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Dynamics of Land Use/Land Cover Change in Dal Lake Watershed of Kashmir Valley- A Remote Sensing and GIS Approach

Arif H Shah[1], Parvaiz A Teli[1], M Sultan Bhat[2]

[1] Ph. D Research Scholars

[2]Professor

[2]Department of Geography & Regional Development,

[2]University of Kashmir, Srinagar. J&K.

***Abstract*- Land use is a Dynamic process and if anthropogenic, it has most often adverse effects on ecological and hydrological processes. For better understanding the impacts of changing physical characteristics, geo spatial tools like remote sensing and GIS have been found useful. In this study the Dynamics of Land use/Land cover has been assessed for Dal Lake, one of the famous watersheds of Jhelum basin. It covers an area of 331 km^2 and lies between 34° 02'-34°13' N latitude & 74° 48'-75° 08' E longitude in Srinagar District and a small portion in Ganderbal District of Jammu and Kashmir state. The present work is an attempt to carry out a detailed study of Land use/land cover Change in Dal Lake Watershed using Multi-temporal satellite images of Landsat ETM September 1992, Landsat ETM$^+$ September 2001 and IRS P6 LISS III September 2010. Eleven land use/Land cover classes were identified using Digital Image Processing technique. Dense forests dominated the Land cover class in all the three time periods with 71.30 km^2, 76.25 km^2 and 82.78 km^2 for 1992, 2001 and 2010 respectively having an average annual growth of 0.89 percent. The highest average annual growth has been found in Plantation (3.45 Percent) and Built-up (3.19 Percent) while the highest negative growth has been witnessed by Wetlands (4.26 Percent) and Agriculture (2.4 Percent). The study demonstrates the significant land use changes especially in Agricultural Land, Built-up, Scrub Land, Wet lands and Plantation from 1992, 2001 and 2010. The findings of the study are useful for developing strategies for the conservation of the important urban lake that is fighting a losing battle for its survival.**

Key Words: Dal Lake, Watershed, Land use/Land Cover, Remote Sensing.

I. Introduction

Land use denotes the human employment of the land and is a synthesis of physical, chemical and biological systems and processes on the one hand and human/social processes and behavior on the other (Meyer and Turner, 1994) while land cover denotes the physical and biotic character of the land surface (Turner-II and Meyer, 1991; Lambin et al., 2001). Sekliziots (1980) defines land use as the human function of a given area while land cover is the physical surface of the land. Land use is the intended employment and management strategy placed on the land cover by human agents, or land managers to exploit the land cover and reflects human activities. On the other hand, land cover is defined by the attributes of the earth's land surface captured in the distribution of vegetation, water, desert and ice and the immediate subsurface, including biota, soil, topography, surface and groundwater (Lambin et al., 2003; Chrysoulakis et al., 2004; Baulies and Szejwach, 1998, Meyer and Turner, 1994). LULC change is defined to be any physical, biological or chemical change attributable to management, like drainage improvements, installation and use of irrigation, plantations, building farm dams, pollution and land degradation, vegetation removal, changed fire regime, spread of weeds and exotic species and conversion to non-agricultural uses (Quentin et al., 2006). Land cover changes have a significant impact on ecosystem conditions (hydrology, climate change and biogeochemical cycles) and create environmental issues (Bonetemps et al., 2008, Skole et al., 1997). LULC change is a dynamic, widespread, continuous and accelerating process driven by natural phenomena and anthropogenic activities (Sarma et al.,

2008) which in turn impel changes that would impact natural ecosystems (Moshen, 1999; Luna and Robles, 2003). Landscape structure, function and processes are related to LULC types and intensities and therefore can be affected by LULC changes (Vitousek et al., 1997). LULC change and land management has principally resulted in deforestation, biodiversity loss, global warming and increase in natural disasters (Mas et al., 2004; Zhao et al., 2004; Dwivedi et al., 2005) contributing to global environmental change (Meyer and Turner-II, 1991; Vitousek, 1992; Dale and Haeuber, 2000; Rindfuss et al., 2004 and Nagendra et al., 2004). Inventory, assessment and monitoring of LULC change provides vital input to environmental decision-making (Prenzel, 2004; Munsi et al., 2009) and are crucial for further understanding and modeling of change mechanism at different scales (William et al., 1994). Land cover change is regarded as the single most important variable of global change affecting ecological systems (Vitousek, 1994) with an impact on the environment that is at least as large as that associated with climate change (Skole et al., 1994). Urban land use/land cover change detection and ecosystems have been analyzed by many researchers (Welch and Ehlers 1987, Pathan et al., 1993, 1996, Riley et al., 1997, and in many more recent articles). Many urban land use studies have assessed the use of remote sensing images through diverse methods of classification to generate accurate urban land use maps and also to detect changes in urban land use/land cover (Jensen and Toll 1982). The short and long term monitoring of LULC change is important in establishing links between policy decision making, regulatory actions and subsequent land use planning activities for management of natural resources.

II. Study Area

Dal Lake Watershed is situated between 34° 5′ 20′′ to 34°13′40′′ N latitude and 74° 48′ 35′′ to 74° 08′ 32′′ E longitude, at an altitude of 1583 m to the north-east of Srinagar city. One of the significant features of Dal

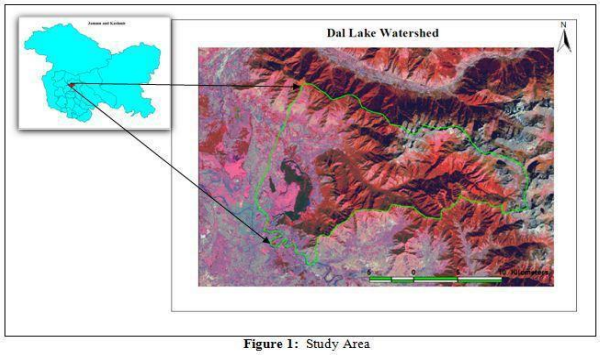


Figure 1: Study Area

Lake is its vast and diverse watershed, which spreads over an area of about 331 sq. km. Dachigam-Telbal in the north-east comprise nearly 70% of the watershed, its other segments are Zabarwan mountains and parts of Srinagar city. Telbal-Dachigham is Dal Lake's largest sub-watershed (230km2), which is further divided into the Telbal- Dara (87 km2) and Dachigham National Wildlife Reserve (143 km2) sub-watersheds. The Lake is surrounded by high mountains on one side and by an urban area on the other side. The Dal lake watershed is fan shaped and broadens in the westward direction. Topographically, the watershed has evolved out of outwash apron of the Dachigam creek and has assumed the shape of a triangle. The stretch of the watershed is a diagonal extension from north-east to south-west. The general relief of the watershed is a basin which comprises the Dal Lake situated at an altitude of 1580 m approx. and a steep escarpment at an elevation of 4390 m located along northern watershed. The main source is the Dachigam Creek (Nallah) that enters into the lake on the northern side after originating from the Marsar Lake, high up in the mountains and draining the Dachigam Reserve Forest. The Creek having a flow length of 39 km approximately is perennial in nature and enters the Hazratbal basin from the northern end. The average annual rainfall is 650 mm at Srinagar and 870 mm at Dachigam. It is in this season that the snow thaw in the higher reaches of the watershed results in the maximum discharge in Dachigam and Dara Nallah.

III. Materials and Methods

The study was carried out in GIS environment utilizing Erdas Imagine 9.0 for Land use/Land cover classification using multi-temporal satellite images of September 1992 and 2010. The various steps employed in the study are given in fig. 2. LULC by conventional methods requires vast human resources and time (Joshi et al., 2001). Visual interpretation and digital classification are two major tools for obtaining LULC information from satellite imagery. Visual interpretation uses various scene elements like tone, texture, shape, size and association in general to identify and delineate objects (Lillesand and Kiefer, 2004). The LULC maps were validated through field studies. A differential Global Positioning System (GPS) was used to collect the accurate locations of the reference points from all watersheds and for all land uses. These points were used for the validation of classified data. The necessary changes resulting from ground truthing were incorporated into the data layers.

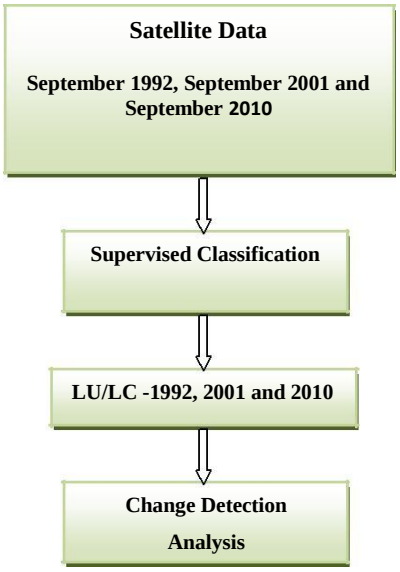


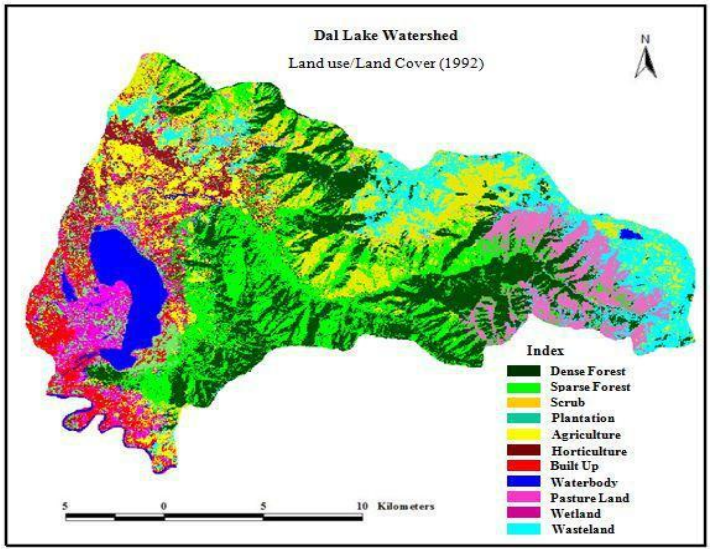
Figure 2: Flow Chat of Methodology

IV. Results and Discussions

The land use /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 is becoming a scarce resource due to immense anthropogenic pressure. Hence, information on land use/land cover and possibilities for their optimal use is essential for the selection, planning and implementation of land use schemes to meet the increasing demands for basic human needs and welfare. The land use/land cover change analysis has become a central component in current strategies for managing and monitoring environmental changes. Human activities play an important part in virtually all natural systems and are forces for change in the environment at local, regional, and even global scales. Such changes have been widespread in the past several decades in the Himalayan region (Rai et al., 1994; Singh et al., 1985). This type of conversion has been necessitated by increasing population pressure and limitation of productive agricultural land (Rai & Sharma 1998).

V. Land Use Land Cover Analysis of 1992:

The LULC analysis of the study area for the year 1992 revealed Eleven LULC classes (fig.3). Forest was the dominant land cover category in the study area with 133.36 sq.kms which constituted more than 40 percent of the total watershed area. Dense forests covered 71.30 sq.kms (21.46 percent) while sparse forests covered 62.07 sq.kms (18.68 percent) of the total area. Scrub Land constituted 12.42 percent while wastelands accounted for 11.41 percent of the total watershed area. Pastures are spread over an area of 22.45 sq.kms (6.76 percent) and Agriculture covered 21.76 sq.kms (6.55 percent) of the total area (table 1). The area under Horticulture was 17.00 sq.kms (4.99 percent) while Wetlands occupied 4.79 percent of the total watershed area.The area under Built-up, Water body and Plantation constituted 4.74 percent, 4.66 percent and 3.55 percent respectively to the total area of Dal Lake Watershed (fig.3).



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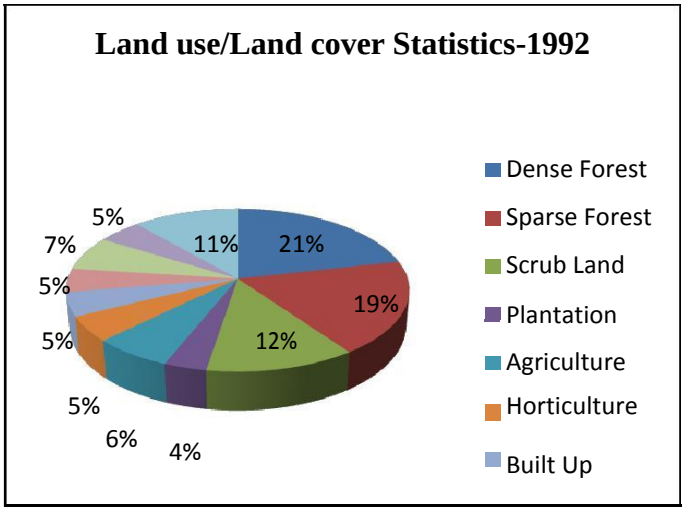
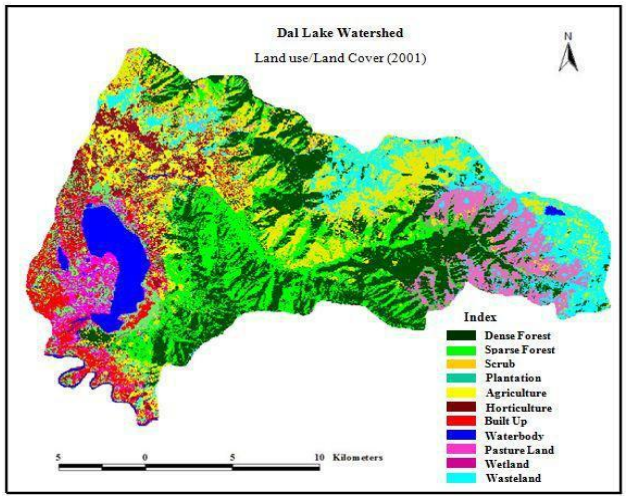


Figure: 4

VI. Land Use Land Cover Analysis of 2001:

The LULC classification of the study area for the year 2001 revealed Eleven LULC classes (fig.5). Forest was the dominant land cover type covering an area of 127.48 sq.kms (38.51 percent) with Dense forests as 76.25 sq.kms (23.35 percent) and Sparse forests as

51.23 sq.kms (15.42 percent). Scrub land was the other dominant Land cover category covering an area of 45.81 sq.kms (13.79 percent) followed by Wastelands as 38.43 sq.kms (11.57 percent) with Pasture land occupying an area of 21 sq.kms (6.6 percent) Table (1). Horticulture was being practiced on 19.51 sq.kms (5.89 percent) followed by Agriculture as 19.35 sq.kms (5.85 percent). However, Built-up covered an area of 17.32 sq.kms (5.21 percent) and Plantation as 16.52 sq.kms (4.97 percent) while Water body constituted about 15.30 sq.kms (4.61 percent) followed by Wetlands as 10.28 sq.kms (3.09 percent) to the total area of the watershed.



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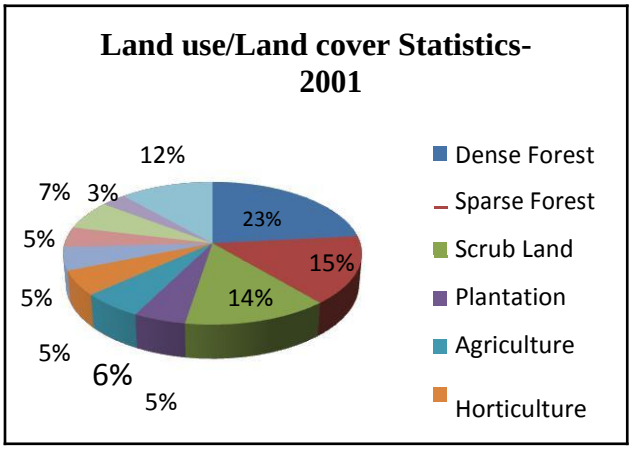
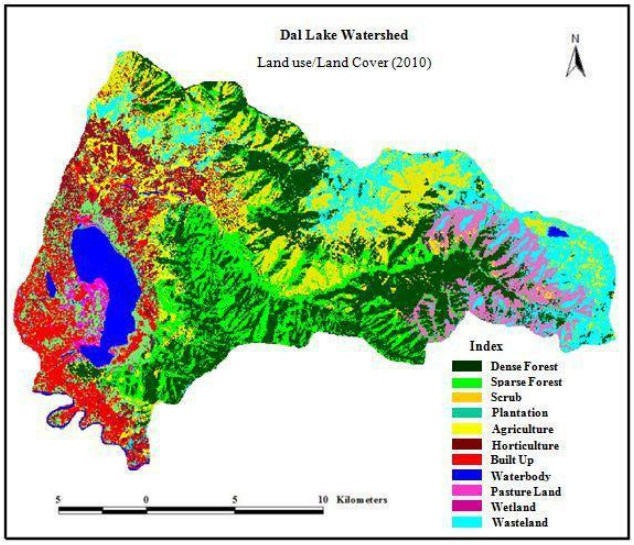


Figure: 6

VII. Land Use Land Cover Analysis of 2010:

The same LULC classification scheme has been followed for the year 2010 as applied for 1992 satellite data in order to facilitate a precise overlay and change detection analysis in the watershed. The LULC classification for 2010 (fig. 4) has revealed that forest land continued to be the dominant land cover type covering an area of 125.85 sq.kms (38.02 percent) of the total watershed area with Dense forests covering 82.78 sq.kms and Sparse forests covering 43.07 sq.kms Table (1). Scrub land was the next dominant land cover category covering an area of 48.77 sq.kms (14.68 percent) followed by Wastelands as 41.84 sq.kms (12.59 percent) and Built-up by 24.80 sq.kms (7.46 percent). Horticulture accounts for 21.07 sq.kms (6.72 percent) while Plantation constituted an area of 19.12 sq.kms (5.75 percent) and Pasture land covered an area of 18.61 sq.kms (5.6 percent). Water body had an area of 14.88 sq.kms (4.48 percent) followed by Agriculture and Wetlands as 12.36 sq.kms (3.72 percent) and 3.71 sq.kms (1.12 percent) respectively (fig.8).



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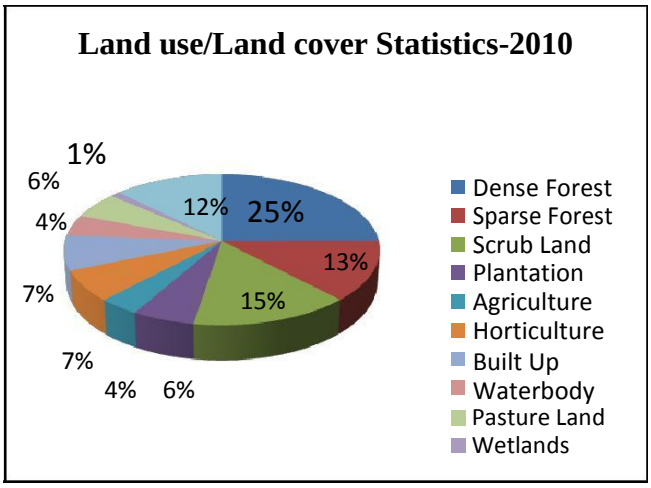

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Table 1: Land use/Land Cover of 1992, 2001 and 2010 and Change Detection.

Class	**Area in 1992 (Sq.Km)**	**Area in 2001 (Sq.Km)**	**Area in 2010 (Sq.Km)**	**(1992-2001)**				**(2001-2010)**				**(1992-2010)**			
Dense Forest	71.30 (21.46)	76.25 (23.35)	82.78 (24.92)	4.95	1.89	8.81	0.98	6.53	1.57	6.71	0.75	11.48	3.46	16.11	0.89
Sparse Forest	62.07 (18.68)	51.23 (15.42)	43.07 (12.96)	-10.84	-3.26	-17.46	-1.94	-8.16	-2.46	-15.92	-1.77	-19.00	-5.72	-30.60	-1.7
Scrub Land	41.25 (12.42)	45.81 (13.79)	48.77 (14.68)	4.56	1.37	11.05	1.23	2.95	0.89	6.45	0.72	7.51	2.26	18.21	1.01
Plantation	11.79 (3.55)	16.52 (4.97)	19.12 (5.75)	4.73	1.42	40.12	4.46	2.60	0.78	15.70	1.74	7.33	2.21	62.13	3.45
Agriculture	21.76 (6.55)	19.35 (5.82)	12.36 (3.72)	-2.41	-0.73	-11.08	-1.23	-6.99	-2.10	-36.13	-4.01	-9.40	-2.83	-43.21	-2.4
Horticulture	17.00 (4.99)	19.51 (5.57)	21.07 (6.72)	2.51	0.58	11.54	1.28	1.56	1.15	20.59	2.29	4.07	1.72	34.51	1.92
Built Up	14.10 (4.74)	17.32 (5.21)	24.80 (7.46)	3.22	0.47	9.95	1.11	7.48	2.25	43.17	4.4	10.70	2.72	57.41	3.19
Water body	15.48 (4.66)	15.30 (4.61)	14.88 (4.48)	-0.17	-0.05	-1.13	-0.13	-0.42	-0.13	-2.77	-0.31	-0.60	-0.18	-3.86	-0.21
Pasture Land	22.45 (6.76)	21.00 (6.60)	18.61 (5.60)	-1.45	-0.16	-2.34	-0.26	-2.39	-1.00	-15.11	-1.68	-3.84	-1.15	-17.09	-0.95
Wetlands	15.90 (4.79)	10.28 (3.09)	3.71 (1.12)	-5.63	-1.69	-35.39	-3.93	-6.57	-1.98	-63.93	-7.1	-12.20	-3.67	-76.70	-4.26
Wasteland	37.90 (11.41)	38.43 (11.57)	41.84 (12.59)	0.53	0.16	1.39	0.15	3.41	1.03	8.88	0.99	3.94	1.19	10.39	0.58

Source: Computed from Satellite Images of Landsat ETM of September 1992, Landsat ETM^{+} of September 2001 and IRS P6 LISS- III September 2010
Note: Figures in Parenthesis indicate Percentage to the Total Area.

VIII. Land Use Land Cover Change Analysis (1992, 2001 and 2010):

The analysis has revealed that there has been a considerable change in various LULC categories (fig.9). The area under Built-up, Horticulture, Scrub land, Plantation and Dense forests has continuously increased while the area under Sparse forests, Agriculture, Water body and Wetlands has continuously shown a decreasing trend from 1992 to 2010. The other land cover categories like, Pastures and Wastelands have shown a variable character as they have registered a fluctuating trend by registering decrease for some decade and then increased or vice versa in different micro-watersheds. The analysis of (table 1) has revealed that the area under Dense forests has increased from 71.30 sq.kms in 1992 to 82.78 sq.kms in 2010 thus registering a growth rate of 16.11 percent with the average annual growth of 0.89 percent.

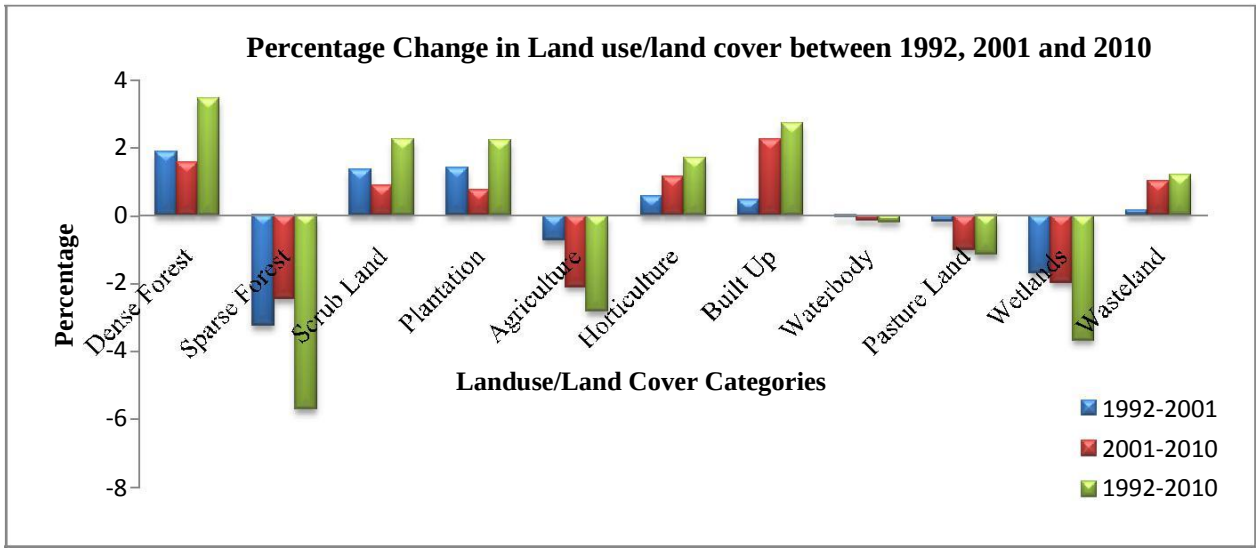

Figure: 9

This change has been continuous with 71.30 sq.kms, 76.25 sq. kms and 82.78 sq.kms for the year 1992, 2001 and 2010 respectively. From 1992-2001, 2001-2010 and 1992-2010 the percentage change has been recorded as 1.89, 6.71 and 3.46 respectively. Unlike Dense forests, Sparse forests have shown continuously decreasing trend from 1992-2010. The area has decreased from 62.07 sq.kms in 1992 to 51.23 sq.kms in 2001 and to 43.07 sq.kms in 2010. Thus, registering a growth rate of -30.60 percent with average annual growth of -1.7 percent from 1992 to 2010.Scrub land has also shown an increasing trend from 1992 to 2010 and has increased from 41.25 sq.kms in 1992, 51.23 sq.kms in 2001 to 43.07 sq.kms in 2010 (Fig. 9) thus registering a growth rate of 11.05 percent, 6.45 percent and 2.26 percent and average annual growth rate of 1.23 percent, 0.72 percent and 1.01 percent from 1992-2001, 2001-2010, 1992-2010 respectively(Fig). Plantation was one of the land use categories which has also shown an increasing trend from 1992 to 2010. From 1992-2001 Plantation has registered an absolute change of 4.73 sq.kms (1.41 percent) with a growth rate of 40.12 percent having average annual growth rate of 4.46 percent Table (1). From 2001 to 2010 2.60 sq.kms change has been recorded with the growth rate of 15.70 percent and average annual growth rate of 1.74 while from 1992-2010 7.33 sq.kms change has been found with growth rate and average annual growth rate of 62.13 percent and 3.45 percent respectively.

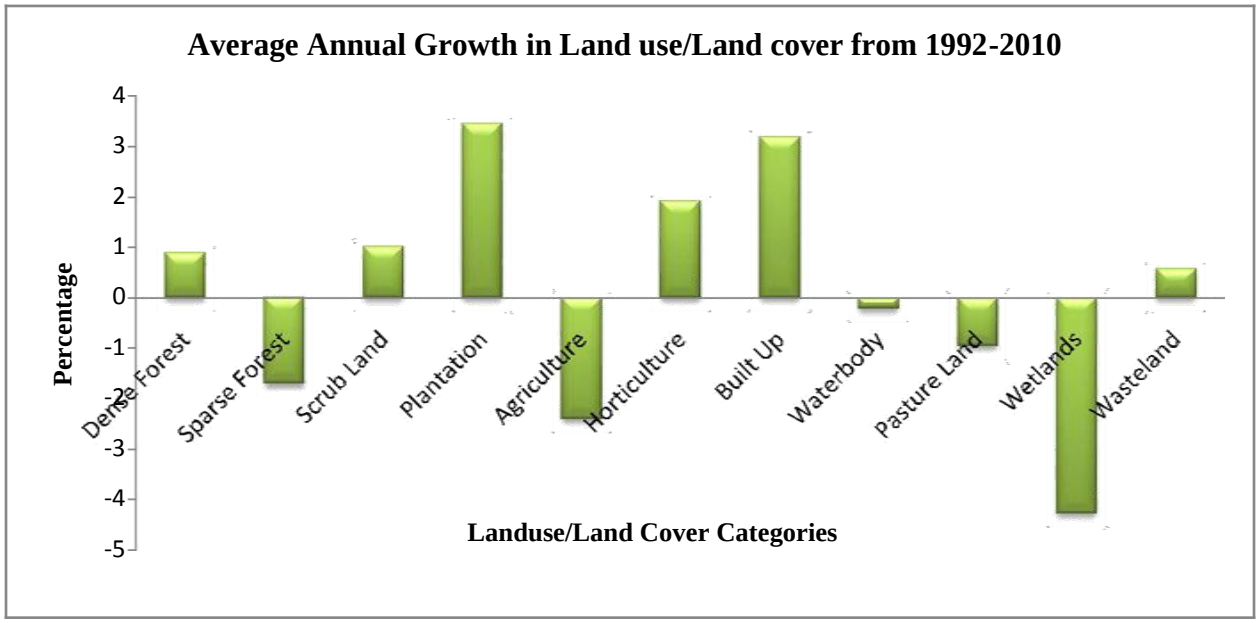

Figure: 10

The area under agriculture has decreased from 21.76 sq.kms in 1992 to 12.36 sq.kms in 2010 on account of the land use change from agriculture to horticulture and partly due to the conversion of agriculture area into residential areas. The growth rate has been recorded as -43.21 percent with average annual growth rate of -2.4 percent from 1992 to 2010 (Fig, 10). Horticulture has also shown a continuous increase from 1992 to 2010 and has increased from 17.00 sq.kms in 1992 to 21.07 sq.kms in 2010 with the percentage growth of 34.51 percent and average annual growth rate of 1.92 percent (Fig 10). The analysis of table (1) has revealed that the area under Built-up has also continuously increased from 14.10 sq.kms in 1992, 17.32 sq.kms in 2001 and 24.80 sq.kms in 2010. This change recorded a growth rate of 57.41 percent and average annual growth rate of 3.19 sq.kms (Fig.10) between 1992 to 2010. The absolute and percentage change has been found as 10.70 sq.kms and 2.72 percent from 1992 to 2010 respectively.

The area under Water body has decreased from 15.48 sq.kms in 1992 to 14.88 sq.kms recording a growth rate of -3.86 percent and average annual growth rate of -0.21 percent from 1992 to 2010. The absolute and percentage change has been found as -0.60 sq.kms and -0.18 respectively between 1992-2010. The area under Pastures has also decreased from22.45 sq.kms in 1992 to 18.61 sq.kms in 2010. This change has recorded a growth rate of -17.09 percent and average annual growth rate of -0.95 percent. The absolute change has been found as -3.84 sq.kms from 1992 to 2010.

The area under Wetlands has also decreased from15.90 sq.kms in 1992 to 3.71 sq.kms in 2010 (Fig.9).Thus recording a growth rate of -76.70 percent with average annual growth rate of -4.26 percent (Fig.) between 1992 to 2010. This is the highest land transformation in Dal lake watershed because most of the Wetlands have been converted either to plantation or for residential purposes. The absolute change has been found to be -12.20 sq.kms between 1992-2010 Table (1). Wastelands is the another land cover category which has witnessed a gradual increase between these two time periods, the area has increase from 37.90 sq.kms in 1992 to 41.84 sq.kms in 2010 with the growth rate of 10.39 percent and average annual growth rate of 0.58 percent. The absolute as well as percentage change was found to be of 3.94 sq.kms and 1.19 percent between 1992 to 2010 respectively.

IX. Conclusion

The results have shown that Eleven Land use/Land cover classes were identified namely Dense forest, Sparse forest, Scrub, Plantation, Agriculture, Horticulture, Built Up, Water body, Pasture Land, Wetland and Wasteland. Between 1992 to 2001 the highest change was found in Sparse forests (-10.84 $Sq.km^2$) followed by Wetlands (-5.63 $Sq.km^2$) and Dense forests (4.95 $Sq.km^2$) while from 2001-2010 the highest change was found in Sparse forests (-8.16 $Sq.km^2$) and lowest change of (-0.42 $Sq.km^2$) was witnessed by Waterbody. During the period of about 20 years (1992-2010), the highest positive average annual growth was recorded by Built-up as 4.4 percent followed by 2.29 and 1.74 by Horticulture and

Plantation respectively while the highest negative average annual growth was found in Wetlands (-7.1 Percent) followed by Agriculture (-4.01 Percent) and Sparse forest (-1.77 Percent). It was finally concluded that remote sensing and GIS plays a very important role in identifying the direction and magnitude of Land use/Land cover change. Such studies are very important for planning and management of land and water resources especially at watershed level.

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