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Estimation of Tropical deforestation and Prediction of Biotic pressure zone for effective Forest management in Eastern Ghats of India

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Abstract

The tropical habitats, one of the most species rich and diversified formations on earth, face extensive loss of forest cover due to anthropogenic pressures. Precise inventory and monitoring using remote sensing and GIS, to estimate and monitor these anthropogenic factors is the need of the hour. This study comparatively analyses the specific forest habitats on Shervarayan hills, Eastern ghats of Tamil Nadu India for its forest cover changes due to anthropogenic pressures that have occurred in a decade (1999 to 2009). Buffer zones are generated for road network, villages and overlaid on vegetation type map. Based on their significant influences, the vegetation communities that are prone (risk zones) to the anthropogenic activities are accessed. It is reported that around 4358 ha. of dense forest and 7243 ha. of open forest area are severely degraded. While on the other hand there is an increase of 6670 ha. of scrub area. Similarly deforestation rate is high in buffer zones comprising roads (250 m) and foot paths (100 m) respectively. It is also reported that 7143 ha. is under low risk zone followed by Moderate risk (421 ha.) and high risk zones (1034 ha.). The study provides us with ideal and concrete information on deforestation and also gives inputs for better management of forest resources under anthropogenic pressure in future.

Keywords: Tropical forests, vegetation, deforestation, impact analysis, biotic pressure, GIS, remote sensing, conservation management.

Introduction

Loss of biodiversity in the tropics and its effect on the global climate and human lifestyles is an established fact[1-3]. Understanding and mitigating the impact of ever increasing population and rising global economic activity in the tropical forests are one of the great challenges currently faced by the biologists, conservationists and policy makers[4]. The tropical forests are currently disappearing at an overall rate of between 0.8 to 2.0% per year[5]. The loss of the natural forest and habitat[6-8] especially due to anthropogenic pressures[9-11] has led to their fragmentation[12,13] in the tropical countries. The ensuing fragmentation of the forest stands may eventually accelerate the extinction of the local plant/animal species[14,15] in the future. In Asia and Pacific region, the human population heavily depends on the fuel wood to meet its energy needs, and the only major sources are the natural forests and consequently are one of the major contributors to forest degradation[16].

To avert the possible loss, the creation of protected areas is believed to be a key strategy to combat deforestation and curtail loss of terrestrial biodiversity[17]. Even after decades of establishment of thousands of protected areas covering millions of hectares, there is inconsistent assessment of deforestation rates inside and outside these protected areas. Various conservation strategies to contain these ecological disasters have been implemented and monitored worldwide[18] to a positive extent, yet the efficiency and success of these measures towards wholesome protection vary and fall short of such expected results, thus demanding a more efficient strategy/policy base, and in some cases extending worldwide. Therefore best alternate would be to obtain precise information about the spatial distribution of virgin forest (area extent) stands and at the same time assess its rate of deforestation using Geographical Information System (GIS) .This would be followed by estimating the impacts of habitat destruction and fragmentation of biological diversity[19-21] in the deforestation prone zones.

In India, the dense forest cover of 46.55 million hectares from the total forest cover of 71.03 million hectares in 1972-73 has now drastically reduced to 36.71 million hectares from the total cover of 63.34 million hectares in 1993-95[22]. It has estimated the annual forest cover loss in India to be 2,708 km^2/year[23] and the extent of loss also includes the forest stand of the Eastern Ghats. The forests of the Eastern Ghats having lower altitudes (300-1700msl) than the Western Ghats are ecologically more diverse than that on the Western Ghats, but for unknown reasons neglected in spite of its ecological status. Comparatively the human and livestock influences on the forest cover are more rampart than the Western Ghats resulting in a heightened rate of deforestation. This present study analyses the extent of deforestation and livelihood influences.

The influence of various biotic pressures exerted on the forest cover/stand estimates the zones of biotic pressure spatially. The study also investigates the deforestation risk prone vegetation communities, by employing GIS tools.

Methodology

Study Area: The Shervarayan hills occupying an area of 469.9 km^2, forms a part of the Eastern Ghats of Tamil Nadu and are located in the northern part of Salem district, South India. The hills lie between latitude 11° 43′ 00″ to 12° 00′ 00″ N and longitudes of 78° 00′ 00″ to 78° 22′ 30″ E (figure-1). Red loamy soil and lateritic and archaean crystalline rocks like amphibolites, leptinites, garnetiferous granites and charnockites are characteristic of these areas. Bauxite and Magnesite are the chief mineral resources in the Shervarayan hills. There are 71 villages administered by Yercaud (67 villages) and Omalur (4 villages) taluks of Salem district. The hill has 49% of its area under forest and rest of the area (51%) is build up land (especially in the Plateau) region. The estate owners had encroached into the adjoining virgin forests on the plateau to make way for the coffee plantation. The rest of the plateau is covered by agricultural fields, which are mainly owned by the native tribal population. The remnant forest stands i.e. on the outer slopes and the fragmented pockets on the plateau are protected (Reserved Forests i.e. RFs) by the Indian Government and administrated by Salem Forest Division.

Analysis of Forest type/Density and forest cover changes: For assessing the changes in the forest cover, IRS 1C, P6 FCC digital data of 1999 and 2009 were used respectively. Optimum care was taken to have a common area on the resulting data set.

The IRS LISS III digital data was geometrically corrected using GCP (Ground Control Points) collected from the SOI (Survey of India) topomaps and GPS (Global Positioning System) readings collected from the field and further, the images were radiometrically enhanced using histogram equalization tool, available in ERDAS imagine 8.5 software. The rectified and enhanced digital data were interpreted for forest cover type and crown density (>40% dense, 10-40% open, <10% scrub). The classification was done based on onscreen visual interpretation of the False Color Composites (FCC) displayed on the computer screen at the scale of 1:50,000 for forest crown density[24]. The reserved forest boundaries are extracted/digitized from the topomaps and drafted on the displayed FCC.

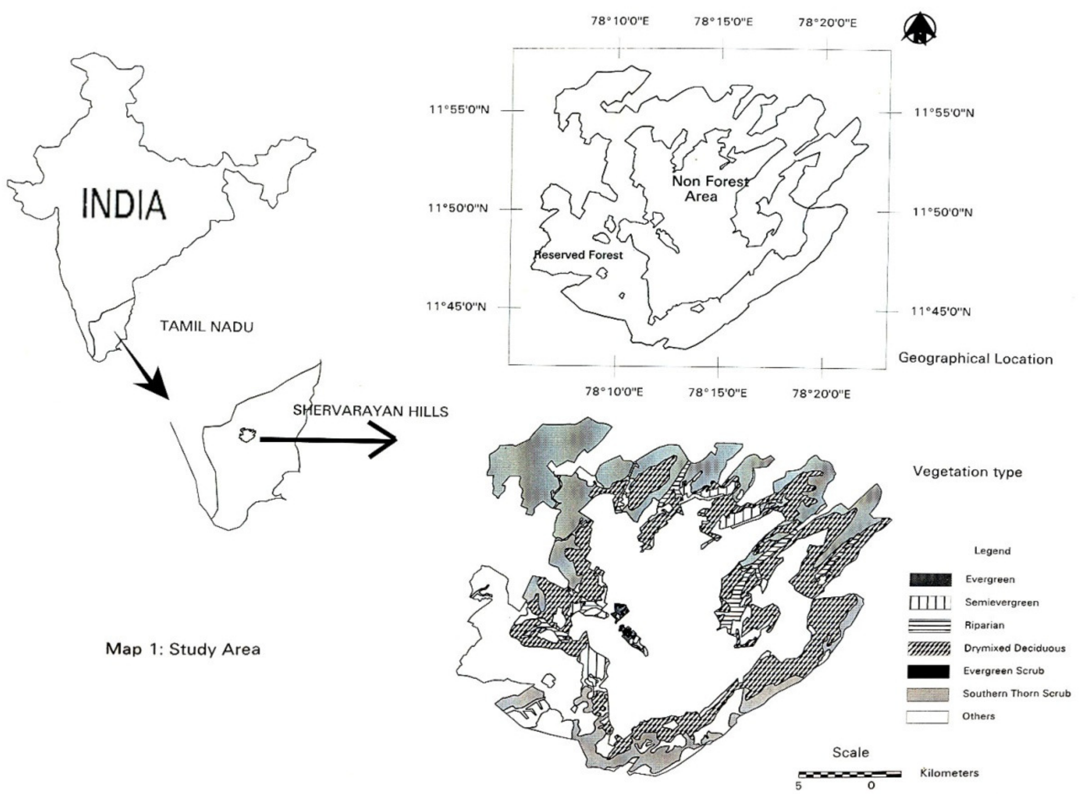

Figure-1
Study area location Map – Shervarayan Hills

The forest cover maps pertaining to the years 1999 and 2009 were crosschecked for any eventual spatial boundary errors and promptly rectified. The uniformity in attribute classes was maintained to ensure accuracy i.e. to minimize any probable factors of error if any. Later, these 2009 forest density maps were overlaid on forest density map of 1999 and the resulting forest cover changes were demarcated based on the respective forest classes. These changes thus identified were assigned the forest classes as for 2009 and the final forest cover changes extracted to produce a new map.

Impact of Anthropogenic pressures on forest cover change: The area of road network (metalled, unmetalled and footpath) and villages were extracted from the SOI maps to generate village and road network buffer zones which were used to analyze the influence of biotic pressure on the surrounding forest cover i.e. to determine the likelihood impact of the proximity of roads, villages on the adjacent natural forest and the changes they inducted to the forest cover. Buffer zones and quantification of the forest cover changes were carried out using ERDAS imagine 8.5 software, which manage both raster and vector data. The buffering was designed based on potential approaches to the adjacent forest stands i.e road networks, foot path or village area. Likewise roads have many footpaths on their fringes transversing into the forest up to 1000m. These footpaths normally connect a hill village to the foothills and are extensively used for transportation of agricultural goods by the hill tribes as they are short cuts whereas the roads are circuitous. The major footpaths have many crisscrossing branches interconnected on the entire hill stretch hence; the study restricts itself to a buffer of 200m on such major paths. Nevertheless the complex network of footpaths (generally) gives a picture of potential vulnerability of the forest cover owing to anthropogenic pressures. Initially a data layer with buffer zones of 250, 500, 750 and 1000 m were generated running parallel to road network (metalled and unmetalled). Secondly, another data layer was generated which consisted of the buffer zones (100m and 200m) on the surrounding footpaths arising from the road network. Finally, third data layers comprising the buffer zones (500, 1000 and 1500 m) around village boundaries were demarcated for these data layers to quantify the forest cover changes for each buffer zone.

Vegetation communities Assessment: Vegetation type map (1999) of the Shervaryan hills[25] is used which covers nearly half of the hill area i.e. 49.50% (ca 23261 ha.) under the category of reserved forests comprising about six major forest types i.e. evergreen, semi-evergreen, riparian, dry mixed deciduous, southern thorn scrub and evergreen scrub (figure-2). This is followed by villages with 17917 ha. (38%) and forest plantation with 5813 ha. (12%).

The importance of the vegetation types is weighed and classified, based on the influence of the biotic regimes. The vegetation types, which are affected by the roads, villages and footpaths, were identified by superimposition of the respective vegetation maps and the vegetation classes were regrouped according to their weight classes. Overlaying of these maps on one another yielded deforestation ranges i.e., probable high, moderate and low risk areas, which were later cross checked by ground truthing for accuracy assessment.

Results and Discussion

Forest density and land cover change: There were 103 polygons (1999) initially drafted using IRS 1C LISS III, which eventually increased to 125 polygons (2009) while juxtapositioning with IRS P6 LISS III data. It is a clear indication of increased forest fragmentation in the respective classes. Based on the percentage of the crown cover, categories such as dense, open, scrub and forest plantation were delineated along with the themes like villages, barren rock/land, encroachment and water bodies. Dramatic negative changes are observed in dense and open forest area (figure-3, table-1). The dense forest cover shows a loss of 70.98%, predictably the open forest too depicts the same trend with a loss of 38.55%. The area under scrub forest has summarily expanded to 70.53%. This trend reflects the ensuing loss in deciduous forest covers, and the eventual gain in the scrub forest cover. This is an indication of severe degradation of the hilly terrain over the decades (20 years in the case). Added to this factor, there has been a steady encroachment into the forest which amount to 65.85% (119.29 ha.), an illegal encroachments of the coffee estates into the adjacent forest land. The area classified as barren land has also increased by 35.8% (316.20ha.).

To arrest the trends of deforestation, the forest department has tried to reduce the loss by introducing effective strategies with plantations. As a result, there is an addition of 4224.35 ha. (70.24%) to the pre-existing plantations. An area of water body as seen in 1999, which had been used for irrigation, has now been covered with forest plantation (2009), which could be attributed to the eventual drying up of the water source over the years. The forest conversion factor has to a great extent affected the local ecology as mentioned above. Around 4356 ha. of dense forests have been converted into open forest and of which 48 ha. has been encroached upon by the surrounding coffee estates. The dense forest has also been converted to scrub forest (161.45ha.) due to indiscriminate felling of trees and thus claimed by the fast intruding scrublands. In some areas, open forest too is further degraded by the invasive species such as *Lantana camera, Eupatorium divergens* (20 ha.). Yet there is a small positive change ie. an increase in the open forest area due to the forest plantation (3824 ha. which includes 487 ha. of the scrub forest). However it is also noticed that open forest areas also include the sun exposed lands (ca.316ha.) due to severe soil erosion.

Impact analysis- Road network buffer on forest cover: The major road network buffer zone data layer, which is overlaid on the forest cover map, depicts areas of dense and open forests. They show a decline of 61.1% and 67% respectively within

250m buffer zone of the roads. The dense and open forests also have registered a decrease and on the other hand the scrub forest exhibits an increase with every class of buffer zones.

Projection of footpath buffer zones with forest cover has indicated that within the 100m buffer zones, there is a maximum decrease in the percentage of dense forest (65.9%) and a conspicuous increase of scrub forest (92.3%), forest plantation (37.7%) and open forest (13.955) area. It means that dense forest has decreased and other forest cover categories have increased especially in the 200m buffer zone (table-2).

Table-1

Changes in forest cover and other land cover areas of Shervaryan hills as derived from IRS satellite images

Categories	**Year of study**		**Difference in forest area**	
	1999 (IRS 1C)	**2009 (IRS P6 LISS III)**	**(in hectares)**	**(in percentage)**
Dense	6139.25	1781.34	-4357.91	-70.98
Open	19308.40	12065.02	-7243.38	-38.55
Scrub	2870.82	9541.69	+6670.87	+70.53
Forest plantation	1588.85	5813.20	+4224.35	+75.24
Barren rock/Land	566.70	882.72	+316.02	+35.80
Encroachment	111.33	230.62	+119.29	+65.85
Mining Dump	47.34	318.09	270.75	79.31
Water body	31.81	-	-	-

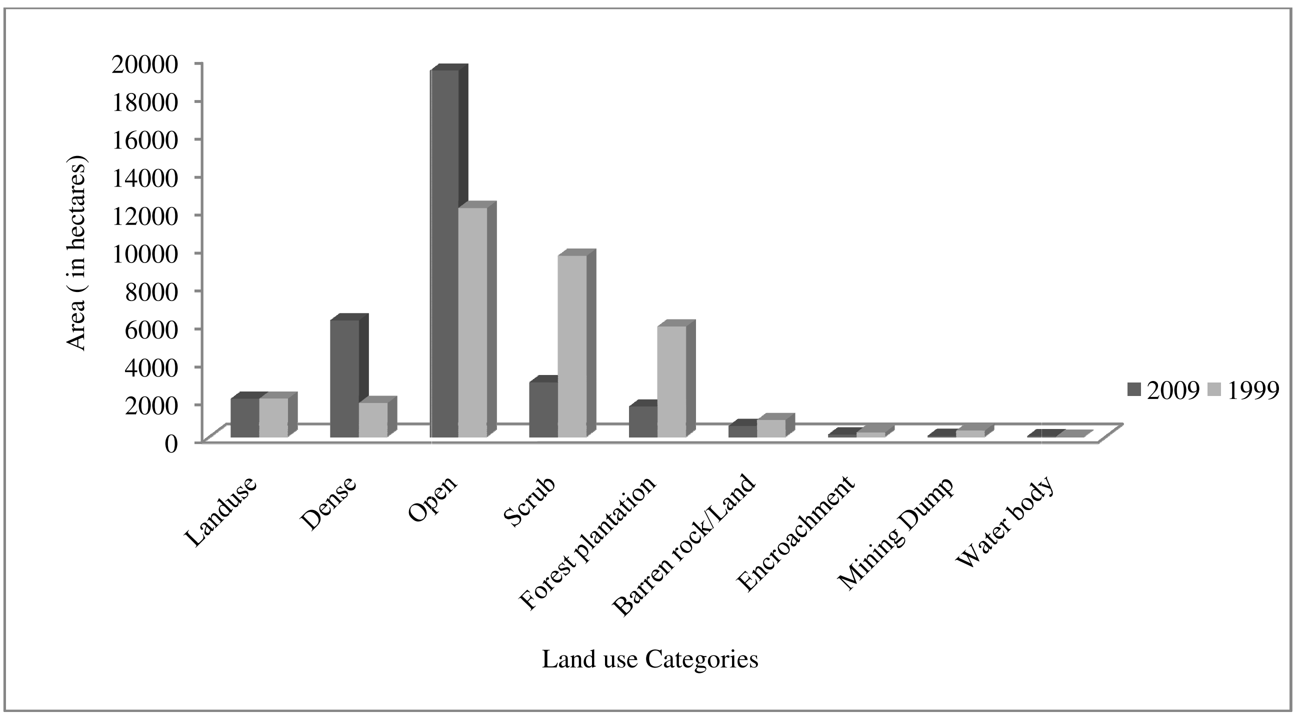

Figure-2
Changes of different land use categories between 1999 to 2009

Impact analysis-Village buffer on forest cover: Coincident data were generated to correlate the changes in forest cover in Shervarayan hills pertaining to the buffer zones of villages (including the coffee estates). The area of forest cover loss has increased in 1500m buffer zone (75.27%) and decreased in 1000m (64.06%) and 500m (56.88%) buffers respectively (table-3 and 4). In contrast, scrub and forest plantations have shown an increase in all the buffer categories. Reforestation efforts by the forest dwellers i.e., the tribal villagers have added significantly to the spread of manmade forest cover, which is a positive approach and can be effectively and encouragingly emulated to the remaining scrub lands in future. As discussed before there remains the instance of rampart encroachment, which falls under the 500m buffer zone, is a problem needing intervention by the government. In general, much of the dense forest has been degraded and converted into open forest and extending even into the scrub lands. This invariably point out the only known reason i.e., an easy access created by network of roads and other pathways.

Table-2
Influence of villages on forest cover changes

Forest cover/ year	Area by buffer zone (in hectares)								
	500 m			750 m			1500 m		
	1999	2009	Changes in%	1999	2009	Changes in%	1999	2009	Changes in%
Dense	2194.86	946.33	-56.88	1837.00	660.03	-64.07	707.76	174.97	-75.28
Open	3260.48	3721.72	+12.93	4151.15	3666.06	-11.68	2974.20	1526.86	+48.66
Scrub	47.71	461.24	+89.65	190.86	1017.91	+81.25	278.33	1383.72	+79.88
Forest plantation	182.90	556.67	+67.14	254.48	1089.48	+75.65	222.67	1097.43	+79.91

Table-3
Influence of roads on forest cover changes

Forest cover/year	Area by road buffer zone (in hectares)											
	250 m			500 m			750 m			1000 m		
	1999	2009	*C in %	1999	2009	C in%	1999	2009	C in%	1999	2009	C in%
Dense	429.43	167.0	-61.11	381.71	174.95	-54.16	310.14	191.06	-38.39	349.91	246.53	-29.54
Open	1288.29	413.52	-67.91	898.62	373.76	-58.41	707.76	373.76	-47.19	874.76	469.19	-46.36
Scrub	71.57	477.14	+85	71.57	198.81	+64	95.429	79.52	-16.67	127.24	119.29	-6.21
Forest plantation	230.62	962.24	+76.03	151.09	755.48	+79.96	127.44	596.43	+78.63	103.38	620.29	+83.26

* C = Changes in percentage

Table-4
Influence of footpath on forest cover changes

Forest cover	Area by buffer zone (in hectares)					
	100 m			200 m		
	1999	2009	% of changes	1999	2009	% of changes
Dense	461.2390	157.0960	- 65.94	214.715	63.6192	- 70.37
Open	493.0490	572.5730	+ 13.88	182.358	254.477	+ 28.34
Scrub	15.9048	206.7620	+ 92.37	16.452	79.509	+ 79.30
Forest plantation	55.6668	89.4288	+ 37.75	7.952	23.872	+ 66.69

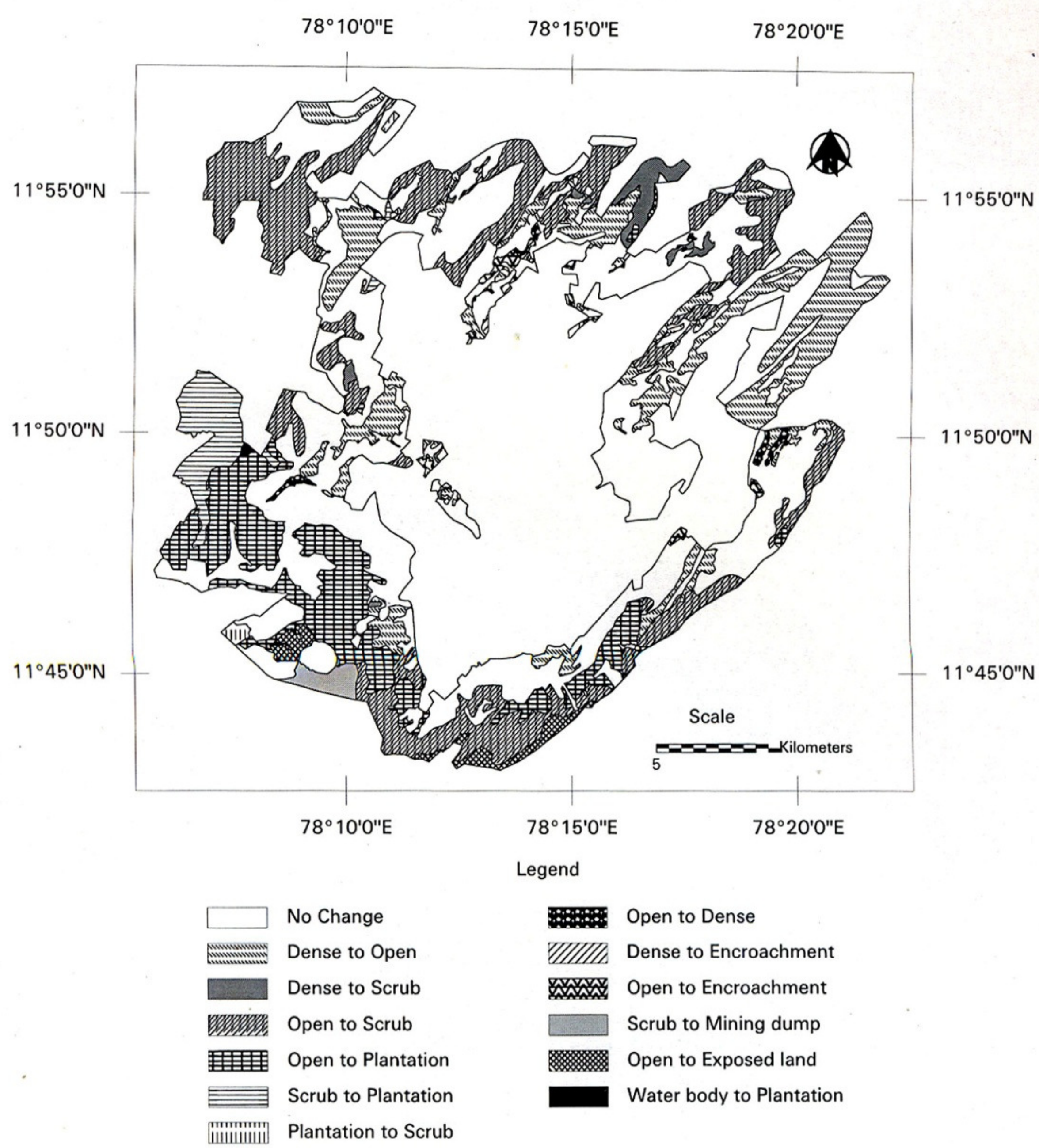

Figure-3
Forest Cover Changes over a period

Deforestation critical risk zones: The analysis of the anthropogenic pressure exerted on forest types shows that an area of about 1033.81 ha. of the vegetation communities have high risk of potential degradation, 421.477 ha. of moderate risk and 7143 ha. with low risk (figure-4). Having defined features at risk and perhaps the causes of these circumstances, our attention turns to using this information to formulate new strategies for protection of these reserved forests. Identification of potential deforestation risk zones will help in their protection from occurrences of further degradation. A distinction must be drawn between threat and priority, for conservation action and priority setting, which may embrace oth er factors in addition to threat. There is a need for some balance to be stuck between strategies for preventing those features which are apparently more secure at present from becoming less so [26].

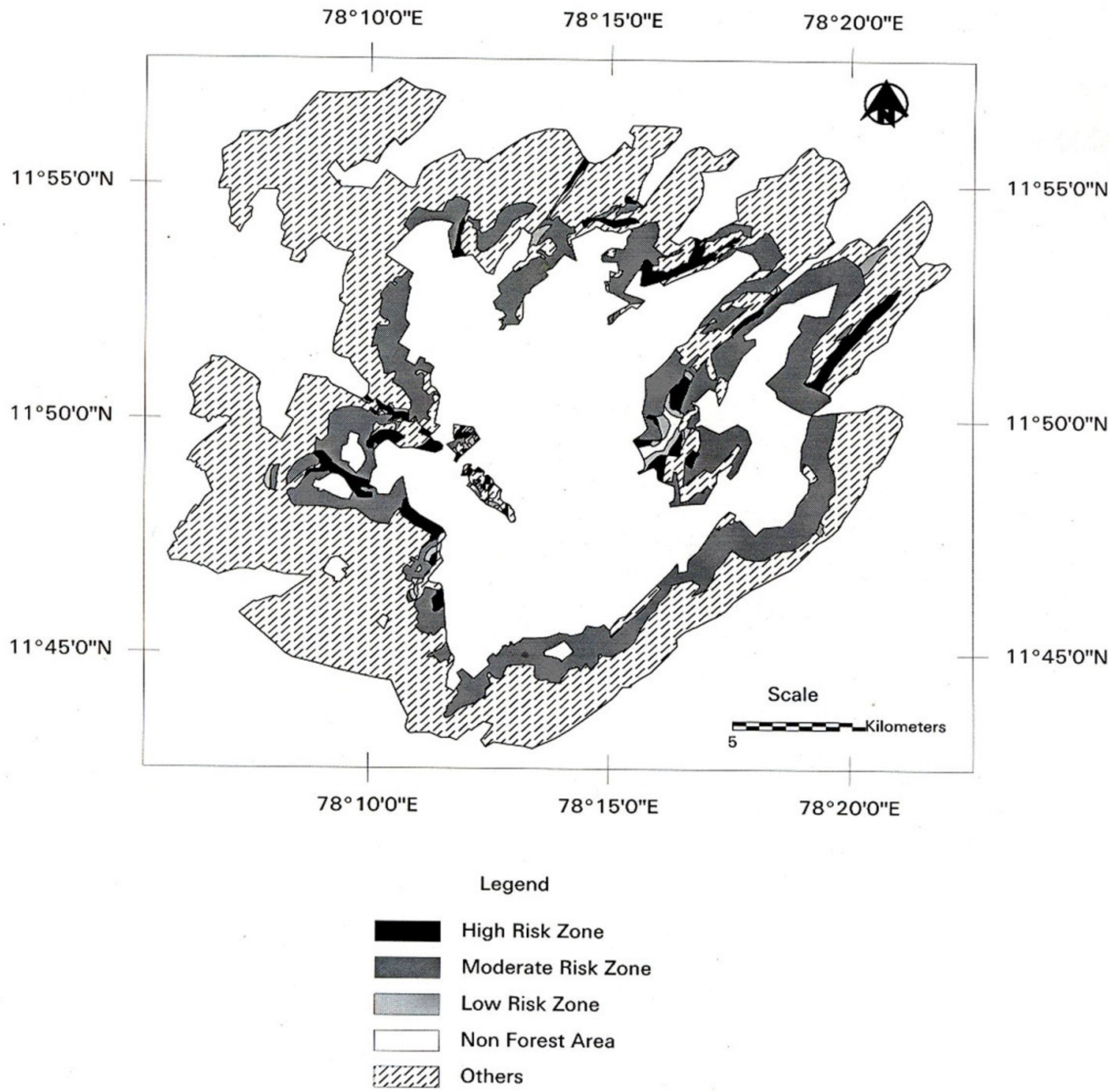

Figure-4
Vegetation Community Risk Zone

Conclusion

The present study is in confirmation to the fact that the forest cover is getting depleted at alarming rate, endangering the habitat because of severe human exploits. The government sponsored forest plantation has been successful to some extent in restoring the green cover in some of the degraded area on the fringes of the Shervarayan hills. Still most of the forest sites are constantly under threat from severe human pressure and are degrading alarmingly endangering the habitat and ecosystem as a whole. Humans have effected great negative changes in the distribution and composition of plant communities and also have contributed to the altered habitat types. Road network opens timber extraction routes and causes further deforestation. The forests vulnerable to human exploitation provides the base information for developing new strategies for sustainability and conservation. Conservation of forest from further degradation should advocate an alternate approach to protected area management that would integrate forest conservation with social development. Deforestation has to be discouraged by formulating tribal security and people oriented joint management schemes. One such sustainable approach; Agro forestry has the potentialities to solve specific land-use problems and sustain the people with fuel and fodder requirements. Moreover, agroforestry is more suited to poor farmers, who have fewer or no prospects of adopting high cost technologies. The systematic plantation, exclusively for raising high density, short rotation fuel wood or energy plantation can be a viable strategy to reduce the anthropogenic pressure on the natural forests. Thus by adopting this approach, both the forest and the community dependent on the forests are effectively benefited.

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