GEOINFORMATICS TECHNIQUE ON LAND USE /LAND COVER AND CHANGE DETECTION ANALYSIS IN MULSHI TALUK OF WESTERN GHATS, INDIA

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Abstract:
The land cover of Mulshi taluk in Pune district over the last two decades, due to infrastructural development. Mulshi taluk in the Western part of Maharashtra encompasses the Western Ghats of India, which are one of the hotspots of biodiversity of the world. Over the last two decades, this area has seen many infrastructural changes urban develop along with the creation of lake cities, extension of highways leading to the coastal areas and development/sale of land. This increase in the urbanized area has put a strain on the water resources of Pune City. The objective of this paper is to detect the change in the land-use/cover of the Mulshi taluk and understand the drivers of change in the rural landscape. This study will help in identifying measures that need to be taken for sustainable development using geoinformatics. Post classification change detection has been performed between two images of the area from (1992 and 2011). The drivers of this were determined by field surveys and interviews with the local people. A future land cover scenario for the year 2020 has been predicted using Idrisi's Land Change Modeller (ILCM). The unplanned expansion of the built up areas into the surrounding parts will have a direct impact on the rural environment. The changes in agriculture indicate a trend towards a migration from traditional crops to cash crops like sugarcane.in other economically important crops in the study area.

KEY WORDS: Land use change detection / Land Cover, Mulshi Taluka, Maharashtra

1. INTRODUCTION

The land use, particularly over the past 50 years, has changed ecosystems more rapidly and extensively than in any comparable period of the study area. This has occurred as a consequence of rapidly growing demand on natural resources (Watson & Zakri 2003). It has resulted in degradation of the natural ecosystem functioning. Thus, to understand land cover and land use change detection analysis and process with its implication for environmental and ecosystem functioning, it is important to recognize the services provided by the natural ecosystems, and to come up with a sustainable land use plan. However, the study of the human impact on the environment and its functioning is a great challenge. The development of suitable and reliable indicators which can provide all essential information about the viability of a system and its rate of change and about how that contributes to sustainable development of the overall system is a key issue (Bossel 1999). Nowadays, this kind of assessment is greatly helped by the data provided by the modern earth observing systems. Remote Sensing (RS) techniques together with Geographical Information Systems (GIS) increase the capability to analyse the dynamic environment and human impact on the environment by using quantitative (hard number), qualitative (subjective valuation) and spatial form.

2. LOCATION AND METHODOLOGY

Land cover and land use maps for 1988, 1997 and 2007 were generated and compared statistically through a cross-tabulation obtaining an overall Kappa index of: 0.41 for 1988-1997, and 0.40 for 1997- 2007, meaning significant changes between the LCLU classes in the studied periods. The LCLU change assessment evaluating area gains and losses and net change in each LCLU class revealed a high dynamic state of the Huatanay watershed landscape, where most of the classes represented changes more than 50% in the studied periods. Most of the LCLU changes were caused by the human action.

Mulshi Taluka lies on Western part of Pune City, between the longitudes 73°19'25.07 E and 73°47'04.37 E, and latitudes 18°40'28.01 N and 18°21'28.98 N, having a total area of a little more than 1018 sq.km. The Western Ghats, which are one of the World's hotspots of biodiversity, are included in this taluka. Agriculture is practiced mostly paddy and sugarcane cultivation in the study area.

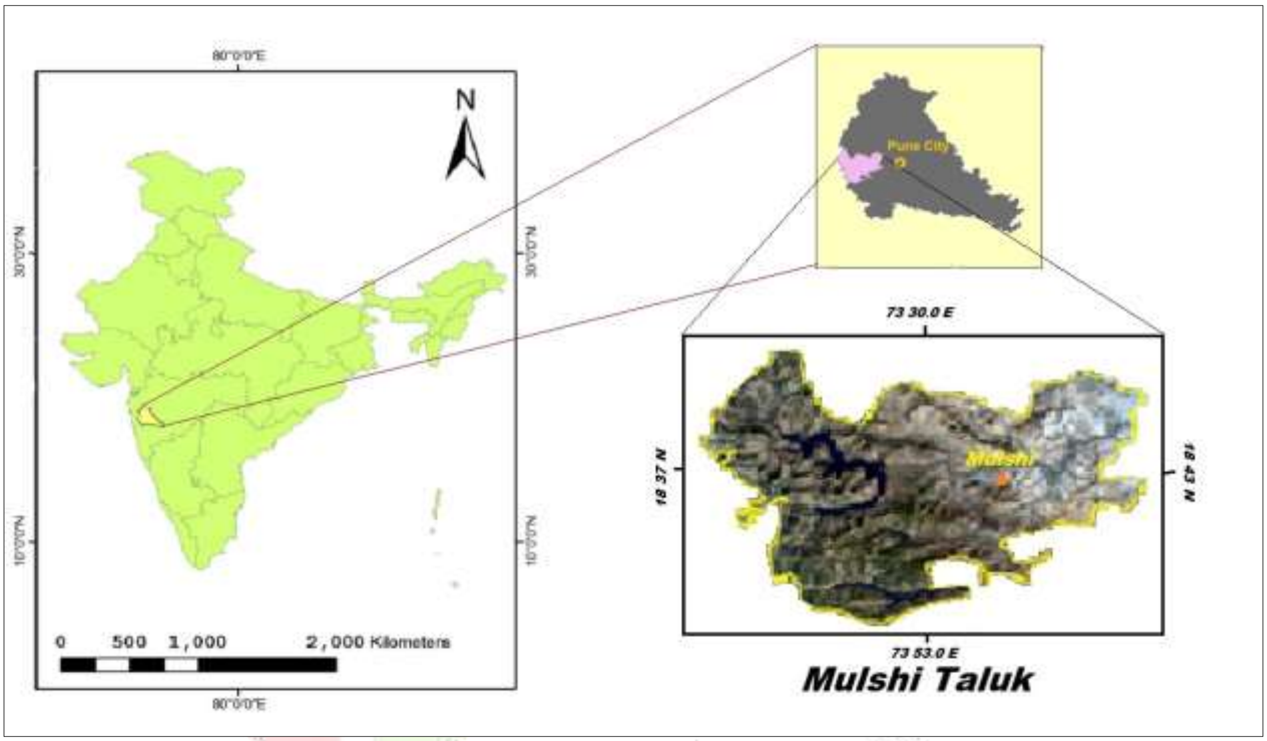

Fig.1: Google Earth image showing the location of the study area.

3. CHANGE DETECTION ANALYSIS:

A time series of remotely sensed images (Landsat TM5), covering 21 years, were used to obtain landuse change information, using the post-classification comparison technique (Lillesand and Kiefer, 2000).

All information extracted from remotely sensed data is obtained in the consistent technical flow: the geometric rectification, image registration and images matching with each other. The classification schemes include urban land, cultivated land, vegetable land, grass and forest, unused land and water (rivers, lakes, ponds and reservoirs). The maximum likelihood method was used for the land use classification in ERDAS IMAGINE 9.1 software. Then, post-classification process method includes sub-region classification method are used in the workflow (Jiang, 2004).

The overall accuracy of the land use maps for 1984, 1988, 1991, 1994, 1997, 2001 and 2005 was determined to be 89.01%, 86.45%, 86.73%, 87.32%, 85.23%, 88.14% and 87.51%, respectively. The Kappa indices for each map were 0.86, 0.82, 0.84, 0.85, 0.83, 0.85 and 0.87, respectively (Jiang, 2004). All these steps above ensure the accuracy of land use pattern for further spatial analysis. Moreover, the distribution maps of land use maps in the study area from 1992 to 2011 are shown as followed (Fig. 2).

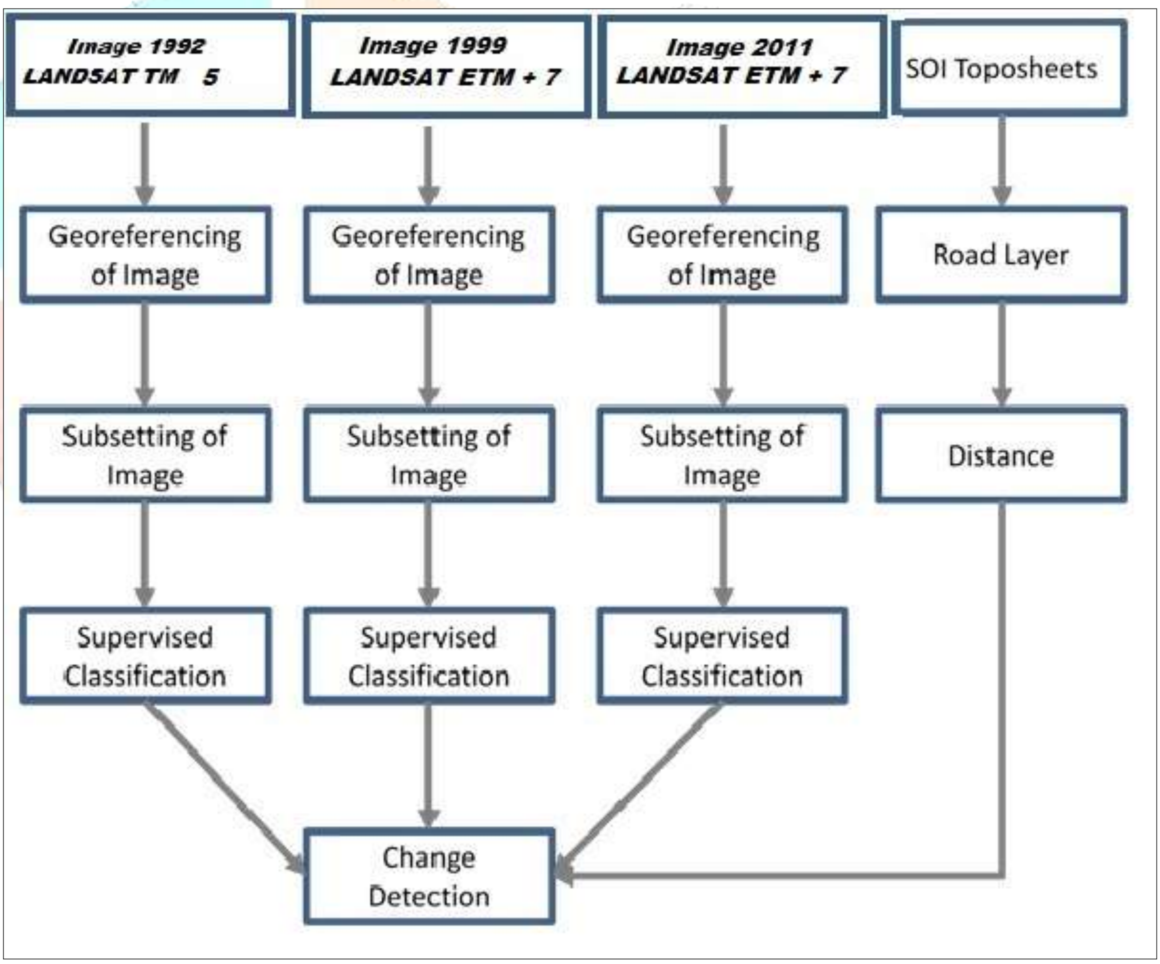

Fig.2. Change detection flow chart

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Huatanay watershed landscape, where most of the classes represented changes more than 50% in the studied periods. Most of the LCLU changes are by the human footprint. In Land Change Modeller, land cover change prediction utilizes two land cover maps from two different dates (time 1 and time 2) to predict what the land cover will be in the future (time 3). Within Land Change Modeller, this has been essentially in two major stages: the transition potential sub-model stage and the change prediction model stage. In the first stage, the user specifies the particular transitions of interest for the sub-model and specifies the variables, which drive the type of transition(s) taking place. For example, to determine in the potential of new development, consider the slope of the terrain, distance to water sources, distance to roads, and distance to previously developed land. In the second stage, the model will predict, for the specified future date, the allocation of land cover change of the study area (Fig3).

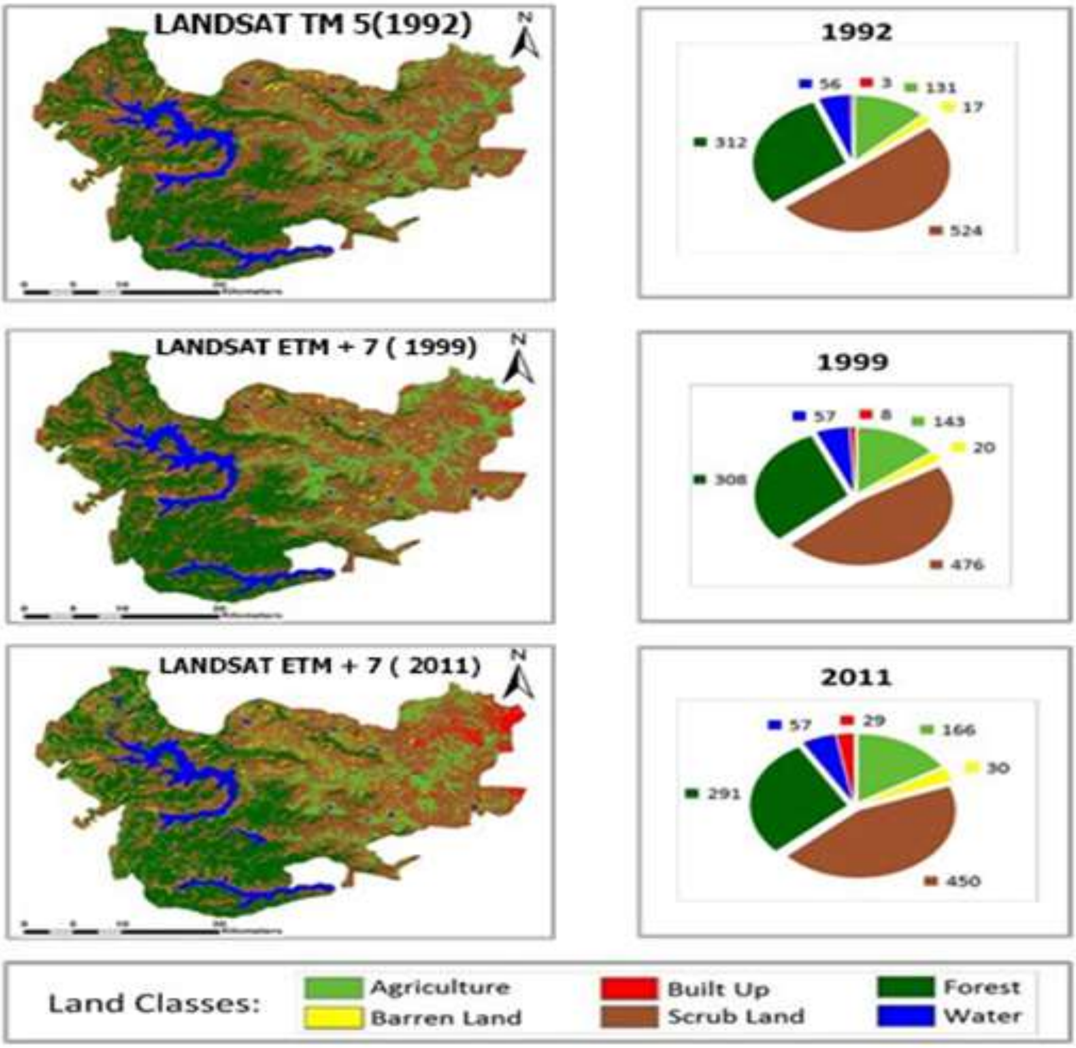

Fig.3: Distribution of land-cover classes in sq.km

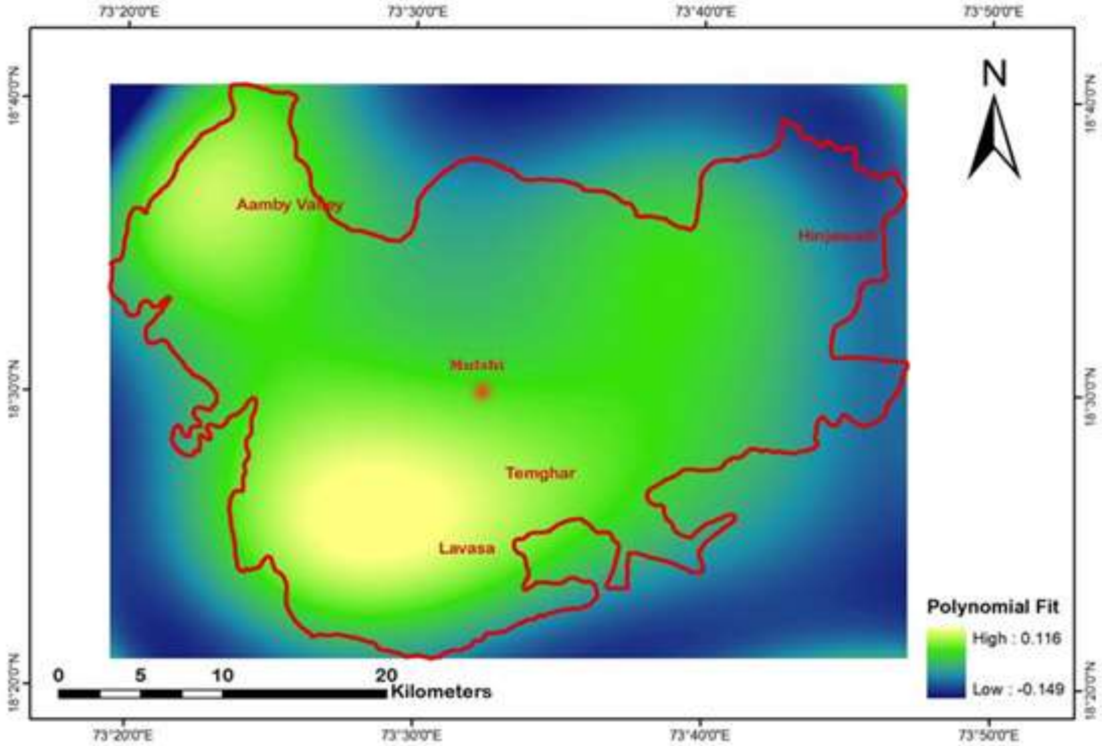

Fig. 4. Deforested areas of Mulshi taluk

In the context of urbanization, a large amount of agricultural land has been converted to built-up or urban land uses. Remote sensing and Geographical Information system (GIS) provide fundamental tools, which can be useful in the investigation at the village district as well as the city levels. Remote sensing becomes useful because it provides synoptic view and multi- temporal Land uses / Land cover data that are often required.

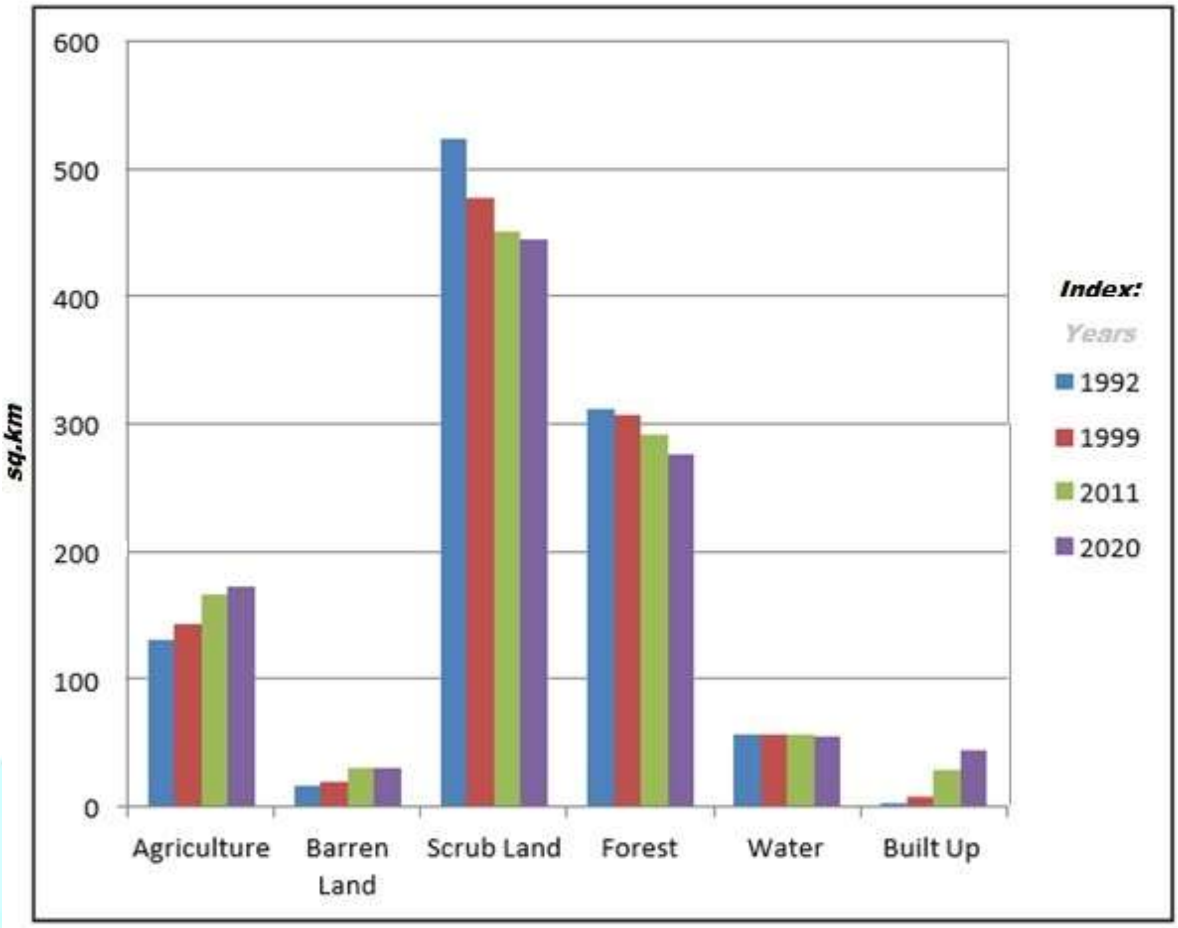

Fig. 5: Areas of land classes with prediction

Markov Chain Analysis

Urban growth dynamics attracts the efforts of scientists from several disciplines with the objectives ranging from theoretical understanding to the development of carefully tuned realistic models that can serve as planning and policy tools. Theoretical models are often abstract and of limited applied value while most applied models yield little theoretical understanding. Urban growth modelling has evolved over recent years to capture increasingly well the details of urban morphology and structure on a qualitative as well as a quantitative level. Markov chain models are particularly useful to geographers concerned with problems of movement, both in terms of movement from one location to another and in terms of movement from one "state" to another. "State", in this context refers to the size class of a town, income classes, type of agricultural productivity, land use, or to some other variables.

The matrix is presented as follows:

$$P = (p_{ij}) = \begin{pmatrix} p_{11} & p_{12} & \cdots & p_{1n} \\ p_{21} & p_{22} & \cdots & p_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ p_{n1} & p_{n2} & \cdots & p_{nn} \end{pmatrix}, \sum_{j=1}^{n} p_{ij} = 1$$

where P = Markov Transition matrix

i,j = land-cover type of the first and second time period

pi,j = probability of conversion from land-cover i to land-cover j

Land use change transition probability in Markov analysis indicates the probability of making a transition from one land use class to other one within two discrete times. The Markov transition probabilities of the observed landscape changes from 2001 and 2009. From using this, two classified image of 2001-2009. We found out the future, land use change of Kathmandu. The transition probability matrix records the probability that each land cover category will change to the other category. This matrix is produced by the multiplication of each column in the transition probability matrix be the number of cells of corresponding land use in the later image. For the 5 by 5-matrix table presented below, the rows represent the older land cover categories and the column represents the newer categories. Although this matrix can be used as a direct input for specification of the prior probabilities in maximum likelihood classification of the remotely sensed imagery, it was however used in predicting land use land cover of 2017.

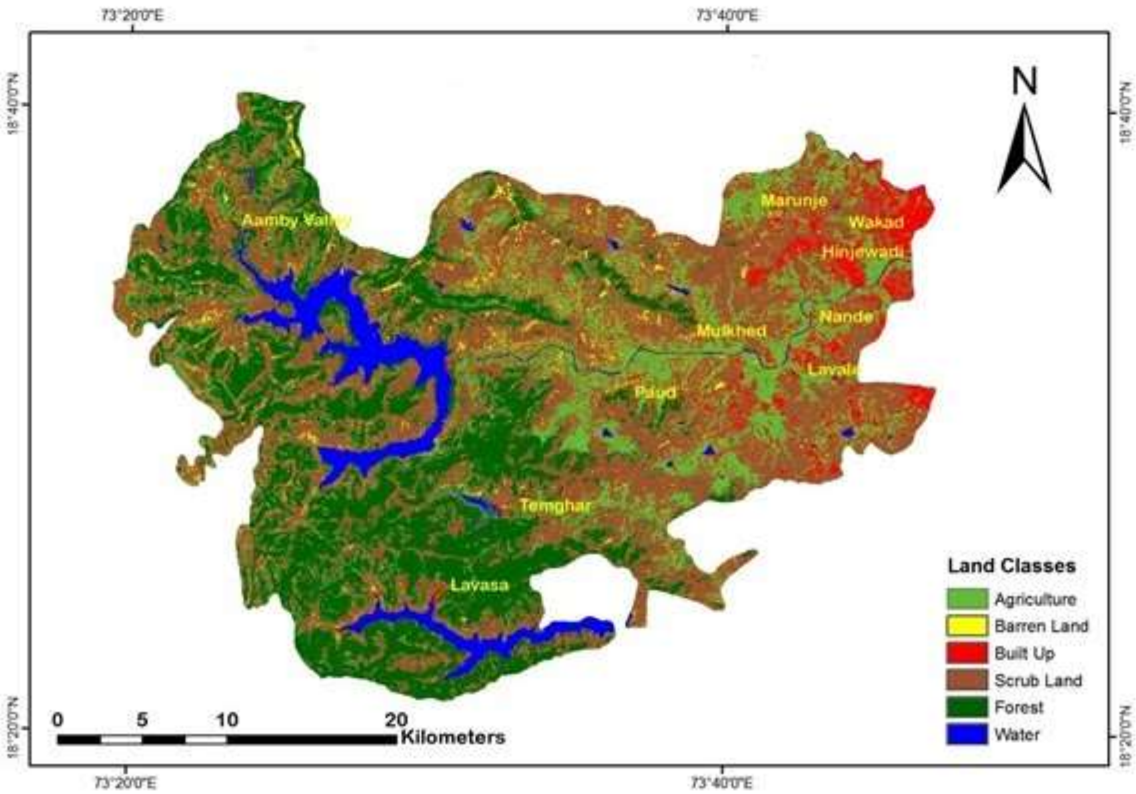

Fig.6. Predicted land-cover of Mulshi for 2020 of the study area

Built Up Land

The built up land class shows a total increase of 26 sq.km, expanding from just 3 sq.km in 1992, to 8 sq.km in 1999, and then to 29 sq.km in 2011 (Figure 2). A major change observed in this land-cover type, is in the conversion of agricultural fields and scrub land into urban areas. The industrial town of Pimpri-Chinchwad has rapidly expanded from being a village to a fully fledged industrial city due to the industrialization of Pune since the 1960s. Places like Wakad and Baner have settlements existing next to agricultural fields. This stark contrast in land-cover type has arisen due to the sale of agricultural land for real estate. The IT boom in Pune during the last decade along with the development of the Rajiv Gandhi Infotech Park has helped transform the village of Hinjewadi into a major IT hub of Maharashtra

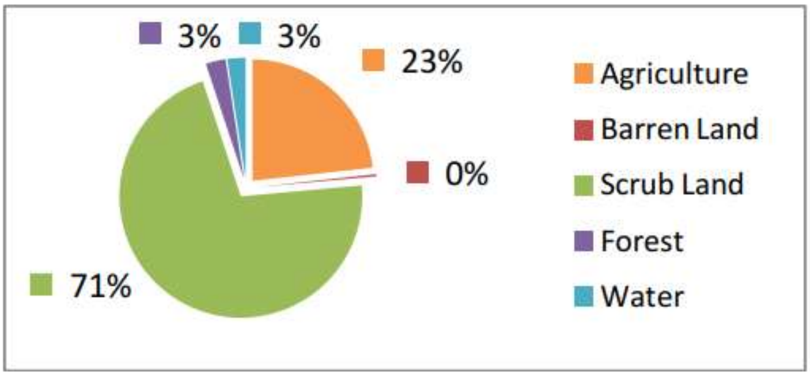

Fig.7. Contributions to increase built up land

Minor contributions from the barren land, water and forest classes are also observed. The reason behind this is the construction of new dams, resorts and townships. Hill stations Like Aamby Valley and Lavasa have been constructed on the slopes of the Western Ghats, spreading over 2,500 and 10,000 hectares respectively. This type of construction poses a threat to the biological richness of the surrounding area. The general trend observed in the urbanization of Mulshi is that the commercial and industrial expansion is mostly seen on flat Ground, while tourist hubs like the townships have been developed on hill slopes.

Agricultural Land

The area under cultivation has increased by approximately 45sq.km, up from 131sq.km to 166sq.km (Fig 2). Agricultural land sees a major shift from traditional crops to sugarcane. The area used for growing sugarcane has almost doubled between 1999 and 2011. This is due to improvements in irrigation which allows the growth of a water intensive cash crop like sugarcane. Agricultural fields are observed expanding upwards along hill slopes, into scrub and forest land. The construction of a number of minor dams in Mulshi is accompanied by the increase in the land under agriculture.

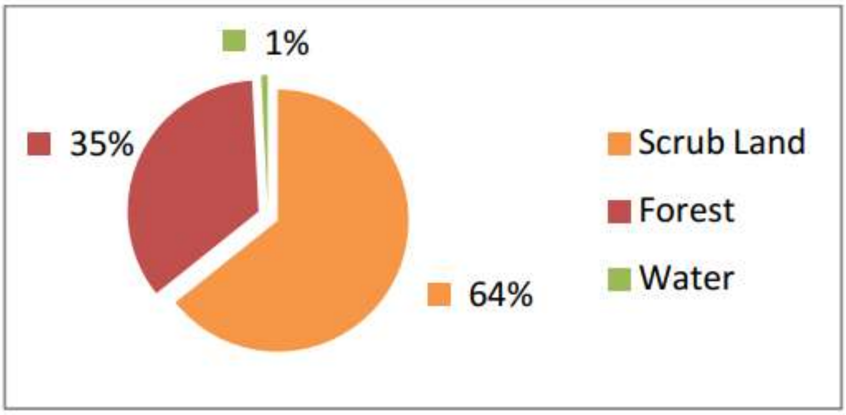

Fig.8. Contributions to agricultural expansion

Scrub Land

Over the last two decades, the area of scrub land has decreased by 74sq.km. One of the significant factors for the decline in scrub land is the increase in agriculture, especially in areas that are close to a water source and along hill slopes. Another significant factor contributing to the decline in scrub land is urbanization.

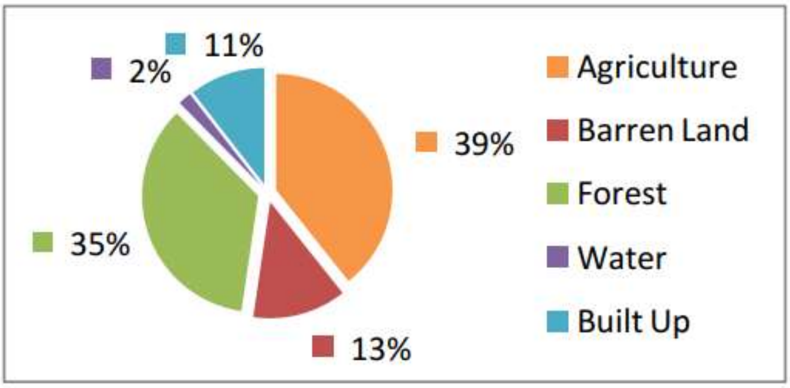

Fig.9. Contributions to the decrease in scrub land

Forest

The area under forest cover has decreased by 21sq.km, from 312sq.km to 291sq.km. The degradation of forests into scrub land is seen near the edges of the forests.

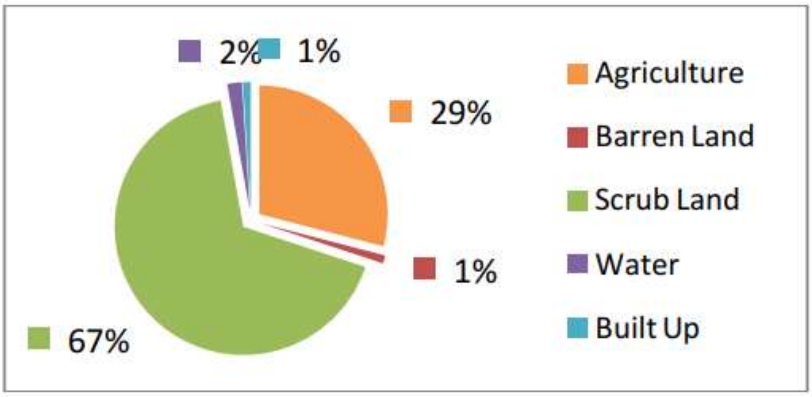

Fig.10. Contributions to the decrease in forest land

This is the largest factor in the reduction of forest area. Forests on the slopes of hills around the former village of Lavasa have been cleared for the construction of a lakeside township. Dams are also a factor contributing to the loss of forest land, due to the submergence of vegetation in the catchment area. Both these effect have been seen in the Northern part of Mulshi where Aamby Valley currently stands. Though the net forest area in Mulshi has decreased, the forests in the Ghats near the lakes show an increase in forest cover.

Water

The overall area under water has witnessed a slight increase over the entire period. However, this has been accompanied by changes in the location of water. The construction of a

Number of dams across the taluka has led to forest and scrub land coming under their backwaters. This is very noticeable in the Temghar dam and the dams created in the Aamby Valley Township. Reduction in the width of the Mula River and the fluctuations in the water levels of the dam catchments (due to the seasonal difference of the images) have partly offset the increase in water coverage.

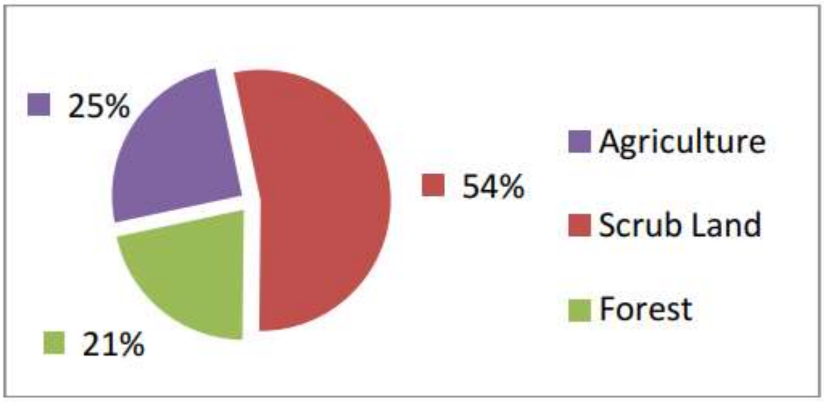

Fig.11.Contributions to the increase in area under water

CONCLUSION

The land-use and land-cover pattern of a region is an outcome of natural and socio-economic factors and their utilization by man in time and space. Land-use and land-cover change has become a central Component in current strategies in managing natural resources and monitoring environmental changes. Urban expansion has increased the exploitation of natural resources and has changed land use and land cover patterns. Rapid urbanization, therefore, brings opportunities for new urban developments, however, it also has brought serious losses of arable land, forest land and water bodies. Land cover change is a major concern of global environment change. The modelling and projecting of land cover change is essential to the assessment of consequent environmental impacts. In Nepal, speedy urbanization took place in the last two decades due to population growth. This growth has significantly changed the landscape of many cities. The taluka of Mulshi, which was once predominantly rural with traditional agriculture, is now witnessing a change in its land-use. The real estate boom, coupled with the rise of the IT and tourism industries are major drivers of change, which have led to the expansion of residential, commercial and industrial properties. These settlements have a direct impact on the integrity of the natural surroundings and pose a direct threat to the biodiversity of the Western Ghats. This study has identified the immediate need of a plan for the sustainable development of rural infrastructure, which will reduce its impact on the local ecology. The IDRISI Andes version has been used for the analysis of image. Markov Chain model applied to find out the future change of LUCC in study area. The land-use information for the year 2020 is predicated in Mulshi. According to the land use classification scheme supervised approach with the maximum likelihood parameter (MLP) system was applied to improve the accuracy of the land use classification for the images for all four dates (1976, 1990, 1999 and 2009). In Land Change Modeller, land cover change prediction utilizes two land cover maps from two different dates (time 1 and time 2) to predict what the land cover will be in the future (time 3). Within Land Change Modeller, this is done essentially in two major stages: the transition potential sub-model stage and the change prediction model stage. In the first stage, the user specifies the particular transitions of interest for the sub-model and specifies the variables, which drive the type of transition(s) taking place. For example, if we want to determine the potential of new development, we may consider the slope of the terrain, distance to water sources, distance to roads, and distance to previously developed land. In the second stage, the model will predict, for the specified future date, the allocation of land cover change.

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