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ANALYSIS OF LAND USE AND LAND COVER CHANGES OF A RURAL SUB-WATERSHED USING RS AND GIS IN TAMILNADU, INDIA

Velayudha Das M[1] and Poongothai S[2]
Research Scholar[1] and Professor[2]
Department of Civil Engineering, Annamalai University, Annamalainagar-608002
e-mail: mvdas6979@yahoo.com

Abstract: Knowledge of the distribution of land use and land cover (LULC) is important for land planning and land management activities. Repetitive nature of IRS IC LISS III and PAN merged imagery data has been utilized for measuring qualitative and quantitative spatial information of LULC changes at different levels for various aspects. In handy, the available three years LULC maps in 1995, 2003 and 2012 have been taken into account to know the past and present patterns of LULC in the upper Manimuktha sub-watershed (4CIA2e) of Tamilnadu. The digitization of these maps, relationship between changes and its trend is analysed using ArcGIS software and compared. The study area is dominated by agricultural land, forest land followed by water bodies, waste land and settlement. The results are presented spatially as well as graphically by GIS maps and bar-chart. From this study, it is inferred that there are significant positive (10.19%) changes in agricultural land and negative (3.09%) changes in forest cover in the study area because of the increasing human population need as well as to generate more income. It is necessary to conserve forest of the study area for sustainable development.

Keywords: Watershed, Land use and Land cover, GPS, RS and GIS.

I. INTRODUCTION

Land is a limited resource of the earth, which plays a vital role in the economic growth of the country [1] and for modelling future society [2]. It is facing a variety of increasing demands due to the growing pressure of human activities on the limited land resources for agriculture, forest, pasture, urban and industrial land uses [3]. Land use refers to man's activities and the varied uses which are carried on over land and its resources. The study of land use pattern is of prime concern to geographers to know the relationship between man and the natural environment [4] have suggested that the land use policies have influenced the direction and magnitude of landscape change and also coupled with the hydrologic characteristics of soils on the land surface can also provide measures of expected percolation and water holding capacity. Land cover implies the physical or natural state of the earth's surface. It refers to natural vegetation, water bodies, rock/soil, artificial cover and others noticed on the land [5]. LU and LC are two separate terminologies which are often used interchangeably [6]. The LULC pattern of a region gives information about the natural and socio-economic factors, human livelihood and development [7]. LULC changes are major issues of global environmental change in space and time [8]. Land cover level classification is divided into unsupervised and supervised approaches which depend on the spatial resolution of the image and a prior knowledge regarding the land cover types [9]. Over the years, the major application data obtained from repetitive coverage at short intervals of earth orbiting satellites, remote sensing has been used for land use/land cover mapping in different parts of India [10, 11]. More recently, small-scale aerial photographs and satellite images of high temporal resolution, precise spectral bandwidths, and accurate geo-referencing have been utilized for LULC mapping [12].Recent development in RS and GIS focus on providing the knowledge of how much, where, what type of LULC change has occurred in data analysis, update and retrieval with better accuracy, at low cost and in less time [13-15]. The aim of the study is to analyse the nature, extent, trend, location and magnitude of land use/land cover changes in the rural sub-watershed (4CIA2e) for the past 22 years. Such studies have helped in understanding the dynamics of human activities in space and time.

II. STUDY AREA

The present investigation area is Muktha river sub-watershed (upper Manimuktha, 4CIA2e) of the Velar basin (Fig.1). It is a part of Sankarapuram and Kallakurichi taluks of Villupuram district in Tamilnadu, India. Muktha river originates in the western side of the Eastern Ghats hill range (Kalrayan hill) and join in the Manimuktha dam. The study area extends between 78°43'9.22''- 78° 59' 21.73" E and 11° 46' 12.80''- 11° 53' 42.38'' N with an area of 251.151 km^2. The western part of the study area is covered by a thick forest cover (85.761 km^2) and the rest is almost plain terrain (165.390 km^2). This rural sub-watershed falls in SOI toposheets 58I/9 and 58I/13. It is an ephemeral river in nature and carries flood water during monsoon rainfall period. Agriculture is the main economical activity of about 80% of the population. The main sources of water are tanks and dug wells apart from rainfall. The average annual rainfall of the study area is 1231.09mm during 1992-2017. The elevation ranges from 130m to 987m above MSL with a gentle gradient from west to east. The soil types are clay soil, red soil, alluvial soil and red gravelly soil. This watershed experiences tropical monsoon climate with normal temperature, humidity and evaporation throughout the year. The Kalrayan hill has also possessed innumerable tourism potentialities like waterfalls, jungle streams, rivulets and lovely jungle walks. It is also called as the poor man's hills of Tamilnadu. It supports life to more than 1lakh people those who have been living in and around the hill.

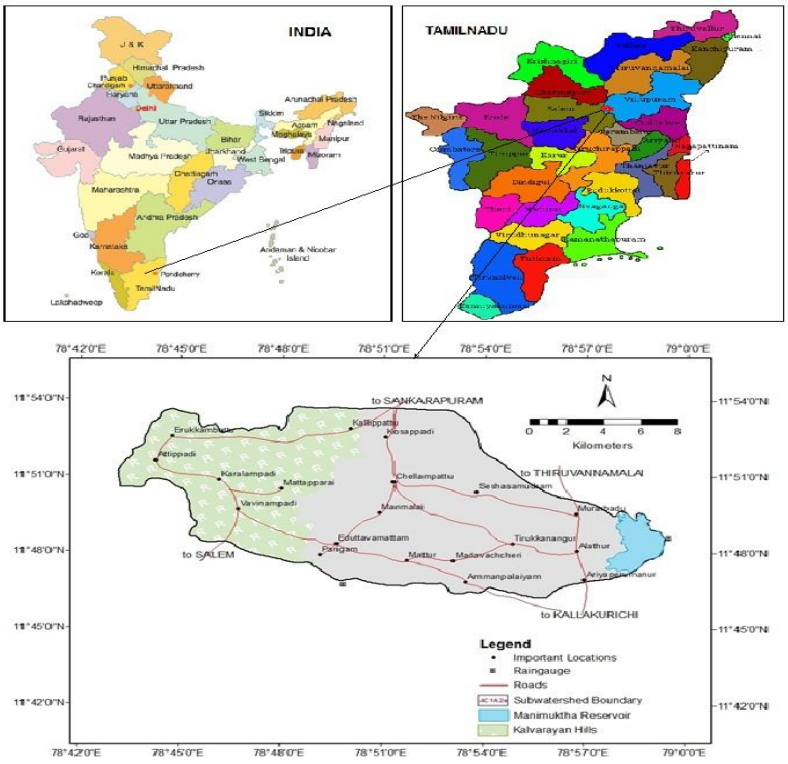

Fig.1 Index map of the study area

III. METHODOLOGY

A) Watershed Database

In this study the following data are used

- Base map of study area (Muktha river sub-watershed, 4CIA2e) from SOI toposheet 58I/9 and 58I/13 (Source: IRS, Anna University, Chennai).
- Remote sensing data (IRS 1C, LISS III) to prepare the land use / land cover maps of year 1995, 2003 and 2012 (Source: IRS, Anna University, Chennai)

Both satellite imagery and toposheets were geo-referenced to get the LULC maps for different years of the study area. After geo-referencing the satellite data were opened in ArcGIS (version 10.5) software and identified the classes by visual interpretation and digitized as shape files to produce a detailed LULC map of the study area. Ground checking was also done by collecting GPS points to make the confirmation of result obtained for different land use characteristics.

IV. RESULTS AND DISCUSSION

LULC maps of years 1995, 2003 and 2012 were prepared from the satellite imageries based on ground observations (Fig. 2-4). Based on the resolution of data, the information available on LULC are arrayed and grouped under a suitable classification system. Initially, five land use (level-1) categories, i.e. agricultural land, forest land, built up land, wasteland and water bodies is identified. These level-1 classes are further converted into other land use classification system as level-2 and 3. The detailed attribute information of the feature classes-area statistics of each land use category were calculated in sq.km and percentage are presented in Table 1-3. The change detection of LULC of the study area was analysed and its areal extents were compared and given in Table 4. The trend in major change of agricultural land (in 1995-2012) and forest land (in 2003-2012) were prepared in GIS environ by overlay/intersection operation of concern land use maps (Fig. 5 and 6).The results are presented spatially as well as graphically by GIS maps and bar-charts.

Change in Agricultural land: It is defined as the land primarily used for farming and for production of food, fibre, and other commercial and horticulture crops. It includes land under crops (irrigated and unirrigated), fallow, plantations, etc. The crops may be of either Kharif (June-September) or Rabi (October-March) or Kharif-Rabi seasons. It is estimated from the table 5 that the study area is dominated by agricultural land in 1995 was 42.742km^2(56.84%) and increased to 157.295km^2(62.63%) in 2012 this is due to trend in change in agriculture (Fig.5). The crop land was increased to 20.64%, but the plantation area was reduced to 98.09% from 1995 to 2012.Fallow lands is an agriculture land but temporarily not used for cultivation. The area under fallow land has 4.02% in 1995, decreased 2.88% in 2003 and increased 9.72% in 2012. The geographical conditions of the study area are quite suitable for paddy and sugarcane cultivation and commercial crops.

Change in Built up lands: The built-up lands are the areas of human inhabitation developed due to non-agricultural activities like building, industries and transportation network. The main settlement towns of this area are Eduttavainatam, Chellambattu, Murarbad, Agarakottalam, Ammanpalaiyam and Alattur. It is observed that the settlement area gradually increased from 3.471km^2 (1.38%) in 1995 to 4.367km^2 (1.74%) in 2003 and it further increased to 4.682km^2 (1.86%) including rock-mining area of 0.092km^2(0.04%) in 2012 which is obvious due to human population growth.

Change in Forest land: India has the fastest rate of deforestation in the world [6].The forest area totally covered in the western part of the study area. It occupied 62.351km^2 (23.79%) of the study area in 1995, increased to 66.796km^2(26.60%) in 2003.This indicates that there was no human interference in the hill ecosystem during this period. But from the year 2003 to 2012 the forest cover declined to 60.421km^2(24.06%) due to competing land uses (agriculture and human settlements mainly), the rising unemployment problem and also demand for fuel wood are the major causes of deforestation. So it should be noticed the awareness of environment in people living nearby by the forest area and conserved it carefully. During the last 22 years the percentage of deciduous and dense/closed forest was decreased (3.09%) because of conversion of forest into agriculture and other land uses (Fig. 6)

Change in Waste lands: Wasteland is described as degraded land, such as land with scrub, without scrub, barren stony land, salt affected land, waterlogged land, etc. Waste land in 1995 was 9.64%, reduced to 6.04 % in 2003 and 3.50% in 2012.This is due to change in agricultural lands during that period.

Change in Water bodies: Streams/rivers, canals, tanks, reservoirs, etc., is considered under this category. Water bodies cover only 7.32% of the total area in the year1995, decreased to 7.00% in 2003 and increased to 7.95% in 2012 probably due to seasonal variation. The study area has 6 anicuts and tanks across the Muktha river (Chellampattu tank, Seshasamutram tank, Thavadipattu tank, Moorarpalayam tank and Paramanatham tank) and 2 rain-fed tanks (Alathur tank and Kosapadi tank) of total ayacut of 729.83ha. In the eastern part of the downstream side, an earthen dam was constructed during 1956-1957 namely Manimuktha reservoir, has a water spread area of 7.37 km^2, gross storage capacity of 736.96Mcft and but irrigates an ayacut of 11,200 ha outside the study area boundary. The study area is also facing the threat of drought because of improper water management.

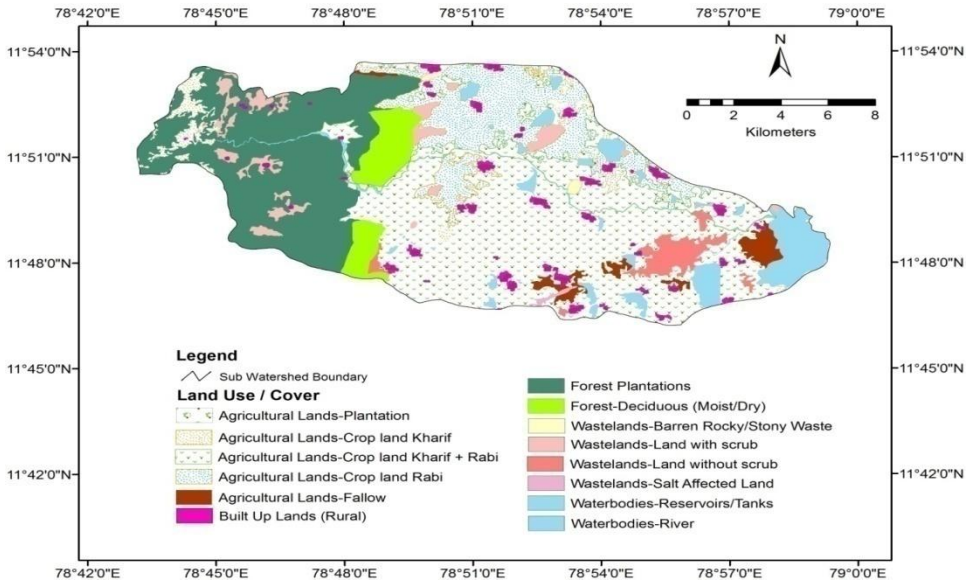

Fig.2 Land use/Land cover classification map of the study area in 1995

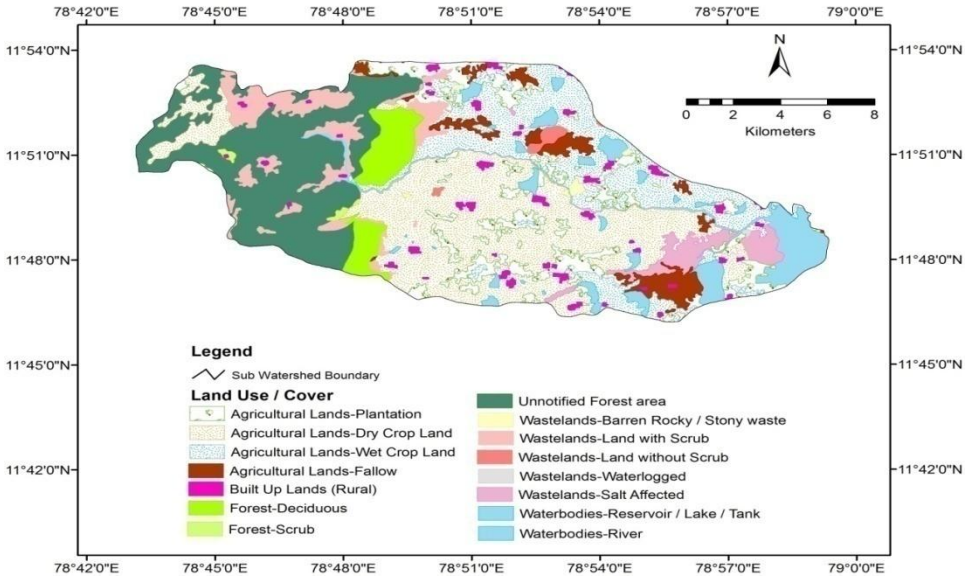

Fig.3 Land use/Land cover classification map of the study area in 2003

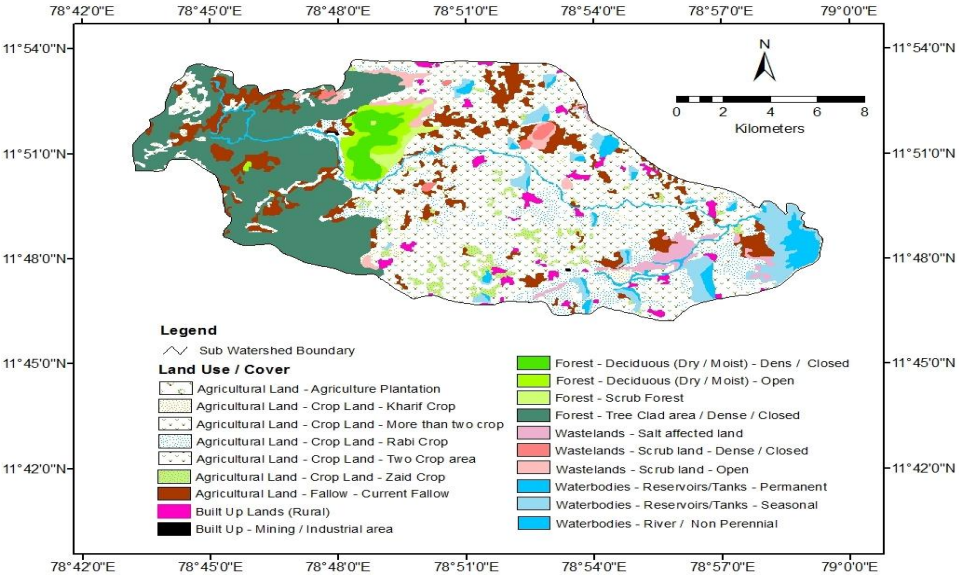

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Fig.4 Land use/Land cover classification map of the study area in 2012

Table 1. Areal extent of different LULC features in the study area in 1995

Land use/Land cover - 1995				
Level 1	**Level 2**	**Level 3**	**Area (sq.km)**	**in %**
Agricultural lands	Plantation		22.886	9.11
	Crop land	Dry crop	13.521	5.38
	Crop land	Wet crop	96.645	38.48
	Fallow		9.691	3.86
Built-up lands	Rural settlements		3.471	1.38
Forest lands	Deciduous		10.744	4.28
	Scrub forest		0.575	0.23
	Unnotified forest		51.031	20.32
Waste lands	Barren/Rocky/Stony		0.721	0.29
	Land with scrub		14.893	5.93
	Land without scrub		1.316	0.52
	Salt affected		7.177	2.86
	Waterlogged		0.105	0.04
Water- bodies	Reservoir/Tank		8.908	3.55
	River/Stream		9.467	3.77
		Total	**251.151**	**100**

Table 2. Areal extent of different LULC features in the study area in 2003

Land use/Land cover - 2003				
Level 1	**Level 2**	**Level 3**	**Area (sq.km)**	**in %**
Agricultural lands	Plantation		0.809	0.32
	Crop land	Kharif crop	5.057	2.01
	Crop land	Rabi crop	33.729	13.43
	Crop land	Kharif + Rabi (Double cropped)	100.415	39.98
	Fallow	Current fallow	7.228	2.88
Built-up lands	Villages (Rural)	Residential	3.557	1.42
	Towns/Cities (Urban)		0.81	0.32
Forest lands	Forest Plantation		55.225	21.99
	Deciduous (Moist/Dry)	Scrub forest	7.847	3.12
	Deciduous (Moist/Dry)	Dense/Closed	3.724	1.48
Wastelands	Land with scrub		7.979	3.18
	Land without scrub		6.122	2.44
	Salt affected		0.52	0.21
	Barren/ Rocky/Stony		0.56	0.22
Water- bodies	Tanks	Sandy area	4.911	1.96
	Reservoir	Reservoir with vegetation	1.64	0.65
	Tanks	Tank bed vegetation	6.625	2.64
	Reservoir	Water spread area	0.036	0.01
	Tanks	Water spread area	2.71	1.08
	River	River bed vegetation	1.647	0.66
		Total	**251.151**	**100**

Table 3. Areal extent of different LULC features in the study area in 2012

Land use/Land cover - 2012				
Level 1	**Level 2**	**Level 3**	**Area (sq.km)**	**in %**
Agricultural lands	Plantation		0.436	0.17
	Crop land	Kharif crop	4.416	1.76
	Crop land	Rabi crop	21.407	8.52
	Crop land	Zaid crop	5.493	2.19
	Crop land	Two crop area	63.887	25.44
	Crop land	More than two crop	37.247	14.83
	Fallow	Current fallow	24.409	9.72
Built- up lands	Settlements		4.590	1.83
	Mining area		0.092	0.04
Forest lands	Deciduous (Dry/Moist/Thorn)	Dens/Closed	4.782	1.90
	Deciduous (Dry/Moist/Thorn)	Open	3.930	1.56
	Scrub forest		1.825	0.73
	Tree clad area/Dense/Closed		49.884	19.86
Wastelands	Scrub land	Open	3.543	1.41
	Scrub land	Dense/Closed	1.319	0.53
	Salt affected		3.932	1.57
Water-bodies	Reservoir/Tanks	Seasonal	10.320	4.11
	Reservoir/Tanks	Permanent	5.950	2.37
	River		3.689	1.47
		Total	**251.151**	**100**

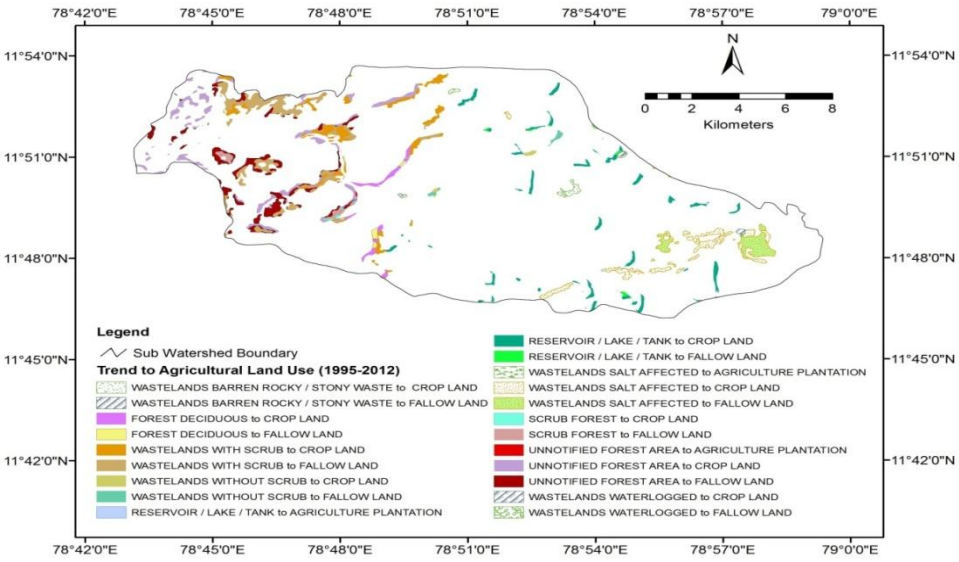

Fig.5 Trend in Agricultural land change map of the study area during 1995-2012

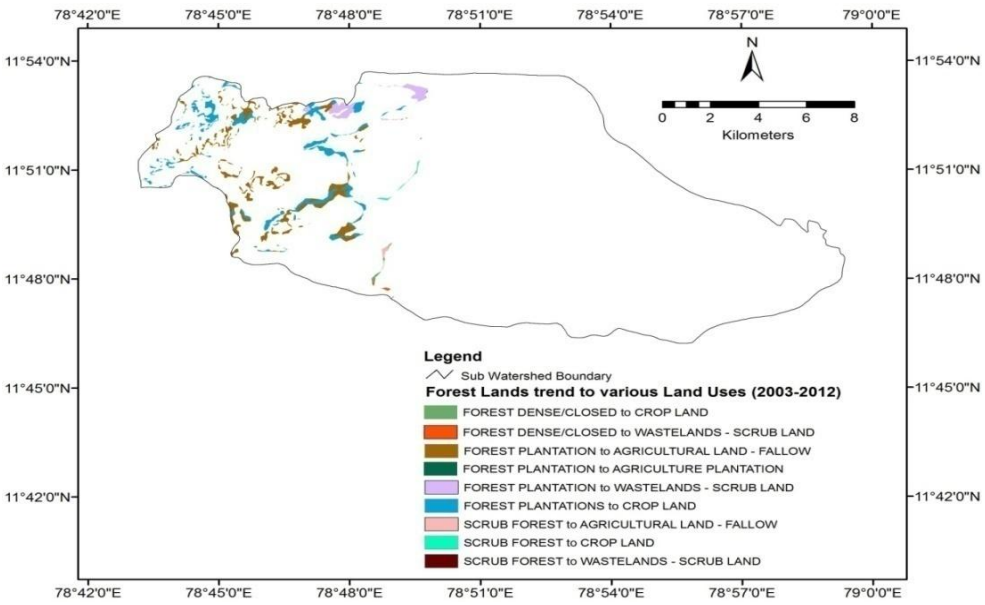

Fig.6 Trend in Forest land change map of the study area during 2003-2012

Table 5. Change detention of LULC of the study area in the year 1995, 2003 and 2012

Land use/ Land cover- Level	In 1995 (sq.km)	in %	In 2003 (sq.km)	in %	In 2012 (sq.km)	in %	Land use Change Detection in %		
							1995-2003	2003-2012	1995-2012
Agricultural Lands									
Plantation	22.867	9.10	0.809	0.32	0.436	0.17	(-)96.46	(-)46.11	(-)98.09
Crop land	109.79	43.71	139.201	55.43	132.450	52.74	(+)26.79	(-)4.85	(+)20.64
Fallow	10.085	4.02	7.228	2.88	24.409	9.72	(-)28.33	(+)237.70	(+)142.03
Subtotal	**142.742**	**56.84**	**147.238**	**58.63**	**157.295**	**62.63**	**(+)3.15**	**(+)6.83**	**(+)10.19**
Built-up Lands	**3.471**	**1.38**	**4.367**	**1.74**	**4.682**	**1.86**	**(+)25.81**	**(+)7.21**	**(+)34.89**
Forest Lands									
Deciduous	10.745	4.28	3.724	1.48	8.712	3.47	(-)65.34	(+)133.94	(-)18.92
Scrub forest	0.575	0.23	7.847	3.12	1.825	0.73	(+)1264.70	(-)76.74	(+)217.39
Tree clad area / Dense/Closed	51.031	20.32	55.225	21.99	49.884	19.86	(+)8.22	(-)9.67	(-)2.25
Subtotal	**62.351**	**24.83**	**66.796**	**26.60**	**60.421**	**24.06**	**(+)7.13**	**(-)9.54**	**(-)3.09**
Wastelands									
Barren Rocky/Stony	0.721	0.29	0.56	0.22		0.00	(-)22.33	(-)100	(-)100.00
Scrub	16.184	6.44	14.101	5.61	4.862	1.94	(-)12.87	(-)65.52	(-)69.96
Salt affected	7.307	2.91	0.52	0.21	3.932	1.57	(-)92.88	(+)656.15	(-)46.19
Subtotal	**24.212**	**9.64**	**15.181**	**6.04**	**8.794**	**3.50**	**(-)37.30**	**(-)42.07**	**(-)63.68**
Water-bodies									
Reservoir /Tank	8.908	3.55	15.922	6.34	16.270	6.48	(+)78.74	(+)2.19	(+)82.64
River/Stream	9.467	3.77	1.647	0.66	3.689	1.47	(-)82.60	(+)123.98	(-)61.03
Subtotal	**18.375**	**7.32**	**17.569**	**7.00**	**19.959**	**7.95**	**(-)4.39**	(+)13.60	**(+)8.62**
Total	**251.151**	**100**	**251.151**	**100**	**251.151**	**100**			

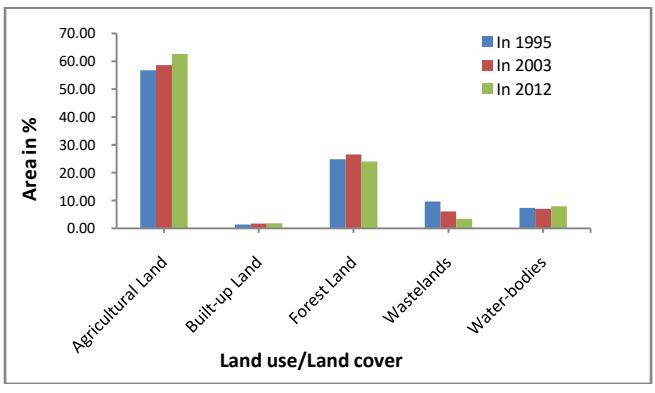

Fig.6 Percentage distribution of LULC in the study area during 1995-2012

V. CONCLUSION

As the study area is a rural sub-watershed the main occupation is agriculture. Hence, it is observed that forest area and waste land has been decreased drastically, which might have been utilized for agricultural activity. So, there is approx 10.19% increase of agricultural land since last 22 years. It is necessary to closely monitor the LULC changes for maintaining a sustainable environment in the sub-watershed. Consideration of the existing socio-economic scenario will be necessary before implementing any sort of land use practices in the study area in the future. The study clearly established that the RS coupled with GIS can be a powerful tool for mapping and evaluation of change detection of LULC of a given area.

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