International Journal of Advanced Technology & Engineering Research (IJATER)
www.ijater.com

ASSESSMENT OF FOREST ENCROACHMENT IN SHIMOGA DISTRICT OF WESTERN GHATS, INDIA, USING REMOTE SENSING AND GIS

Hemanjali, A.M.[1], Pramod Kumar, G.R.[1], Somashekar, R.K. [2] and Nagaraja, B. C[3] .
1: Research Scholar, Department of Environmental Science, Bangalore University, Bangalore, India.
2: Professor, Department of Environmental Science, Bangalore University, Bangalore, India
3: Assistant Professor, Department of Environmental Science, Bangalore University, Bangalore, India

Abstract

Sustainable management of Forest ecosystem is necessary as it serves the important functions such as supplementing human dietary requirements, ecological significance in terms of biodiversity conservation, flood control, water purification and micro climate regulation etc. Hence, an inventory of reserve forest in a given area is a pre-requisite for their conservation and management. The present study is focused on RS and GIS based assessment of forest encroachment in Shimoga district of Karnataka for the years 1990, 2000 and 2010 using Landsat TM/MSS/ETM+ for 1990 and 2000, and IRS P6 LISS III for the year 2010. It's located in the mid south western part of malnad region of Karnataka state, geographically lies between 13°27' and 14°39' N latitudes and 74°38' and 76°4'E longitudes. It covers an area of 8,482.32 km^2 a apart of western ghats areas (Sahayadrihill ranges), the densely forested high hilly Malnad in the west and sparsely forested tablelands semi-malnad in the east of Karnataka state with a forest area constituting 32.66% of the total geographical area of the district. The study revealed that the encroachment in reserve forest area accounts for 282.92 km^2, 257.27 km^2 and 192.43 km^2 for the year 2010, 2000 and 1990 respectively. Extension of cultivation is the major cause of large-scale encroachment in the district. There is no proper demarcation of the forest boundaries in some places. This has also resulted in encroachment of forest land. It has led to forest fragmentation, loss of habitat and corridor for movement of wild animals, etc. The policy makers and judiciary have stressed the need for use of recent satellite data to assess the forest encroachment in Western Ghats region. In this regard, an attempt has been made to study the two decadal forest encroachment patterns of Shimoga district. The extent of encroachment was observed to be 12.13 % in 2010. Encroachment is more prevalent in the moist and dry deciduous forests than the evergreen forests and is seen increasing day by day. This information will help for frontline forest officials to trace and book forest offences occurring in their jurisdiction and also to prevent encroachments.

Keywords: Western Ghats, Hotspots, Encroachment, Zonal classification, Deforestation

Introduction

Forests are among the most diverse and widespread ecosystems on earth and millions of people living in tropical countries derive a significant part of their livelihoods from various forest products for centuries. These products also play a vital role to the livelihoods of people living within or adjacent to forests. They also provide a wide range of environmental services which mainly include biodiversity conservation, watershed protection, protection of soil, mitigation of global climate change etc., [8], [12]. In the last several decades deforestation and biodiversity loss have become a common event throughout the globe [3]. The first and foremost cause of forest degradation and deforestation is encroachment [4], [15], [9], [17], [2], [1], 16]. Nearly 36 per cent of the total forest area of Karnataka falls under severely degraded category. The causes of degradation are unsustainable-harvests, encroachment, fire, grazing and illicit felling. The moist and dry deciduous forests are more vulnerable to fire due to leaf litter accumulation & dry conditions and also grazing is rampant in the forest causing damage to the regeneration and degradation [5].

Encroachment of forest land for cultivation and other purposes continues to be the most pernicious practice endangering forest resources throughout the country. Statistical information compiled by Forest Survey of India during early 1987 revealed that nearly 7 lakh hectares of forest land is under encroachment in the country. Out of this, 0.2 million hectares has been regularized as per Forest Conservation Act, 1980. Totally an area of 13.5 lakh ha is categorized under encroached forest in the country till date. Among the states, Karnataka lists 96,230 ha of the encroached land and towards the Karnataka western ghats stretch Belgaum heads the list with 161.33 km^2 to 290.1 km^2 from 1990 to 2010 about 15.27% of the encroached land in the Reserve forest area [14], followed by Shimoga. Kodagu district of Karnataka is with 2.916 km^2 of the encroached land of 0.94 % of the Reserve forest [13] and in Chikmaglur the reserve forest status of encroachment is 51.74 km^2 to 92.143 km^2 for the years 1990 to 2010 respectively [7].

Many state government and farmers have approached the court stating that survey done by Forest Department is not

scientific and court also stress the need for use of spatial data for encroachment assessment. Compared to ground survey of forest resources, remote sensing and GIS technology has some obvious advantages for example, remote sensing provides rapid coverage of large areas, permanent and objective records, map-like products, efficiency in time and money, and access to inaccessible areas [8], [12]. In many places, it has led to fragmentation, honey combing, loss of corridor for movement of wild animals, etc. Also, in Karnataka there are valuable patches of private forests that require protection [6]. Hence in the present study the last two decade satellite data have been assessed to find out the area of forest under encroachment and its patterns in the reserved forests of Shimoga district of Karnataka.

Study area

Shimoga district is located in the mid south western part of malnad region occupying 4.42 % of the total area of the Karnataka state (Figure. 1). The district geographically lies between 13°27' and 14°39'N latitudes and 74°38' and 76°4'E longitudes spread over 8482 km^2 area Apart from part of western ghats (Sahayadrihill ranges), the densely forested high hilly Malnad in the west and sparsely forested tablelands in the east constitutes 32.66 % of the total geographical area of the district. Several rivers Kali, Gangavathi, Sharavathi and Tadadi take birth in Shimoga district. The other major rivers flowing in this district are Tunga, Bhadra, Tungabhadra, Kumudvathi, Varada, Varahi and Chakra. For forest management purpose, Shimoga district has been divided into three territorial forest divisions namely, Shimoga, Sagar and Bhadravathi. The Shimoga subdivision with 6 ranges comprises of Shimoga, Bhadravathi and Thirthahalli taluks. The Sagar sub-division with 10 ranges comprises Sagar, Shikaripura, Sorab and Hosanagara and Bhadravathi division has 7 ranges. Kodachadri is the highest point which is 1343 m, above msl and the lowest is the Nagavalli valley in Sagar taluk. The population of Shimoga is 17,52,753 with a density of 206 persons per sq.km (2011 census). The overall climate is of tropical monsoon type which is influenced by elevation and local aspects, generally the weather is hot and humid in the eastern part and very pleasant in the remaining parts. With the regular southwest monsoon, the intensity of rainfall is more during June to September, the highest rainfall is recorded at Agumbe with average annual rainfall is 8,275.7 mm. April is usually the hottest month with the mean daily maximum temperature at 35.8°C and the minimum at 22°C. From the vegetation point of view, the reserve forest resource of Shimoga is 2331.81 km^2. Shimoga has a rich and varied flora and it harbours Southern tropical wet evergreen forests, Southern tropical Semi evergreen forests, South tropical moist deciduous forests, Southern tropical dry deciduous forests and South tropical (Thorn) Scrub forests. In the Sagar division Kans are special kinds of forest lands having typical microclimate sustaining evergreen and semi-evergreen vegetation otherwise surrounded by deciduous forests. These lands are very rich in bio-diversity, occur more or less adjoining villages and are vulnerable to encroachment. The dense forest and green shrub jungles are main producers of sandalwood, rosewood, teak and other exotic timber. Mangos, Jackfruit, Tamarind etc., are the other important trees. The dense forests are home for wild animals like Elephant, Tiger, Lion, Leopard, Wild boar, Bear, Antelope, Bison, Porcupine, Monkeys, wolves and many other animals.

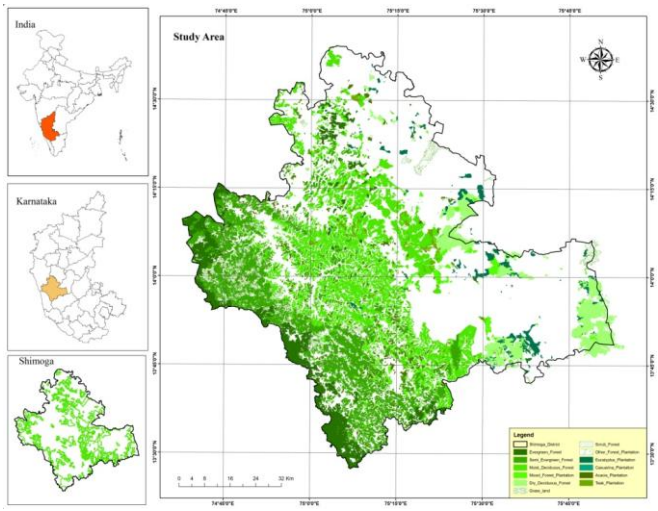

Figure. 1: Location map showing Reserve forest Boundary, Taluk Boundary and Major Forest types in Shimoga district

Material and Methodology

The Survey of India (SOI) toposheets (48J-11/12/14/15/16, 48N-2/3/4/6/7/8/11/12/16, 48K-9/13/14 and 48O-1/2/3/5/6/9/10/13) of 1:50,000 scale pertaining to the study area were geo-referenced mosaiced and sub-setted to aid further analysis. These toposheets were used for geo-referencing of satellite images, creation of cultural features and ground truthing. The forest administrative boundaries extracted from the working plan and wildlife management plan of Karnataka Forest Department were transferred to topomaps. Simultaneously, the Landsat MSS data products of January 1975 and Landsat TM of January 1990 and Landsat ETM+ data of January/ March 2000 procured from the online web portal of USGS Global Visualization Viewer (http://glovis.usgs.gov), IRS P6 LISS III data of January/ February/ March / April 2010 from National Remote Sensing Centre (NRSC), Hyderabad.

Pre-processing of the acquired geo-coded sub-scene of selected study area for 1975, 1990, 2000 and 2010 was performed using ERDAS Imagine (version 9.1). Map to image geo-rectification process was adopted for geometrically cor-

recting the satellite images by obtaining ground control points (GCP) from geo-referencing, SOI toposheets employing polyconic projection parameters [Spheroid Name: Everest; Datum name: India (Bangladesh)]. Selection of points was done by referring to the image and choosing prominent landmarks. The geo-rectified images were later fine tuned to account for greater degree of details and attribute information were labelled separately. Later, different thematic maps viz., vegetation land use/land cover, soil, forest density, transportation networks (roads and rail), drainage network and forest type and vegetation mapping, etc., were digitized from SOI toposheets and fine tuned with respective satellite images, using GIS mode of ArcGIS (version 9.2) and ERDAS Imagine (version 9.2) software. Further, the major settlement locations were also generated as point coverage's from SOI topomap, and the forest encroachment map using ERDAS (version 9.2). This information was put into the GIS tool for digital database creation. Field visits were undertaken to assess the encroachments patterns, such as crop grown, trees retained, period of cultivation and other human induced driver on the forest. 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 out for assessing the changes that have taken place during the decades.

Results and Discussion

The forests of the Shimoga district have been classified into five general types: Southern tropical wet evergreen forests, Southern tropical Semi evergreen forests, South tropical moist deciduous forests, Southern tropical dry deciduous forests and South tropical (Thorn) Scrub forests (Champion & Seth 1968). The forest of Agumbe state forest and Balehalli state forest of Agumbe range, Hosanagara, Nagara, Kargal and Sagar Ranges are the examples of Southern Tropical wet evergreen forest with an extent of 438.73 km^2. The tropical evergreen or rain forests are characterised by great luxuriance of vegetation which consists of several tiers, the highest containing lofty trees, often with buttressed bases, reaching a height of 150 feet. The intermediate tiers consists mainly of evergreen trees crowded through and struggling for light. In the Semi-evergreen Forests with an extent of 879.43 km^2 with 20.72 % is very variable and difficult to define except in comparative terms, being intermediate between the tropical evergreen and moist deciduous but usually includes groups or patches typical of both. These forests mostly occur in Thirthahalli, Mandagadde and Sacrebyle ranges. The borders of of Shankar and Rippanpet range have moist deciduous forests at places of higher elevation. The south tropical moist deciduous forests are extended over 1251.15 km^2. The western and north-western aspects of the hillocks of these forests show a tendency of a better quality as compared to southern and eastern aspects. Forests of Purdal, Anesara, Shankar, Sacrebyle, Hanagere, Bommenahalli, Mugudthi, Kumsi, Sudur, part of Kudi, Masrur, Arasalu part of Kumudvathi and Burve are typical representatives of this type. South tropical dry deciduous forests are found mostly in Ayanur range of Shimoga taluk. The South tropical Scrub forests types are found in northern portion of Ayanur and Honnali ranges. Regeneration is very poor as the areas are subjected to heavy grazing and fire. The grassland occupies 3.73% of the total area. The respective density of Mixed plantation, Eucalyptus, Casuarina, Acacia and Teak is 2.09 %, 5.29 %, 0.01%, 4.73% and 1.45% (Table 1). The rest of the district is occupied by Cotton, Rubber and Pineapple which has lured people of the surrounding villages to encroach upon forest lands.

Table. 1: Vegetation Land Use / Land Cover of Shimoga District

Land Use /Land Cover Classification	Area (km^2)	Percentage (%)
Evergreen Forest	438.73	10.34
Semi Evergreen Forest	879.43	20.72
Moist Deciduous Forest	1251.15	29.48
Mixed Forest Plantation	88.55	2.09
Dry Deciduous Forest	694.42	16.36
Grassland	158.46	3.73
Scrub Forest	209.7	4.94
Other Forest Plantation	36.33	0.86
Eucalyptus Plantation	224.53	5.29
Casuarina Plantation	0.28	0.01
Acacia Plantation	200.89	4.73
Teak Plantation	61.74	1.45
Total	4244.21	100

Around 55.23 % of the evergreen forests have more than 70 % canopy density whereas Semi evergreen forest has more than 40-70 %. The moist deciduous forests also have more than 40-70 % canopy density. Dry deciduous forests canopy range between 10 – 25 % (Table 2)

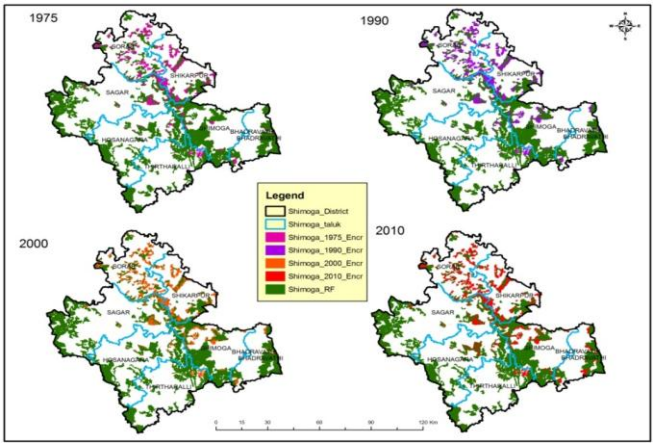

Figure. 2. Forest Encroachment Map of Shimoga District of the Year 1999, 2000 and 2010

Table. 2: Vegetation Density of Shimoga District.

Forest type	Density (%)	Area (km^2)	Total Area (km^2)
Evergreen Forest	<10%	2.85	438.728
	10-25%	10.133	
	25-40%	28.174	
	40-70%	155.238	
	>70%	242.333	
Semi Evergreen Forest	<10%	26.783	879.43
	10-25%	52.014	
	25-40%	155.043	
	40-70%	468.454	
	>70%	177.136	
Moist Deciduous Forest	<10%	199.309	1251.15
	10-25%	226.083	
	25-40%	254.395	
	40-70%	571.362	
Dry Deciduous Forest	<10%	44.493	694.423
	10-25%	315.425	
	25-40%	200.751	
	40-70%	133.754	
Others		980.48	
Total			4244.21

Extent of Encroachment

A total of 12.13 % of reserved forests in Shimoga district are encroached as per 2010 satellite data. The area of reserve forest boundary were mapped based on 1968 SOI topomaps, with a total forested area of 2331.81 km^2 the extent of encroachment is identified as 282.92 km^2 , 257.27 km^2, 192.43 km^2 and 37.40 km^2 for 2010, 2000, 1990 and 1975 with the variation of 12.13 %, 11.03 %, 8.25 % and 1.60 % respectively (Table 3). The encroachment has considerably increased from 1.60 % to 12.13 % between 1975 and 2010. The majority of encroachment appears to have taken place during 1990 and 2000 (Figure. 2). This is mainly due to unauthorized occupation and cultivation as per Section 4 of the Karnataka Forest Act, 1963. The encroachment is majorly found in Shikaripur, Sorab and Shimoga taluks with the less reserve forest highest encroachment is in 2010, with an weighted average percentage of 31.25 %, 27.86 % and 14.31 % respectively and the following forest types are moist deciduous, evergreen and semi-evergreen type. The forests encroached by the villagers are subjected to hacking. Unsystematic felling and mal treatments in the past have completely changed the dense nature of the forests with better growth to poor, open and scrubby type. Most of the places have been found to be devoid of good and sound timber which has been cut and removed in the past without strictly following the principles of silviculture. The southern and eastern portions represent the degraded type of forests with almost mixed species with trees having no proper form and shape. Small bamboo has in most places invaded the areas. Encroached forestland is being used for extension of cultivation has caused considerable damage to the forests. The total encroachment to the forestland in Shimoga district is 282.92 km^2 as on 2010 satellite image. The forests of Shimoga district, particularly the deciduous and scrub forests are subjected to uncontrolled and unrestricted grazing. This has caused loss of regeneration and degradation of forests. Also overgrazing has rendered most of these forests unproductive.

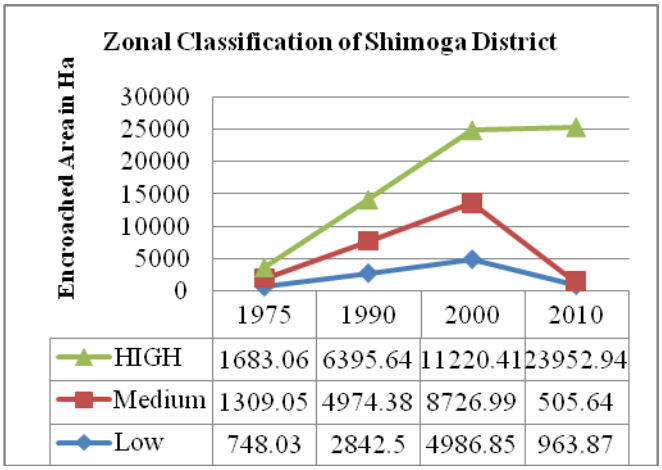

Figure 3: Zonation Classification of Forest Encroached Area in Shimoga district for the Year 2010, 2000, 1990 and 1975.

Table 3: Taluk wise Forest Encroachment in 1975, 1990, 2000 and 2010 in Shimoga 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	%	Area	%	Area	%	Area	%
1	Sorab	Evergreen to semi evergreen	1148.5	229.17	18.7	50	71.1	36.93	77.6	30.16	78.81	27.86
2	Shikaripur	Moist Deciduous	912.21	241.71	9.2	24.5	34.82	18.1	71.09	27.63	88.41	31.25
3	Sagar	Evergreen to semi evergreen	1934.58	494.83	0.7	1.9	22.7	11.8	27.74	10.78	30.49	10.78
4	Shimoga	Evergreen to semi evergreen	1114.37	464.62	7.5	20	38.43	19.97	39.87	15.5	40.47	14.31
5	Bhadravthi	Scrub Forest	689.71	232.13	0.4	1.2	11.71	6.08	22.99	8.94	24.13	8.53
6	Hosanagara	Evergreen to semi evergreen	1429.16	357.14	0.5	1.3	8.15	4.23	9.24	3.59	10.68	3.77
7	Thirthahalli	Evergreen to semi evergreen	1253.79	312.18	0.4	1.1	5.56	2.89	8.74	3.4	9.93	3.51
	Total		**8482.32**	**2331.81**	**37.4**	**100**	**192.43**	**100**	**257.27**	**100**	**282.92**	**100**
	Percentage				**1.52**		**7.8**		**10.43**		**11.47**	

The encroached forest area categorized under high class (i.e., area > 10 ha) for all the three decades (i.e., 1975-90, 1990-2000 and 2000-2010) and it is evident that the ratio of small, medium and larger encroachments have almost increased year by year. In the year 2010, the encroached area that is categorized under small, medium and large classes are 963.87, 505.64 and 23952.94 ha respectively as shown in the (Figure 3).

Conclusion

Encroachment is more prevalent in the moist and dry deciduous forests than the evergreen forests. The forests are no longer looked upon as mere revenue earning resources but are mainly recognized for their role in ensuring the environmental stability and ecological balance, vital for sustenance of all life forms. To improve and maintain natural and man-made forest structure and growth in non-degraded reserve forest area is essential for sustainability of forest production. The forest encroachment in Shimoga district was assessed for the year 1975, 1990, 2000 and 2010 and accordingly it was delineated that the rate of forest encroachment was maximum during transition period from 1975 to 1990 followed by 1990 to 2000. It is observed that the forest encroachment have considerable increased from 1.52 % to 11.47 % from 1975 to 2010 and the majority of encroachment was observed in 1990 and 2000. Extension of cultivation is the major cause of large-scale encroachment in the district. There is no proper demarcation of the forest boundaries in some places. This has also resulted in encroachment of forest land. It is also likely that some of these encroachments are on account of forest lands being granted by Revenue Department to land less people. There are instances where Revenue records have not been updated after forests were notified and Revenue department continued to grant from these lands treating these as Revenue lands. It is therefore very important to ensure that the Revenue records are updated so that no grants are erroneously made by the Revenue department from out of forest lands. Thus Forest, being the major biological investment of the earth system and its contribution and influences reaching all other sub-system, its management has an pervasive ramification. The role of forestry and their influence on global prospect has been stressed for maintaining ecological balance.

Acknowledgement

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

Reference

[1] Ali, M., (2003). Scientific forestry and forest land use in Bangladesh: A discourse analysis of people's attitudes. International Forestry Review, Vol-3, pp. 214–222.

[2] Asian Development Bank. (2002). Country Assistance Plans – Bangladesh: III. Sector Strategies. http://www.adb.org/documents/caps/ban/0301.asp

[3] Benhin, J., (2006). Agriculture and deforestation in the tropics: a critical theoretical and empirical review, Ambio, Vol-35, Issue-1, pp. 9-16.

[4] Capistrano, A.D., and Kiker, C.F., (1995). Macro-scale economic influences on tropical forest depletion. Ecological Economics.

[5] Center for International Forestry Research. Annual Report (2010), (CIFOR 2010). Focus on forest Time to Act. www.cifor.cgiar.org

[6] Gokhale, Y., (2004). Reviving traditional forest management in Western Ghats: Study in Karnataka. Economic and Political Weekly, pp3556–3559.

[7] Hemanjali A. M., Pramod Kumar G. R., R. K. Somashekar and B.C Nagaraja.(2014)., " Assessment of forest

encroachment in Chikmagalur district of Western Ghats using RS and GIS" International Journal of Remote Sensing & Geoscience, 3(6), pp 31-35.

[8] Hirakuri, S.R., (2003). Can Law Save the Forests: Lessons from Finland and Brazil. CIFOR, Bogor, Indonesia.

[9] 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.

[10] Karnataka Forest Department (2003). Working plan of Shimoga forest division, Karnataka State Forest Department, Government of Karnataka, Bangalore.

[11] Karnataka Forest Department (2003). Working plan of Sagar forest division, Karnataka State Forest Department, Government of Karnataka, Bangalore.

[12] Landell Mills, N., and Porras, I.T., (2002). Silver bullet or fools' gold. A global review of markets for forest environmental services and their impact on the poor. IIED, London.

[13] 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).

[14] 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

[15] Rasheed, K.B.S., (1995). Participatory forestry as a strategy for reforestation in Bangladesh. Geo journal, 37(1), pp39-44.

[16] 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

[17] Salam, M.A., T. Noguchi and M. Koike. (1999). The causes of forest cover loss in the hill forests in Bangladesh. Geo. J., 47, 539-549.

.