agro forestry Principles and Practices*, Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi, 365.
- [8]. Flint, E.P., (1994). Changes in land use in south and Southeast Asia from 1880 to 1980: a database prepared as part of a coordinated research program on carbon fluxes in the tropics. *Chemosphere* 29(5), pp1015– 1062.
- [9]. Forest Survey of India. (1999, 2001, 2003, 2005, 2007,2011) State of Forest Reports - 1997, 1999, 2003, 2005. FSI, Dehradun.
- [10]. Gokhale, Y., (2004). Reviving traditional forest management in Western Ghats: Study in Karnataka. *Economic and Political Weekly*, pp3556–3559.
- [11]. Hansen, A. J., and De Fries, R., (2007). Ecological Mechanisms linking protected areas to surrounding lands. *Ecological Applications*.19, 974-988.
- [12]. Iftekha, M.S., and Hoque, A.K.F., (2005). Causes of forest encroachment: An analysis of Bangladesh. *Geo Journal*, 62, pp95-106.
- [13]. Jha, C. S., Dutt, C. B. S., and Bawa, K. S., (2000). Deforestation and land-use changes in Western Ghats, India. *Current Science*, 79, pp31–237.
- [14]. Kamal, A., Kamaluddin, M., and Ullah, M., (1999). Land policies, Land Management and Land Degradation in the Hindu Kush-Himalayas. Bangladesh study report. MFS Case Study Series International Center for Integrated Mountain Development. 99(1), p63.
- [15]. Karnataka Forest Department (2007). Working plan of Chikmagalur forest division, Karnataka State Forest Department, Government of Karnataka, Bangalore.
- [16]. Karnataka Forest Department., Annual Plan Of Operation For Utilization Of State CAMPA Funds, For the year 2010-2011.
- [17]. Melani, Abdulkadir, Sunito and Felix Sitorus, M.T., (2007). From ecological to political buffer zone: ethnic politics and forest encroachment in Upland Central Sulawesi. The stability of tropical rainforest margins, linking ecological, economic and social constraints of land use and conservation, Springer Verlag Berlin, pp167-180.
- [18]. Pramod Kumar, G.R., Hemanjali, A.M., Ravikumar, P., Somashekar, R.K., and Nagaraja, B.C., (2013). Assessing the historical forest Encroachment of Kodagu region of Western Ghats, South India using remote sensing and GIS. UMI-2013 NRSC/ISRO, (<http://nrsc.gov.in/uim/assets/presentations/pram.pdf>).
- [19]. Pramod Kumar G.R., A.M. Hemanjali, P. Ravikumar, R.K. Somashekar and B.C Nagaraja. (2013) "Assessment of forest encroachment at Belgaum district of Western Ghats of Karnataka using Remote Sensing and GIS". *Journal of Environmental Biology*, 35, pp259-264.
- [20]. Promode Kant, R. P., Katwal, S., (2003). Exploring Possibilities of Reforestation of Forest Lands Exposed to Encroachment and Shifting Cultivation in the North Eastern India through Clean Development Mechanism. Proceedings of the National Workshop on Technological Innovations and Research Advancements for Application in Joint Forest Management held at ICFRE, Dehradun, pp53 – 159.
- [21]. Rabindra, K. Panigrahy., Manish, P. Kale., Upasana-Dutta., Asima Mishra., Bishwarup Banerjee., and Samam Singh., (2010). Forest cover change detection of Western Ghats of Maharashtra using satellite remote sensing based visual interpretation technique. *Current Science*, 98, (5), pp657-664.
- [22]. Range Gowda., IFS (2010). Government of Karnataka Working Plan for Koppa Forest Division, (Approved by Govt. of India and Government of Karnataka), for the period - 2001-02 to 2010-11.
- [23]. Rasheed, K.B.S., (1995). Participatory forestry as a strategy for reforestation in Bangladesh. *Geo journal*, 37(1), pp39-44.
- [24]. Rasul, G., Thapa, G.B., and Zoebisch, M.A., (2004). Determinants of land-use changes in the Chittagong Hill Tracts of Bangladesh *Applied Geography*, 24 (3), pp217–24.
- [25]. Wendy, McWilliam., Paul Eagles., Mark Seasons., & Robert Brown., (2012). Evaluation of planning and management approaches for limiting residential encroachment impacts within forest edges: A Southern Ontario case study. *Urban Ecosystem*, 15(3), pp753-772.