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SPATIO-TEMPORAL LAND USE/LAND COVER ANALYSIS OF MURREE USING REMOTE SENSING AND GIS

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Abstract

Land use land cover (LULC) patterns are significantly effecting the urban/rural spaces in the encompassing areas. Murree being tourist resort is always under pressure of tourists from all over the country. The population increase in peak season of tourism in summer season and extreme winter, causes a tremendous growth and expansion of urban area of Murree. So a relic of blue pine forest and Chir pine forest is expected to undergo tremendous change and to undergo expansion or degradation depending upon the tourist's behavior. The present study uses Multi-Temporal Landsat (TM and ETM+ for year 1998, 2003, 2005, 2010) images to detect LULC change in Murree due to the enhanced activities of ecotourism. Change detection of three tourist hotspots of Murree region including Murree Mall, Bhurban and Patriata was evaluated through Maximum Likelihood Classification (MLC) algorithm. The urban expansion has impacted the land use, as it has increased from 57.37% to 69.10%. Result indicates that the Built-up area have increased by 11.73%, reserve forest by 8.11% while grassland and dense natural forest decreases by 7.50 and 12.37 percent respectively. The results provided the better knowledge and understanding of former and current spatial dynamics of LULC change in Murree region along with its ecotourism hotspots.

Keyword: GIS/Remote sensing, land use/land cover, forests of Murree, ecotourism

1. INTRODUCTION

LULC dynamics are two fundamental factors that describe the environmental and economic condition of a country. It is essential for understanding the impact of natural and anthropogenic activities on environment that in turn leads to soil erosion, deforestation and global temperature rise (Dwivedi *et al.*, 2005; Mas *et al.*, 2004; Zhao *et al.*, 2004). Rapid growth of population coupled with industrialization, and unplanned infrastructure developments are altering the LULC patterns at large scale (Shukla *et al.*, 2014) especially in developing countries like Pakistan. Appropriate and precise detection of changes on earth's surface provides fundamental prerequisites for selection, planning and enactment of land related policies to meet the needs of burgeoning population, to monitor land use dynamics and for the management of natural resources (Rawat and Kumar, 2015). Comparison of two or more multi-source, multi-scale remotely sensed images provide important information for detection of land use/land cover dynamics (Hansen *et al.*, 2012). It is an essential tool for land management practices and meeting sustainable development needs.

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Murree is considered to be the most important tourist spot of Pakistan, however the region is facing severe environmental degradation due to population growth. Traditional methods of assessing land and forest cover are practiced from centuries but now such methods are considered to be laborious and time consuming as they are difficult to implement in complex topographic regions and in inaccessible areas (Ning *et al.,* 2015). Remote sensing and GIS provides useful information regarding spatio-temporal data of earth's surface (Ulbricht & Heckendorf, 1998). The information about any urban environment and built-up area can be acquired through high resolution satellite data at desirable spatio-temporal scale (Miller & Small, 2003). As urban environment exhibit spectral diversity, the spatio-temporal variability of a region is necessary to monitor the land use/land cover feature of a region (Maktav *et al.,* 2005). The varied land features, conversion of forest into built up areas and ongoing infrastructural changes to accommodate increasing population is affecting the local area at great pace. Monitoring such changes are necessary as they prove to be useful in decision making process (Anirban *et al.,* 2013). Many researchers have studied the dynamics of urban and forested spaces. Coppin *et al.* (2004) and Lu *et al.* (2004)analyzed the LULC of built-up extent by geo-spatial information technology. Singh (1989) describes that the change detection can be quantified through supervised and unsupervised approaches.**(**Bruzzone & Prieto, 2002) illustrates the unsupervised technique which utilizes raw imageries to evaluate change detection however the method is declared to be have some limitations. Adepoju *et al.* (2006) declared the supervised classification with maximum likelihood classifier (MLC) the most suitable one with reduced spectral confusion problem between some land use classes. He also describes that the post-classification method also describes "from-to" interpretation. It minimizes the problems caused by variation in sensors and atmospheric conditions (Shukla *et al.,* 2014). Jensen (1996)declares that the accurate classifications are imperative to insure precise land use/land cover patterns. The current research is designed to investigate the temporal and spatial land models of Murree region. Specifically the study will identify the spatial patterns of LULC, evaluate the extension of built-up area and resultant deforestation occurring in targeted region. Change detection analysis to determine forest cover loss, proportion of LULC and fragmentation over time and space enable us to generate visual representation of land feature transformation. The study also revealed the LULC patterns of tourism hotspots including Bhurban, Murree Mall and Patriata. The predicted changing trend in vegetation cover along with altered land patterns assist land planners in managing natural resources and conserving local biodiversity through sustainable strategies.

2. MATERIALS & METHODS

2.1. Study area

Murree is a famous tourist spot of Pakistan. It is among the major tehsils of Rawalpindi District. The tehsil Murree lies at 33° to 34°North latitude and 72° 42' to 73° 30' East longitude. It is situated along the Kohala high way 30 km North of Islamabad. Elevation of area is 2,291.2 m. It is a famous tourism spot and hill station of Pakistan. The area is important in having dense forest cover at high altitude that mainly includes chirr pine and blue pine forests. These forests not only provide firewood, timber and other benefits to local people but also act as water shed areas and tourist spots.

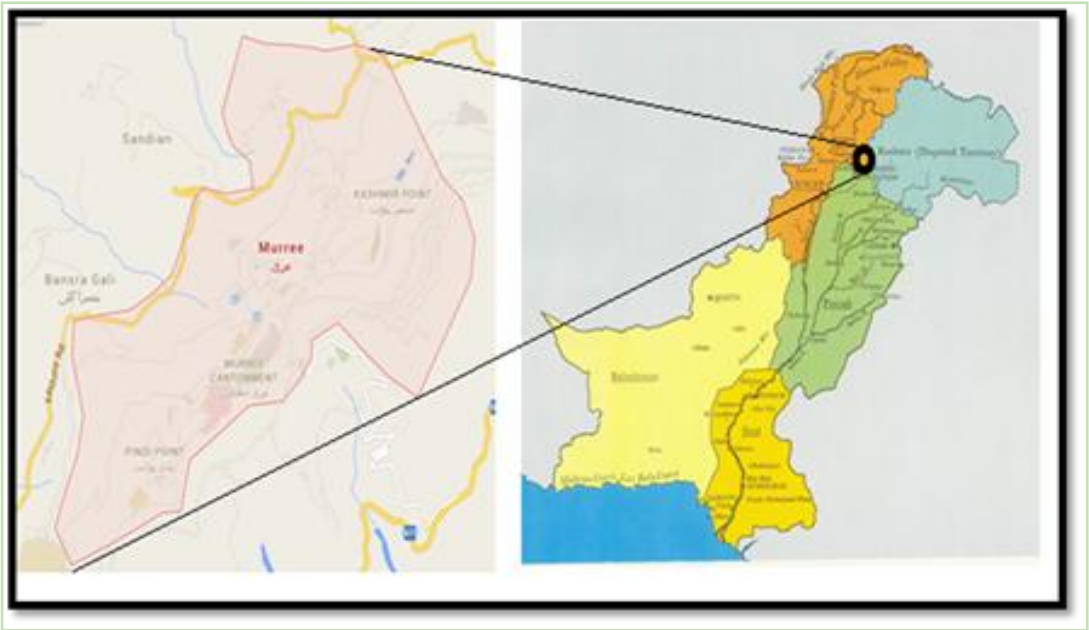

Figure 1: Map of study area

2.2. Data collection

The present study utilizes satellite dataset of Landsat 7 and 4 (TM and ETM+) over Murree region. Three images of Landsat 7 and one of Landsat 4 was downloaded to conduct the study. Images of 30m resolution was utilized to conduct quantitative analysis and dynamic changes of Land cover/use in Murree. USGS global visualization viewer (Glovis) was used to acquire data. De-striping to adjust incorrect brightness values was conducted. Layer staking was carried out to create the multicomponent image. The images were rectified to common coordinate system (Almas *et al.*, 2005). The images were masked to study area with the aid of Erdas 13 prior to classification. Histogram equalizer was applied to increase their brightness level.

Supervised classification with maximum likelihood classification (MLC) technique was conducted to classify the rectified images. Land cover consisting of dense natural forest, grasslands, built up areas and reserve forests were generated for the images of four years.

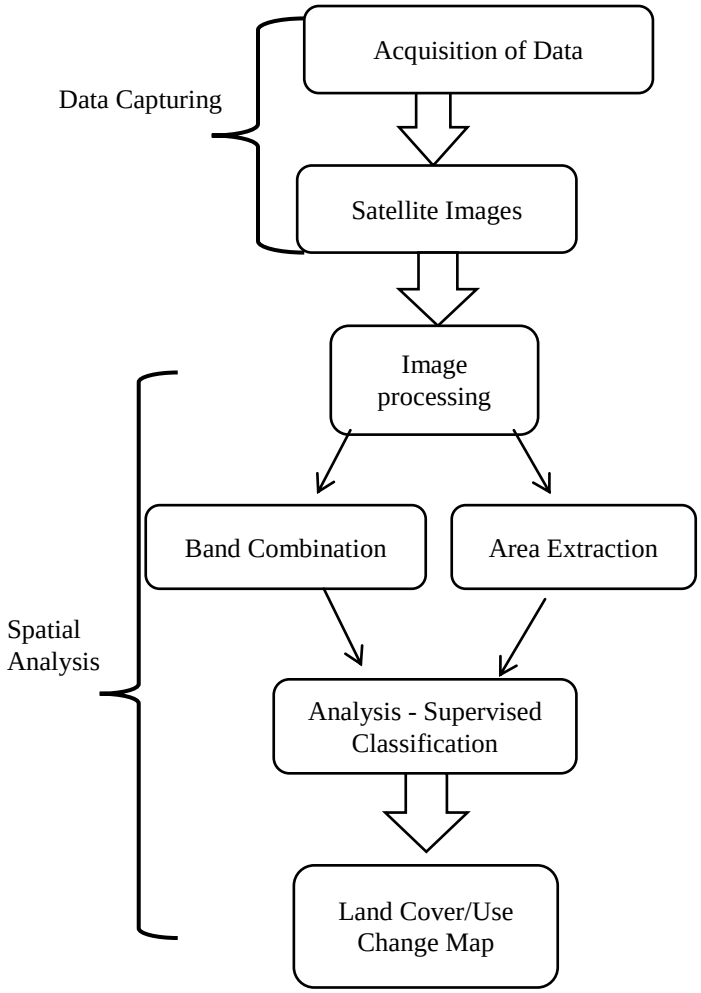

Figure 2: Methodology flowchart of work

Four LULC classes were identified in the images and used in the study namely Dense Natural Forest, Grasslands, Built up Areas and Reserve Forests. Ground verification was done by Google Earth for doubt full areas and for better interpretation & visualization purpose. Different band combinations were used in order to enhance the images for extraction of required information from the imageries of specified time scale. The second phase of Land cover/use analysis includes re-projection of the image. The statistics including total area and changed area of classified images were calculated using ARC-GIS Desktop 10.1. Tabular representation to present the stated result were adopted to compare the statistics obtained. Quantified results in form of land use/cover types, LULC change and district trends were analyzed and presented.

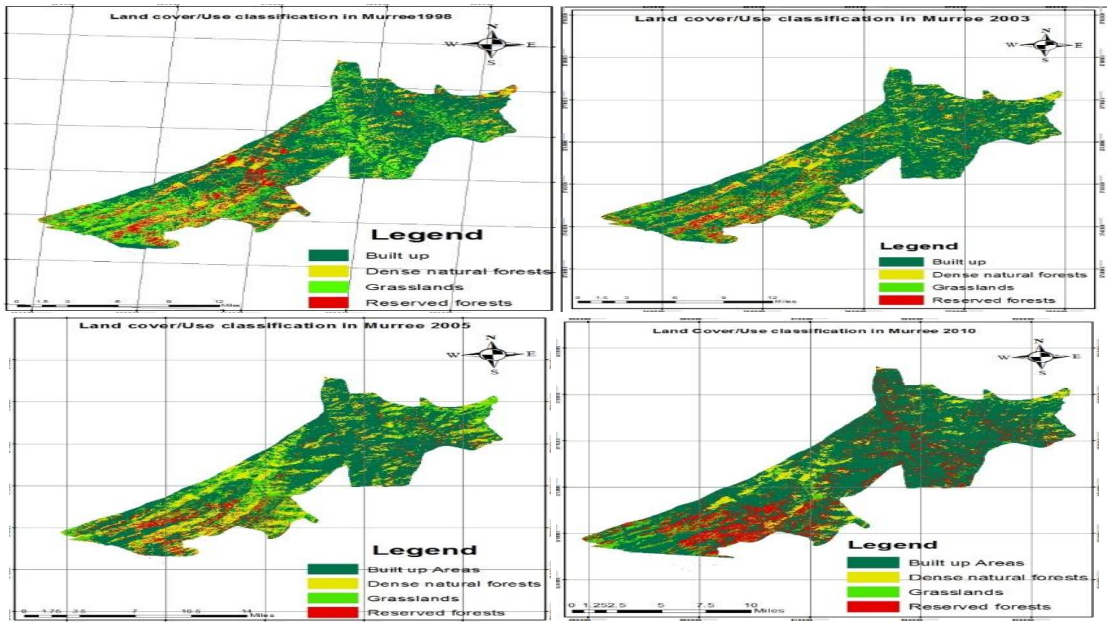

Figure 3: LULC map of study area

Table 1: Land Use/Cover statistics of Murree 1998-2010

Land-use Type	Area (ha)		Change Area	Growth (%)
	1998	2010		
Built-Up	36251.41	42792.188	6540.778	11.73
Dense natural forest	9504.34	4658.362	-4845.978	-7.50
Grassland	11354.22	3450.207	-7904.013	-12.37
Reserve forest	6124.35	11020.663	4896.313	8.11

Source: Authors' own calculations

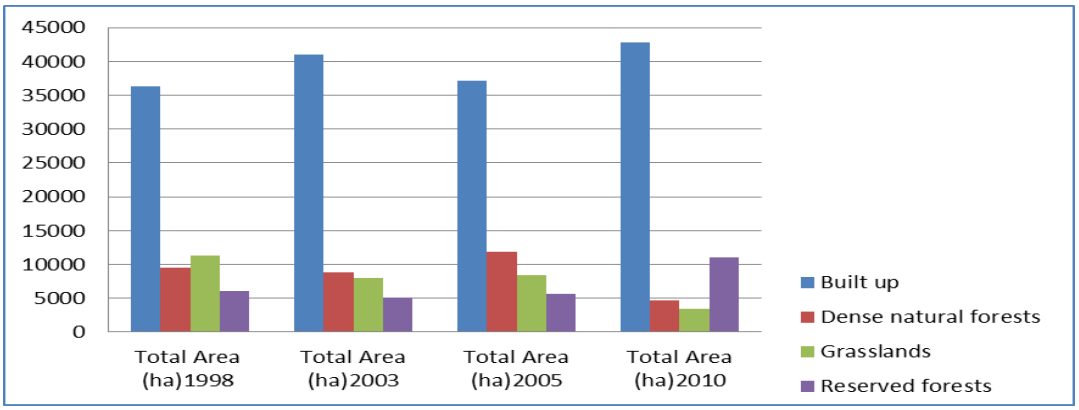

Figure 4: Land Use/Cover change of Murree 1998-2010

3. RESULTS

The research study employed the "supervised classification approach" to detect the land use/cover patterns, if classification was done using "coarse resolution satellite datasets" the presence of mixed pixels was encountered. After thorough study of the data, the Variables i.e. total area and changed

area to compute urban land use dynamics were adopted ultimately to acquire results. Results obtained highlighted the gain/loss coverage of land feature classes.

Image analysis revealed the increasing trend of build-up area and reserve forests while decrease in area occupied by dense forest and grassland recorded. Mainly the built up area has increased from 57.37% to 69.10% during study time. It's revealed that in 1998 area occupied by some dense forests, grasslands and reserve forests were subjected to continuous degradation. In the year 2003 built up area increased further i.e. 65.02 % of total area, that is due to population growth and increase in settlements.

However the constructed area shows downfall in year 2005 from 41043.43 ha to 37198.97 ha. During earthquake 2005, 40% of the houses were damaged and destroyed and land sliding was triggered out (IUCN) so the area shows the decreasing trend in built up area for year 2005. The results shows that two types of vegetation i.e. thick forests and grassland illustrate an increasing trend in their area coverage as a response to these climatic factors i.e. high precipitation and availability of optimum temperature from 2003 to 2005. In 2010 there is a vivid gain in the area occupied by settlements and decreasing trend is observed in the coverage of forest land cover class.

3.1. Murree mall

The study also revealed the land use/cover trend of three tourist hotspot of Murree, including Bhurban, Murree Mall and Patriata. Changes in form of built-up area and forested or grassland were calculated with respect to time and space. The result indicates the positive trend in built-up area while negative trend in all three classes (Dense natural forest, Grassland and Reserve forest) observed. Results obtained for Murree Mall indicates the negative and positive trend of land use classes. It is revealed that in the year 2003 built up area wasreally high i.e. 1114.08 ha that is 72.51% of the area due to the development of infrastructure. This land cover type increases from 1998 to 2003. As we know that there is a vivid increase in population in the concerned years so there is an increase in settlements to cater this increase in the population of this area. As Murree mall is the most commercialized area and tourism spot of Murree it is dominated by infrastructure to cater overwhelming thrush of tourists.

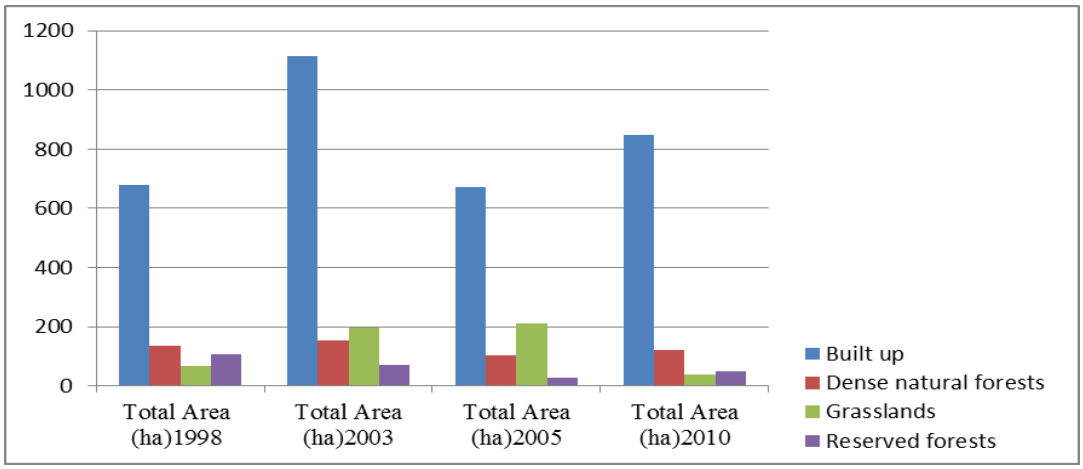

Figure 5: Land Use/Cover change of Murree-mall 1998-2010

3.3. Bhurban

Change occurring at Bhurban were also analyzed in the study. Figure 6 shows that there is a slight decrease in the area acquired for built material. In year 1998, about 545.553 ha area was covered that was 58.25 % of the total area, in 2003 and 2005, 422.38 ha and 380.62 ha of the area

respectively was built up while in 2010 this area increased at a faster rate i.e. up to 1197.992 ha i.e. 69.2 %.The decrease seems to be due to land sliding issue that was a consequence of earthquakes of low magnitude but after 2005 there is a clear increase in construction. The forest cover of the area also showed a random trend. In year 1998 thick forests used to cover 171.027 ha area (18.26%).

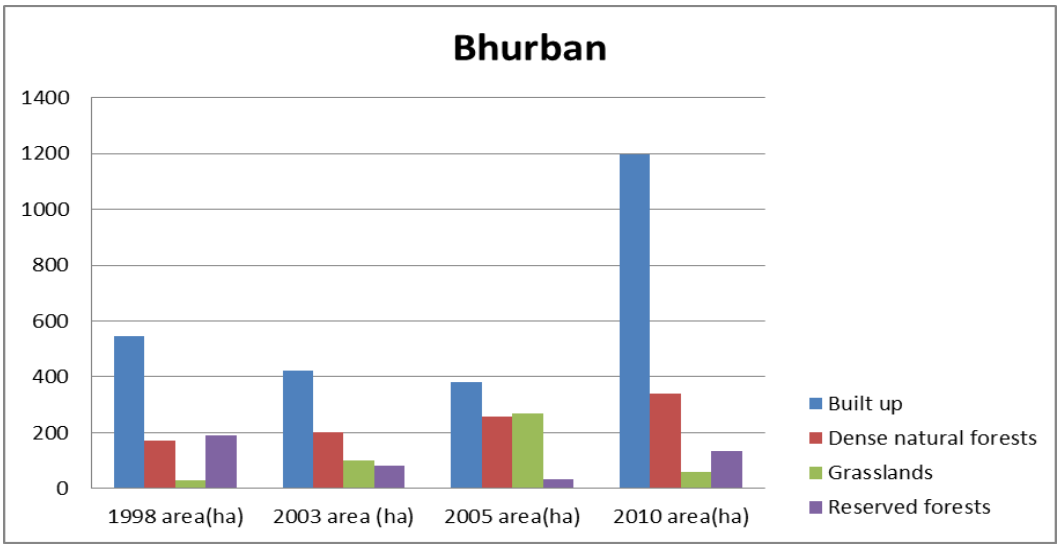

Figure 6: Land Use/Cover change of Bhurban 1998-2010

Table 3: Land Use/Cover statistics of Bhurban 1998-2010

Land-use Type	Area (ha)		Change Area	Altered (%)
	1998	2010		
Built-Up	545.553	1197.992	652.439	10.99
Dense natural forest	171.027	340.968	169.941	1.44
Grassland	28.28	58.0718	29.79	0.346
Reserve forest	191.69	132.942	-58.74	-12.78

In 2003 it decreased to 200.85 ha, in 2005 it increased further to 259.37 ha and in 2010 a decreasing trend was observed that is 340.96 ha was occupied by thick forests this kind of highly dynamic trend was result of various climatic factors that varied on irregular patterns.

3.4. Patriata

The situation of land use/cover trend in Patriata is minor as compared to other areas. The year 2010 shows a significant increase in grassland, reserved forests and dense natural forest area because in 2005 National Environmental Policy commits to increase the forest cover. Table represent then significant increase in built up area in 2010 that is 841.11ha (57.99%) but in the same year considerable increase in reserved forest is also observed. As the Pakistan poverty Reduction Strategy makes projection to increase forest cover from 4.8 to 5%. Built-up areas are more susceptible to land sliding as compared to vegetation so dense natural forests show increasing trend. As it is clear from the results that vegetation (both forests and grasslands) is showing an increasing trend from 2003 to 2005 in Murree even at all three tourism spots the same trend is observed so it verifies this point that during 2003 -2005 climatic conditions were quite favorable for the growth of vegetation as IUCN appraisal illustrates that rainfall rate was high during 2003 to 2005.

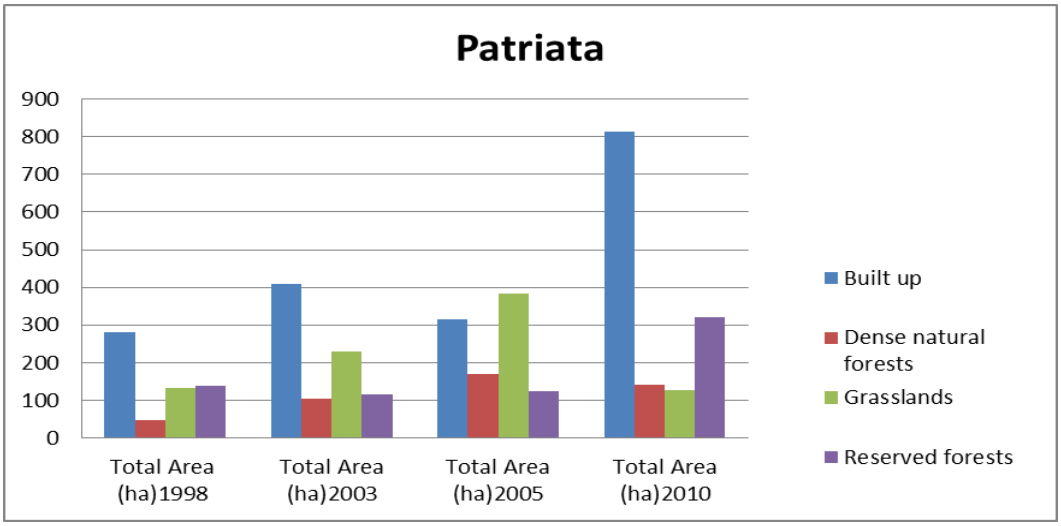

Figure 7: Land Use/Cover change of Patriata 1998-2010

Table 4: Land Use/Cover statistics of Patriata 1998-2010

Land-use Type	Area (ha)		Change Area	Altered (%)
	1998	2010		
Built-Up	281.170	814.115	532.94	11.29
Dense natural forest	47.98	140.205	92.22	2.08
Grassland	132.93	127.596	-5.333	-13.03
Reserve forest	138.76	321.782	183.2	-0.17

4. RECOMMENDATION

The data analysis depicts that changes in the distribution of various land cover classes directly or indirectly influence the productivity of precious forest reserves. The land use classes are very much related to each other i.e. uncontrolled and unplanned expansion or contraction on the land coverage of any class can impart positive and sometimes negative effects on the other, so there is a need of proper and pre planned strategies in order to cater these issues. As this study shows infrastructure build to entertain the hot issues of population rise and urbanization is causing serious problems for the local biodiversity residing nearby areas. The study encourages further research work in order to assess the change in the area occupied by different land feature classes i.e. dense forests, grasslands, built up area and reserved forests with respect to specified period of time along with the factors that trigger such changes.

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