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ASSESSMENT OF SPATIAL AND TEMPORAL CHANGES IN FOREST USING GIS AND REMOTE SENSING TECHNIQUES: A CASE STUDY OF SANGMESHWAR TALUKA, MAHARASHTRA, INDIA

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ABSTRACT

The present study has been conducted to assess the spatial and temporal changes in forest cover of Sangmeshwar taluka in Maharashtra. The temporal satellite images 1989, 1999 and 2009 have been obtained from the USGS and Bhuvan. The supervised image classification method has been followed for the identification of the existing forest cover and temporal changes their in. The result of analysis shows that, spatial covers of forest in the study have been increased slightly but the areas of dense forest have been decreased while scrubs and sparse forest have been increased. The result of temporal changes depicts that, the transformation of dense forest to scrubs and sparse forest is high during the decade 1999 to 2009 than 1989 to 1999.

KEY WORDS: Forest Cover Change, Remote Sensing, Temporal Analysis, Image Classification

INTRODUCTION

The forest ecosystem plays a vigorous role in the preservation of the ecological healthiness of the earth. The forests play an important role in the biospheric energy flow as well as proper operation of the geo-bio-chemical cycles. The destruction of forests leads to destabilize these processes. The maintenance of the soil biome on which, agriculture and food supply is depend, intimately related to the forest ecosystem (Shafi, M., 1992). In the protection of quantity and quality of the soil and water, forests play significant role. In India, in the last few decades deforestation is going on at very fast rate (Saxena, H. M., 2007, p. 82).

The human activities upturn the loss of forest cover at an alarming rate, which may affect ecological, social and economic processes including extinction of biotic communities. The study of deforestation in tropical biodiversity hotspots like Western Ghats (WG) is important, because of its rich biodiversity and a high concentration of globally endemic species. It has been evaluated that, in recent decades the biodiversity of this region have been declined with the march of time. As noted by Patil 2012, the quantity and quality of the forests have been declining in the region, which would adversely effects on the environmental conditions and leads to environmental degradation that ultimately leads to negative environmental change.

The invention of space born remote sensing technology has been increased the efficiency of change detection analysis, especially the spectral bands obtained in the region of red and infra-red have been greatly used to assess of vegetation changes. Remote Sensing has been a valuable source of information over the course of the past few decades in mapping and monitoring forest cover change (Bhatia, S. C., 2008, p. 378). The sustainable forest management at various levels can be attained with the help of remote sensing. India is one of the leading countries in the development of the Geo-Spatial technology, where several studies have been done for change detection using remote sensing data. The remote sensing technique only provides the data of the land surface, so there is the need of GIS and GPS techniques for the analysis and associate the data with the earth surface. Therefore, the study has been conducted to analyze the forest cover change of the Sangmeshwar Taluka over twenty years with the help of above said techniques, and the result of the study can be used to suggest the comprehensive plan for the sustainable management of forest resources in the study area.

2. STUDY AREA

The present study has been done for Sangmeshwar Taluka of the Ratnagiri District, which covers the geographical area of 1275.5 km^2. The study region is part of the Western Ghat, which house, rich fauna and flora

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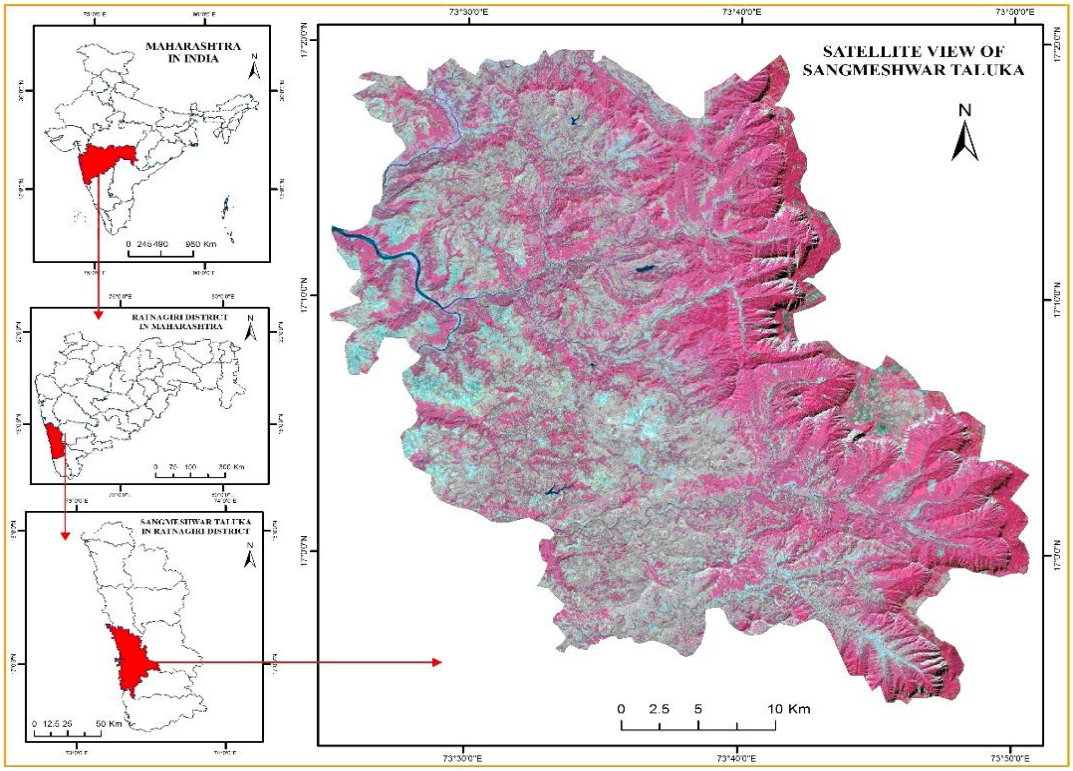
within it. Chiplun Taluka surrounds the study region in the north, Ratnagiri Taluka in the west, Lanja Taluka in the south, Kolhapur, Sangli and Satara districts are east. The geographical extension of the region is between 16^{O} 54' 15.98" and 17^{O} 19' 55.54" latitude and between 73^{O} 24' 52.59" and 73^{O} 50' 38.1" longitude (Fig. 1). The altitude of the Taluka is ranges between from 1 and 1038 meters from Mean Sea Level. The east-west length of the study region is 32 km while north-south width is 40 km, in an average. The population of the study region is 1, 98, 343 persons, according to 2011 census, with 198 villages and a town.



Map 1: Location of Study Area

3. METHODS AND MATERIALS

The present study has been conducted through the satellite images, which downloaded from the concern websites namely Landsat TM for the year of 1989, Landsat ETM+ for the year of 1999 and LISS III for the year of 2009. The Landsat images have been downloaded from Global Land Cover Facility and LISS III image has been downloaded from ISRO's Bhuvan. The Garmin's Oregon 550 GPS has been used for ground verification and accuracy assessment of classification.

The collected satellite data have been manipulated and analyzed in popularly known Erdas Imagine 9.1. The supervised classification method has been used to find out existing forest cover of the selected years from satellite data and then the change detection tool in the software has been used to find out the forest cover changes between the selected years. Then the processed final classified data in Erdas have been exported to Arc-GIS for the numerical analysis and final preparation of maps.

4. ANALYSIS OF YEAR WISE EXISTING FOREST COVER

The analysis of existing forest covers has been done for selected three years. The methods mentioned above have been followed for the analysis and the results have been classified spatially into four groups based on the density of forest, such as Dense Forests (DF), Moderate Forests (MF), Scrubs & Sparse Forests (SSF) and Non-Forest Area (NFA). The detailed discussions of existing forest cover in study region for the selected years are discussed below.

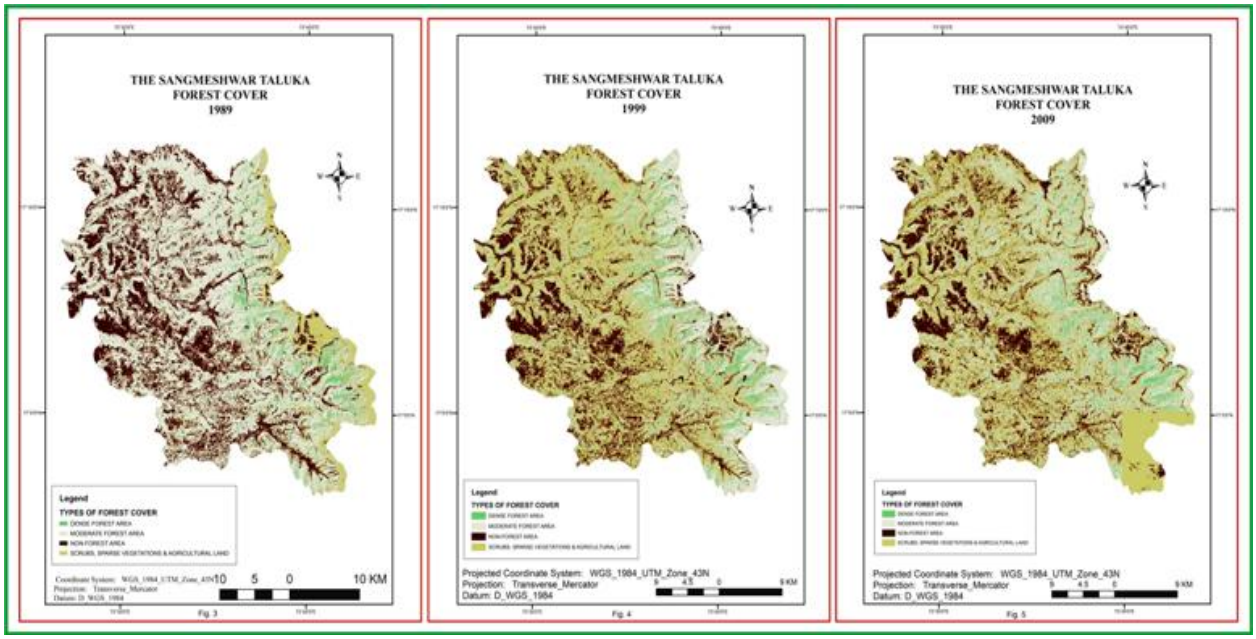
4.1 FOREST COVER IN 1989

The analysis of forest cover in the year 1989 depicts that, 72.19 per cent of geographical area of the Taluka had been covered by forest, in which 3.47 covered by DF, 57.10 covered by MF and 11.62 covered by SSF. The overall result of 1989 forest cover validates that, in this year, MF had covered vast geographical area followed by SSF and DF.

Table 1: Spatial Extension of Existing Forest Cover in Selected Years							
Sl. No.	Classification of Forests	Years					
		1989		1999		2009	
		Area (Km^2)	Area (%)	Area (Km^2)	Area (%)	Area (Km^2)	Area (%)
1	Dense Forest (DF)	43.86	3.47	80.69	6.38	49.21	3.89
2	Moderate Forest (MF)	722.64	57.1	227.15	17.95	245.83	19.42
3	Scrubs and Sparse Forest (SSF)	147.07	11.62	656.43	51.87	682.72	53.95
4	Non- Forest Area (NFA)	351.9	27.81	301.21	23.8	287.81	22.74
Source: Analyzed by Researcher							

4.2 FOREST COVER IN 1999

The result of forest cover in the year 1999 represents that, totally 76.20 per cent of geographical area in Taluka had been covered by forest area, which was 4.01 per cent higher than the total forest cover of the year 1989. In this year, DF covered 6.38 per cent of land, MF covered 17.95 per cent of land and SSF covered 51.87 per cent of land. Undoubtedly, this denotes the decreased geographical area in MF and slightly increased area in DF. While vast geographical area increased in SSF.



Map 2: Existing Forest Cover

4.3 FOREST COVER IN 2009

The assessment of existing forest cover in the year 2009 shows that, totally 77.26 per cent of area had been covered by forest, which was higher by 1.06 per cent than the year 1999 and 5.07 per cent higher than the year 1989. The classification of result into four groups exposes that, DF had covered 3.89 per cent of area, MF had covered 19.42 per cent of area and 53.95 per cent area had been covered by SSF. This clearly proves that, DF had been decreased by 2.49 per cent while MF and SSF had increased by 1.47 and 2.08 per cent respectively.

The overall result of existing forest cover denotes that, the area under forest cover in the study region has been increased slightly, but the density of forest has been decreased, which can be openly seen from the increasing area under SSF. The area under SSF in the year 1989 was 11.62 per cent, it had been increased to 53.95 per cent in the year 2009, that means the area under DF and MF has been decreased and converted into SSF. Finally, result shows the degradation of DF and MF cover, so it is necessary to take proper steps to sustain and increase the healthy forest in the Taluka. If the present scenario continues, in the future it would make a severe problem in the ecological balance in the Taluka.

5. TEMPORAL CHANGES IN FOREST COVER

The temporal changes in forest cover have been analyzed after the completion of identifying existing forest in the Taluka. The result of selected year's existing forest area has been used to find out the temporal changes in it. As mentioned in the methodology the change detection tool in Erdas has been used to find out the overall changes of forest cover and the overlay analysis in ArcGIS has been used to find out the changes between selected four classes. The temporal analysis of forest cover changes have been done between 1989 - 1999 and 1999 – 2009, the detailed report of change detections between selected years are given below.

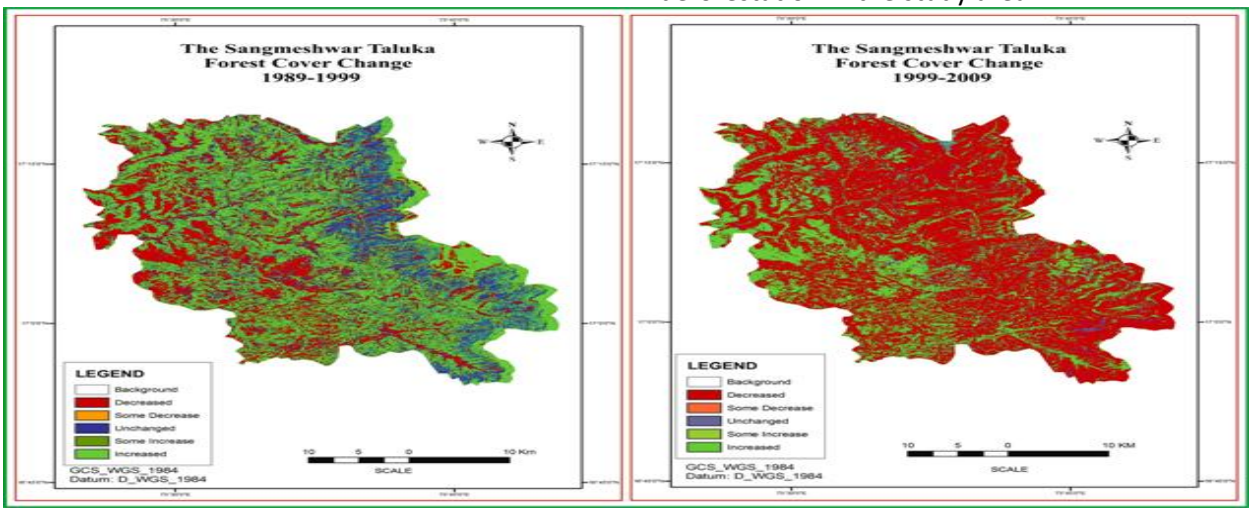
5.1 OVERALL CHANGES BETWEEN 1989 and 1999

The result of overall temporal changes between 1989 and 1999 represents that, areas having higher elevation are remain without much changes and experienced little increase in forest cover. This must be due to the inaccessibility of human beings in this region. The lower altitude areas in the eastern side have been witnessed high decreasing of forest cover, which might be caused by the exploitation of forest areas by the increasing population. The spatial pattern of changing result depicts that, the forest cover has been decreased highly along the riverbanks, areas in the vicinity of transportation network and low elevated areas while increased at the high-elevated and inaccessible areas. It is observed that the low lands had higher accessibility and connectivity as compared to uplands. By the analysis of the spatial pattern of forest cover change in the decade, it is clear that the areas adjacent to national highways and other roads are worst affected by the deforestation. The overall results illustrate that the deforestation in the decade was caused by the development of transportation and interferes of human on the low elevated areas.

5.2 OVERALL CHANGES BETWEEN 1999 and 2009

The analysis conducted to find out the overall temporal changes between 1999 and 2009 represents that, vast areas of forest have been decreased in overall while very few places have been increased. The rate of forest decrease is massive in this decade when it compared with the previous one, so the need of field survey is necessary to find out the reasons behind it. Therefore the field visit has been conducted in the study area, through which it has been observed that, there are vast area of forest cover has been cleared for the transportation and communication network. It also has been witnessed that, the total number of sawmills in the study region are sixteen. In spite of this, every day around six trucks of timbers have been transported to the other parts of the country. Out of that sixteen, ten saw-mills have been opened in this decade which clearly shows the increasing amount of cutting trees in the region. The areas near Vanzole, Kurli, Kundi, Belari, Devale, Murshi, Tulsani, Kinjale, Shrungarpur, Aaravli, parts of Amba Ghat, etc. have been experienced worst deforestation in this decade. The newly developed stone crushing industries at the hilly areas also one of the major reasons for the decreased forest cover in the study area. The stone crushing industries are clearing the forest cover for grinding the mountain as well as the dust particles which comes out from the grinding mills also affect the health of forest around it.

The development of GAIL gas pipeline project also caused the decreasing of forest cover in the study region, the GAIL gas pipeline is passing through the study region for the 56 km. The trees along the pipeline have been cut around 08 meter wide and 56 km length (an average the concerned authority cut around 18000 trees during the GAIL project), which also one of the reasons for the deforestation in the study area.



Map 3: Overall Changes in Forest Cover

5.3. CLASS WISE CHANGES BETWEEN 1989 and 1999

The analysis of class wise forest cover change in the study area during 1989-1999 deacde, depicts that the area under DF and SSF is increased by 84.01 and 346.59 per cent respectively whereas the area under MF and NFA is decreased by the 68.58 and 14.41 per cent respectively while 62.71 percent DF remained constant.

Table 2: Class Wise Forest Cover Change (1989-1999)

Sl. No.	Change To → / From ↓	Dense Forest		Moderate Forest		Scrubs and Sparse Forest		Non- Forest Area		Total	
		Area	%	Area	%	Area	%	Area	%	Area	%
1	Dense Forest	27.49	62.71	10.43	23.79	5.17	11.79	0.75	1.71	43.84	100
2	Moderate Forest	41.64	5.76	141.85	19.63	484.72	67.09	54.27	7.51	722.48	100
3	Scrubs and Sparse Forest	8.91	6.06	69.19	47.08	52.23	35.54	16.62	11.31	146.95	100
4	Non- Forest Area	2.63	0.75	5.55	1.58	114.15	32.45	229.46	65.23	351.79	100
5	Total	80.67	6.38	227.02	17.95	656.27	51.88	301.10	23.80	1265.06	100

Source: Calculated by the researcher

37.29 percent DF area changed its position to MF, SSF and NFA and it was 23.79, 11.79 and 1.71 per cent respectively. It is attention grabbing to note that during 1989-99 decade, only 19.63 per cent area of the MF was remain unaffected and 5.76, 67.09 and 7.51 per cent area of the MF is encroached by the DF, SSF and NFA correspondingly. Majority of the SSF positively changed to moderate forest (47.08 per cent). Very little area of SSF has transformed to DF (6.06 per cent) and NFA (11.31 per cent). During 1989-99 decade, 35.54 per cent SSF area continued in the same class. It is noteworthy that out of total NFA, 0.75, 1.58, and 32.45 per cent area has transformed to the DF, MF and SSF respectively. Table-2 and Map -4 denote information of class wise changes in forest cover in the study region. The total of the class wise forest cover area given to right side of the table depicts the facts for the year 1989 whereas total given at the bottom of the table provides data of the total forest cover in the year 1999.

It is clear that the overall class wise change is towards positive side, during the decade. It observed because of the limited human influence due to limited connectivity and accessibility. It is also interesting to note that during the decade majority of the population of the region was migrated towards the metropolitan city like Mumbai; this is also one of the causes of positive change in forest cover during the said decade.

5.4 CLASS WISE CHANGES BETWEEN 1999 and 2009

During 1999-209 decade the study region has recorded unreasonable class wise change in the forest cover. It is heartining to note that during 1999-2009 decade, the area under DF is decreased by the 38.90 per cent. The area under MF and SSF is increased only by 8.26 and 3.93 percent individually. The NFA is decreased by the 4.37 per cent.

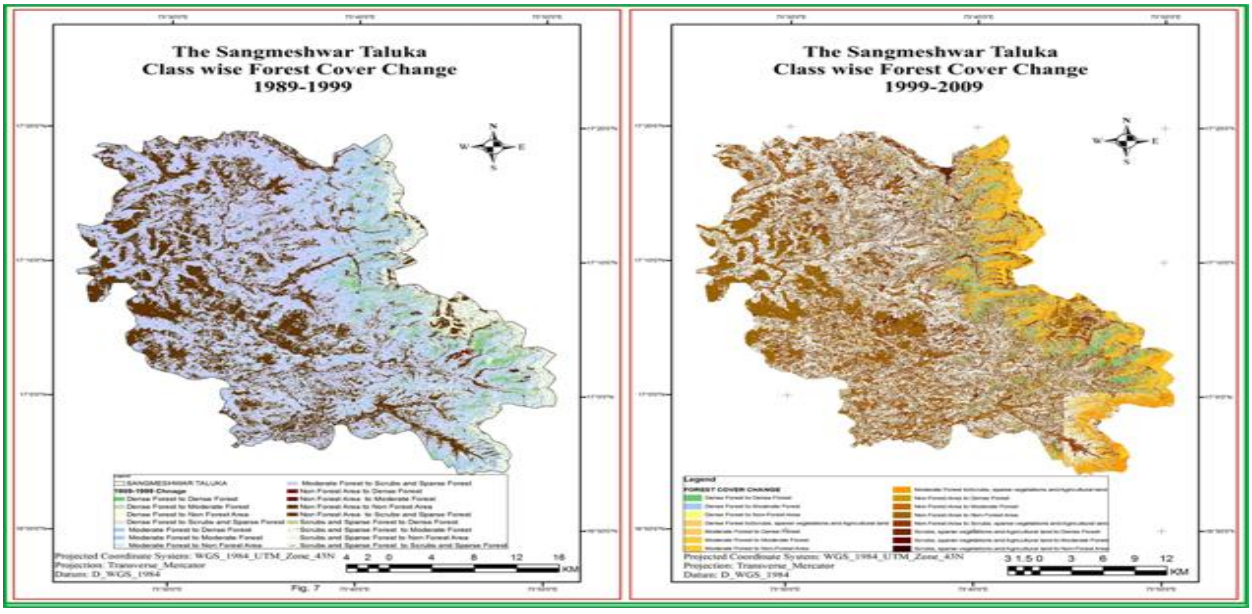
Table 3: Class Wise Forest Cover Change (1999-2009)

Sl. No.	Change To → / Change From ↓	Dense Forest		Moderate Forest		Scrubs and Sparse Forest		Non- Forest Area		Total	
		Area	%	Area	%	Area	%	Area	%	Area	%
1	Dense Forest	29.87	37.04	32.97	40.88	17.00	21.08	0.81	1.00	80.65	100
2	Moderate Forest	10.98	4.84	87.34	38.49	116.44	51.32	12.13	5.35	226.89	100
3	Scrubs and Sparse Forest	7.72	1.18	120.90	18.42	455.42	69.40	72.23	11.01	656.27	100
4	Non- Forest Area	0.71	0.24	4.43	1.47	93.17	30.97	202.50	67.32	300.81	100
5	Total	49.28	3.90	245.64	19.42	682.03	53.93	287.67	22.75	1264.62	100

Source: Calculated by the researcher

Only 37.04 per cent DF continued in the same group, during 1999-2009 decade. Utmost DF transformed to the MF, SSF and NFA and it is 40.88, 21.08 and 1.00 per cent respectively. It is striking to note that during 1999-2009 decade, 51.32 per cent area of the MF transformed to the SSF due to increased human intervention. Out of the total area at the beginning of the decade, only 38.49 per cent area is remained unaffected whereas 4.84 and 5.35 per cent area of the MF encroached by the DF and NFA correspondingly. Around one-fifth of the SSF exalted to MF (18.42 per cent) and DF (1.18 per cent). During 1999-2009 decade, 69.40 per cent SSF remained steady and 11.01 per cent area degraded to the NFA. It is noteworthy that out of total non-forest area, 0.24, 1.47 and 30.97 per cent area upgraded to the DF, MF and SSF correspondingly. The table-3 and Fig. 4 provides inclusive information regarding the class wise forest cover change during 1999-2009 decade.

The overall class wise change is towards negative side, during the decade. It observed because of the increased human influence, development in connectivity and accessibility, immigration in the region, developmental projects, increased No. of sawmills, etc.



Map 4: Class wise Changes in Forest Cover

6. FINDINGS AND RECOMMENDATIONS

The population explosion, extension of agriculture, growing need of fuel wood, developmental projects, forest fires, industrialization and urbanization have necessitated in an irresponsible destruction of forests in many parts of the world and the study region is also not exception to this. The study region has also experienced deforestation at the devastating rate. The followings are the major findings of the present research work.

1 It proved during the course of investigation that the Geo-Spatial Technology (GST) plays very substantial role in forest cover change analysis. The researchers could demarcate very micro regions of covers that they could not be able to locate manually.

2 The study revelas that, during the dacade 1989 to 1999 high elevated areas have not changed much while increased little. In the lower altitude parts there are few pockets where there is no change in forest cover and an increase or some increase observed in some pockets. Over all majority of the forest area was remained constant during 1989-1999 decade, with few exceptional pockets in the eastern part of the study region. This is because of the limited encroachment of the human and human activities in the region due to inaccessibility of the region.

3 It authenticated through the remote sensing data that the area, which was not affected during 1989-1999 decade was worst affected during 1999-2009. Majority of the parts experienced decrease and some decrease in the forest cover and very little parts experienced increase and some increase in forest cover. It happened due to the developmental projects like GAIL gas pipeline, development of timber industries, increasing use of fuel wood, transportation network, urbanization, population explosion, increased trade of the timber, etc.

4 It is clear that the overall class wise change is towards positive side, during the 1989-1999 decade whereas, the overall class wise change is towards negative side, during 1999-2009 decade.

7. RECOMMENDATIONS FOR CONSERVATION OF FORESTS

In developing countries, the landscape surrounding agricultural and residential area is significant for the maintaining biodiversity and conservation of forests. Forests of the study region provide a full suite of goods and services to the farmers and to the others engaged in primary activity. The Sangmeshwar taluka is a part of the Sahyadri Mountain, which is one of the bio-diversity rich regions of the world. Variety of species of plants and animals are existing in the study region. The study region is the source of most significant medicinal and edible plants. Thus, the conservation of forests is essential for the preservation of bio-diversity and ecosystem. The conservation of forests will give birth to the sustainable utilization of the forest resources in the study region that will conserve the right of the future generation in the locality. Followings are some of the major recommendations for the forest conservation and sustainable development of the forests in the study region.

a) Creation of awareness and responsiveness among the people in the locality is the first indispensable footstep in the conservation forests in the study region. It will reduce the proportion of deforestation and will preserve the forests and related resources.

b) At the time of using firewood as a fuel, the care should be taken that the deforestation should not be beyond the self-regulatory mechanism of the forests. The people should cut only dead plant species.

c) The importance should be given on the use of non-conventional energy resources like, biogas, solar energy, etc.

d) The emphasis should be given on afforestation, reforestation agro-forestry, social forestry, farm forestry, etc. The funding should be provided for the plantation of medicinal plants and threatened plant species in the individual farm. Where deforestation is already took place, at that location fast growing species of plants should be planted, it will help to the fast recovery of the forests in the study region.

e) There should strict implementation of law and it should ban the timber and furniture industry in the region. The development of substitute industry should promoted by providing financial support and ancillary benefits. The alternatives for the timber should have utilized, for that purpose responsiveness should have created in every individual of the society.

f) At the time of giving permission to the developmental projects, the care should take that they will not affect the forests. If deforestation took place, the concerned developer should practice re-plantation of the same.

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