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RESEARCH ARTICLE

AN ANALYSIS OF LANDUSE AND LANDCOVER IN TIRUCHIRAPPALLI DISTRICT USING LEAST SQUARE METHOD

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ABSTRACT

Landuse and Landcover changes for the years 1990, 2000 and 2010 have been analysed. Each of the landuse and landcover types exhibit positive and negative changes in all decades that have been considered. Agricultural land, Natural vegetation and water bodies show a decrease in area whereas fallow land, built-up land, scrub without scrub lands and sandy areas go on increasing. The change in land use and land cover category shows a decrease in agricultural land 2088.48sq.km; natural vegetation; 492.52sq.km and water bodies 247.03sq.km respectively whereas an increase in built-up land I & II 316.16sq.km and 359.37sq.km, fallow land 346.91sq.km, scrub without scrub land 367.42 sq.km and sandy area 165.23sq.km. In 2020, the area of agricultural land would decrease to 2010.98 sq.km as per the estimation. It has been estimated that in 2020 the area of built-up land-I would be 338.12 sq.km and Built-up land –II would be 381.11sq.km.The major reasons for these changes are increase in population, climate change and socio economic development activities.

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INTRODUCTION

Land is the basic resource of human society. It is the most significant among the natural resources of the country and most of its population depends on agriculture for the livelihood. The basic requirement of human society is food. Land is being used by people for various purposes. Landuse and change always been of interest to geographers. This topic of geographic research in landuse and landcover change using the least squares statistical method.LSM (Least Square Method) is one of the techniques of Statistics. Anderson (1971) studied the land use classification using GIS. Byrant (1976) studied the interaction among the forces and the effects of land use changes on associated attributes such as land quality and land value. These investigations offer further insight into lands, enhance the knowledge, and provide a sound basic from which both management and planning policies, regarding land resources can be made. Rhind and Hudson (1980) described the land use studies with reference to agriculture and urban land use pattern. Jensen (1981) explains change detection that can be performed manually by means of visual digital change detection techniques. Gautam et al. (1982) dealt with the technique of remote sensing and how far it helps in the rapid study of geographical phenomena especially land use within a very short time and accurate manner. According to Singh, (1989) change detection is the process of identifying differences in the state of an object or phenomenon by observing it at different times. It can be used in monitoring and managing natural resources and urban development because it provides quantitative analysis of the data. Prithvish Nag and Smith Sengupta (1992) made an attempt on the general geographical details of India, land use in India, climate, irrigation agriculture, and population. Luong (1993) studied present Land use and land cover mapping and change detection in Tripura using LANDSAT data. The LANDSAT data were analyzed on a sophisticated interactive Multispectral Data Analysis System (MIDAS) with the help of training sets of each category collected during field visits. Ninety percent accuracy of these categories was achieved, which were compiled with the ground survey. The area of each land use category was also calculated for monitoring land use changes. This paper also utilizes the NRSA (1998) report on the land use and land cover and degradation surveys using remote sensing techniques. Yaoqi Zhang and Jussi Uusivuori (2000) have studied to estimate the rainforest cover in Hainan China by Least Square estimation method. Bernardo Campolina (2014) studied the method of least squares to create the econometric model to calculate the anthropized area using the covariates like population density, size of the cattle group, plant area of grains etc., In 2013 Mulatu and Vanderveen studied a global

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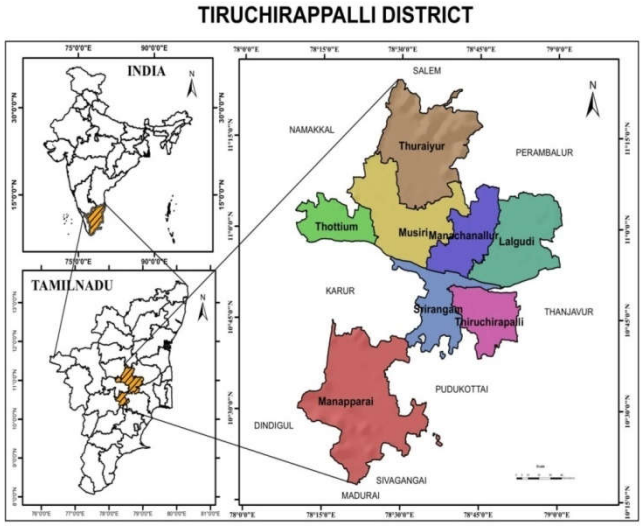
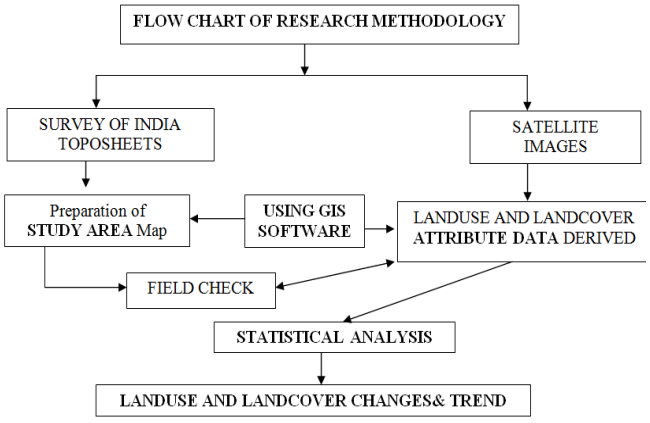
Ordinary Least Squares (OLS) regression model to evaluate the relationship between population and landuse and landcover types. In this study the technique of Least Square Method is used to calculate and estimate the changes in landuse and landcover with the data collected for the years 1990, 2000 and 2010

Study area

The study area Tiruchirappalli district is located at the central part of Tamil Nadu surrounded by Perambalur district in the north, Pudukottai district in the south, Karur and Dindigul districts in the west and Thanjavur district in the east. It lies between 10°10' and 11°20' of the Northern latitudes and 78°10' and 79° 0' of Eastern latitudes. It covers an area of 4403.79 sq.km and it forms parts of the Survey of India (SOI) topographic sheets having the index of numbers, 58/E 16, 58/I 4,7,8,11,12,14,15,16 58/M 3,4,7,8 58/F 13, 14 58/J 1,2,5,6,7,9,10,13 and 58/N 1 on a scale of 1:50,000 (Fig. 1).



The general slope of the district is towards east. It has a number of detached hills, among which Pachamalai Hill is an important one, which has a peak up to 1015m, located at Sengattupatti Rain Forest. Tiruchirappalli district is comprised of eight taluks. This includes 14 blocks, 408 Village Panchayats and 1590 Villages. This district consists of four municipalities. Tiruchirappalli is the only Corporation which is also the Head Quarters of the District.



Objective

The main objective of the study is to analyse each type of landuse and landcover and to determine the trend of change using the least square method.

MATERIALS AND METHODS

The methodology adopted (flow chart) here is based on a hybrid approach of visual and digital techniques and analyses with GIS software. The study is to understand the state of the present, past and future landuse and landcover change in Tiruchirappalli district.

For this analysis, three sets of satellite imageries were taken to project the future trend of each type of landuse and landcover.

Table 1. Agricultural land

Year X	Agriculture land Y	X=X- 2000	XY	X2	Trend yt
1990	2257.31	-10	-22573.1	100	2264.18
2000	2193.57	0	0	0	2179.78
2010	2088.48	10	20884.8	100	2095.38
Total	∑y= 6539.36	∑x = 0	∑xy =-1688.3	∑x2 =200	∑yt=6539.34

By the method of least squares using the formula
$\sum y = NA + B\sum x$
$\sum xy = N\sum x + B\sum x^2$ the trend has been studied.

$\sum y = NA + B \sum x$
$=3(A)+B(0)=6539.36$ $A=6539.36/3$
$A = 2179.78$

$\sum xy = N \sum x + B \sum x2$
$=3(0)+B(200)=1688.3$
$=0+B200=1688.3$
$B= 1688.3/200$
$B = -8.4415$

The trend equation $Y= A +Bx$

X= 1990, Trend yt = 2179.78 +-8.44 (-10)
= 2179.78 +84.4 = 2264.18

X= 2000, Trend yt = 2179.78 + -8.44 (0)
= 2179.78 - 0 = 2179.78

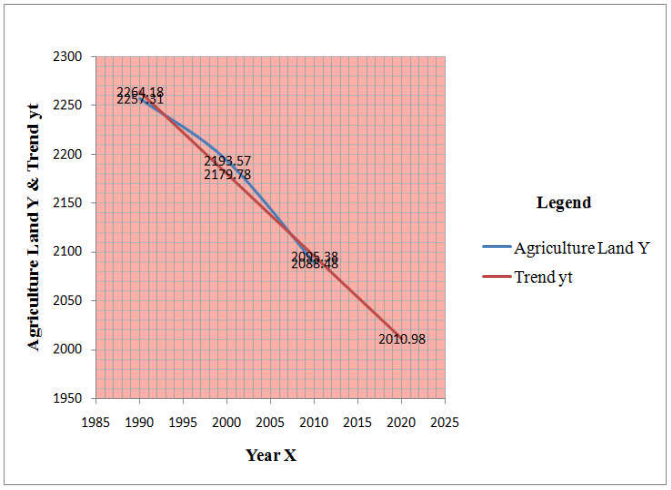
X= 2010, Trend yt = 2179.78 + -8.44(10)
= 2179.78 -84.4 = 2095.38

X = 2020, Trend yt = 2179.78 +-8.44 (20)
=2179.78 +-168.8
= 2179.78 -168.8 = 2010.98

The agriculture lands were highly concentrated in the year 1990 of the study area, which is 2264.18sq.km. In the year 2000 the agriculture lands were identified as 2179.78sq.km. As

the population started to increase, cultivatable lands were transformed into built-up land for residential as well as industrial purposes.

With the beginning of the above said industries, the agricultural lands surrounding them were transformed into built up lands. The available agricultural land started to decline gradually as 2095.38sq.km in the year 2010 and with the same trend there will be an estimated further reduction of 2010.98sq.km by 2020 (Graph-1).



Agriculture land trend line by least square method (Graph-1)

Table 2. Built- up land-i (Urban)

The given table was computed based on the least square formula (like Built-up land- I)

Year X	Built-up Land -I Y	X=X- 2000	XY	X^2	Trend yt
1990	271.09	-10	-2710.9	100	270.62
2000	292.12	0	0	0	293.12
2010	316.16	10	3161.6	100	315.62
Total	∑y= 879.37	∑x = 0	∑xy = 450.7	$\sum x^2$ =200	∑yt= 879.36

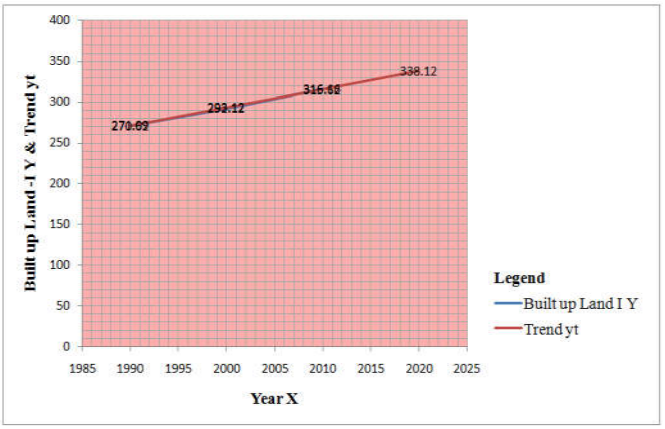
Built-up land –I (Urban)

The cause for the decline of agricultural lands is also the cause for the increase in built-up land in Tiruchirappalli district. By estimating through the method of least squares and also by general observation it is evident that the landuse for built-up land has increased particularly from the year 1990 to 2010.The rate of increase is around 20sq.km every decade. In 1990 the extent of built-up land was 270.62sq.km and it has increased 293.12sq.km in the year 2000.Whereas in 2010 it had further increased to 315.62sq.km. By employing the method of least squares it is estimated that by the year 2020, built-up land usage will shoot up to 338.12sq.km (graph-2).

Table 3. Built- up land-II

YearX	Built-up land - II Y	X=X-2000	XY	X^2	Trend yt
1990	315.65	-10	-3156.5	100	315.71
2000	337.52	0	0	0	337.51
2010	359.37	10	3593.7	100	359.31
Total	∑y= 1012.54	∑x = 0	∑xy = 437.2	$\sum x^2$ =200	∑yt= 1012.53

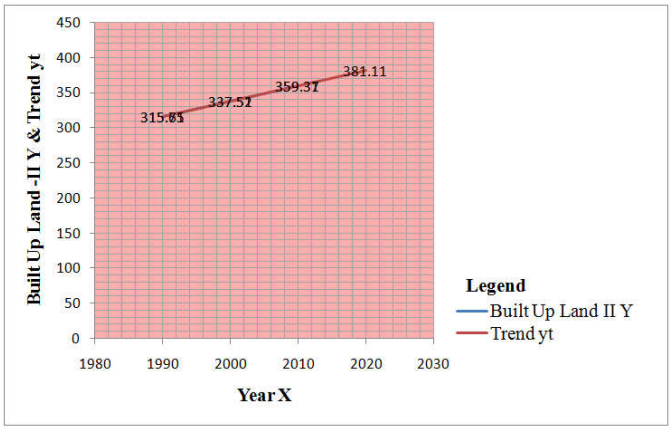
The above table was computed based on the least square formula (like Built-up land-II)



Built- up land- I trend line by method of least squares (Graph-2)

Built-up land-II (Suburban)

The industrial growth and settlement as a result made the utilization of lands for buildings in the urban area to come to a saturation point. From the calculation of the landuse in suburban areas by the method of least squares it is shown that there is a speedy increase in suburban built-up areas every 10 year at the rate of approximately 20 sq.km. In 1990 suburban built-up land area was 315.71sq.km and it is estimated that it would shoot up to 381.11sq.km (graph-3) by the year 2020. It was 337.51 sq.km in the year 2000 and 359.31in the year 2010.



Built-up land- II trend line by method of least squares (graph-3)

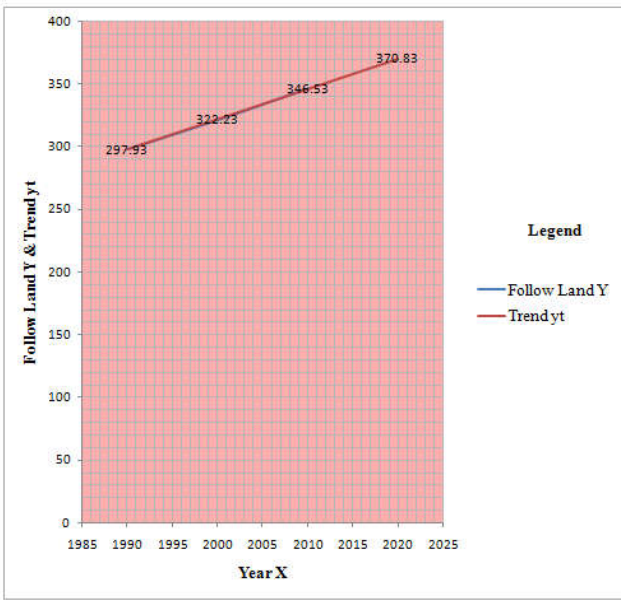
Table 4. Fallow land

Year X	Fallow land Y	X= X- 2000	XY	X^2	Trend yt
1990	298.22	-10	-2982.2	100	297.93
2000	321.58	0	0	0	322.23
2010	346.91	10	3469.1	100	346.53
Total	∑y= 966.71	∑x = 0	∑xy = 486.9	$\sum x^2$ =200	∑yt= 966.69

The above table was computed based on the least square formula (like Fallow land)

Fallow land

Giving up of agricultural activities, migration and boom of industries and climatic changes have made many an agricultural land become fallow . A steady increase is observed every year in the case of fallow lands. In the year 1990 fallow land occupied an area of 297.93sq.km whereas in 2000 it was 322.23sq.km and in 2010 it was 346.33sq.km. From the calculations using the method of least squares it is estimated that the fallow land area will be 370.83sq.km by the year 2020 (Graph-4)



Fallow land trend line by method of least squares (Graph-4)

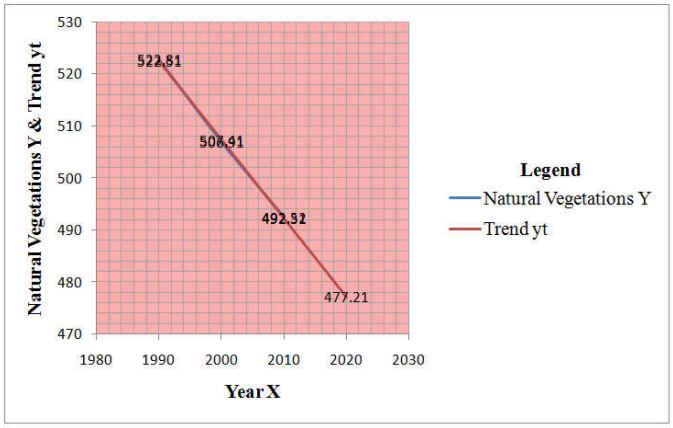
Table 5. Natural vegetation

Year X	Natural vegetation Y	X= X- 2000	XY	X^2	Trend yt
1990	522.81	-10	-5228.1	100	522.51
2000	506.91	0	0	0	507.41
2010	492.52	10	4925.2	100	492.31
Total	∑y= 1522.24	∑x = 0	∑xy = -302.9	$\sum x^2$ =200	∑yt=1522.23

The above table was computed based on the least square formula (like Natural vegetation)

Natural vegetation land

From the estimations and calculations of changes in the land cover of natural vegetation an alarming rate of decrease is understood. The trend estimation shows by a leap of 15 hectares every 10 years the natural vegetation is destroyed more than anything else, which is a threat to the eco-system. In 1990 natural vegetation occupied an area of 522.51sq.km, whereas in 2000 it was 507.41sq.km and 2010 it was 492.31sq.km. From the extent of natural vegetation cover of 522.51 sq.km the 1990, it is estimated, that it would steeply stoop down to 477.21 sq.km by 2020 (Graph-5).



Natural vegetation trend by method of least squares (Graph-5)

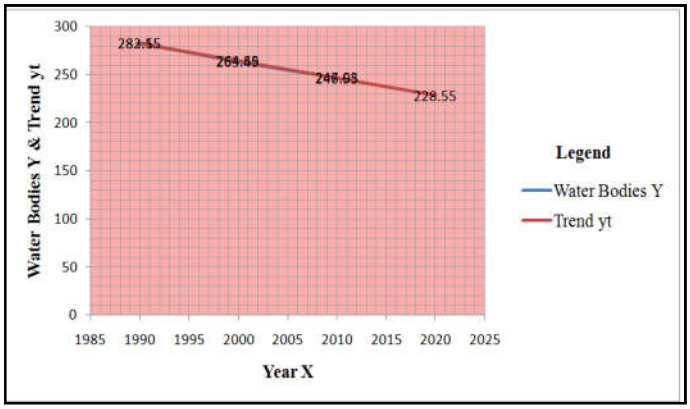
Table 6. Water bodies

Year X	Water bodies Y	X= X- 2000	XY	X^2	Trend yt
1990	283.15	-10	-2831.5	100	282.55
2000	263.49	0	0	0	264.55
2010	247.03	10	2470.3	100	246.55
Total	∑y= 793.67	∑x = 0	∑xy = -361.2	$\sum x^2$ =200	∑yt=793.65

The above table was computed based on the least square formula (like Water bodies)

Water bodies

The estimation of changes in the landcover of water bodies, a great decrease is shown. The reasons for the decrease are increased water usage, underground water depletion, irregular seasonal changes and encroachment. In the year 1990 water bodies occupied an area of 282.55sq.km, whereas in 2000 it was 264.55sq.km and in 2010 it was 246.55sq.km. In every 10 years landcover of water bodies decreased by 18sq.km. It will be 228.55sq.km by 2020 (Graph-6).



Water bodies trend line by method of least squares (Graph-6)

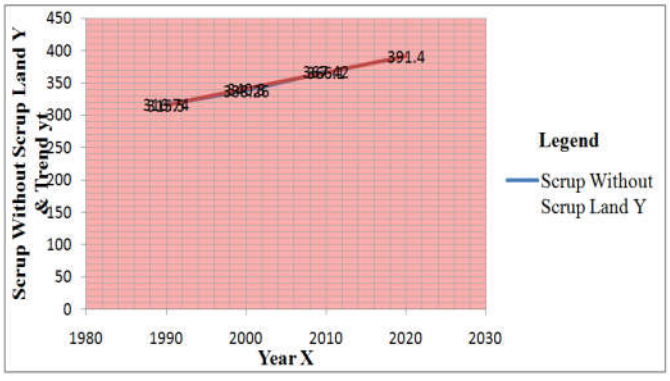
Table 7. Without scrub land

Year X	Scrub without scrub land Y	X= X- 2000	XY	X^2	Trend yt
1990	316.74	-10	-3167.4	100	315.5
2000	338.26	0	0	0	340.80
2010	367.42	10	3674.2	100	366.1
Total	∑y= 1022.42	∑x = 0	∑xy = 506.8	$\sum x^2$ =200	∑yt=1022.4

The above table was computed based on the least square formula (like without scrub land)

Scrub without scrub land

Every decade, scrub without scrub land goes on increasing at the rate of 25 hectares per 10 years. The un-administered lands and abandoned lands become scrub without scrub lands and hence the increase. In 1990 scrub without scrub occupied an area of 315.5 sq.km, whereas in 2000 it was 340.80 sq.km, and in 2010 it was 366.1 sq.km. In 1990 it was 315.5 sq.km and the increase will be 391.4 sq.km 2020 (Graph-7). Due to population increase scrub lands are converted into plots and this is also the reason for the increase in the lands without scrub.



Scrub without scrub land trend line by the least squares method (Graph-7)

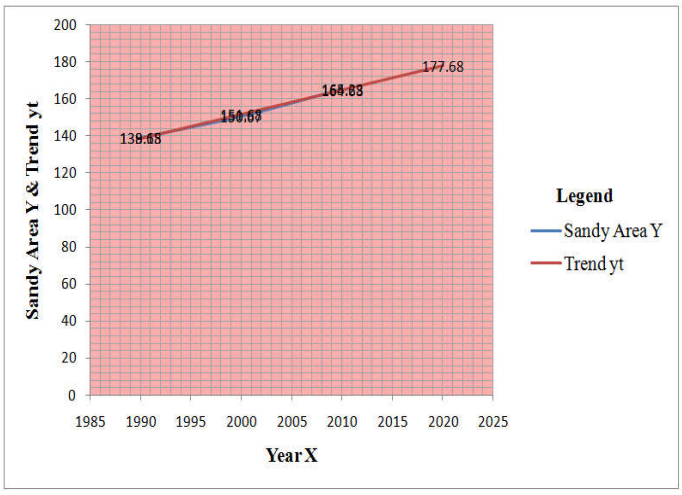
Table 8. Sandy area

Year X	Sandy area Y	X=X- 2000	XY	X2	Trend yt
1990	139.15	-10	-1391.5	100	138.68
2000	150.67	0	0	0	151.68
2010	165.23	10	1652.3	100	164.68
Total	∑y= 455.05	∑x = 0	∑xy = 260.8	∑x2 =200	∑yt=455.04

The above table was computed based on the least square formula (like Sandy area)

Sandy area

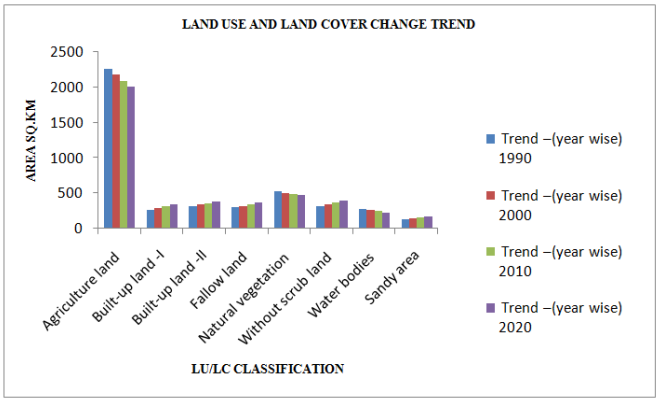
The increase in sandy area is known from the table and the estimated sprawl of sandy area in 1990 was 138.68 sq.km whereas in 2000 it was 151.68 sq.km and 2010 it was 164.68 sq.km. In 2020 it has been calculated using least square method and it will be nearly 177.68 sq.km (Graph-8) compared to the past sprawl of 138.68 sq.km in 1990. The increase is due to the decrease of water bodies. The water bodies dry up and in course of time they become sandy area.



Sandy area trend line by method of least squares (Graph-8)

Table 9. Land use and land cover change trend in Tiruchirappalli district

Classification Types	Landuse and Landcover Trend –(year wise)			
	1990	2000	2010	2020
Agriculture land	2264.18	2179.78	2095.38	2010.98
Built-up land -I	270.62	293.12	315.62	338.12
Built-up land -II	315.71	337.51	359.31	381.11
Fallow land	297.93	322.23	346.53	370.83
Natural vegetation	522.51	507.41	492.31	477.21
Without scrub land	315.5	340.80	366.1	391.4
Water bodies	282.55	264.55	246.55	228.55
Sandy area	138.68	151.68	164.68	177.68



Conclusion

Landuse and landcover change is a phenomenon, which is of serious concern and needs immediate attention in all the growing rural and urban areas globally. Thus the least squares method which operates under the principle 'The error or residual sum of squares be the least' has been successfully adapted to estimate the changes in the land use and land cover of Tiruchirappalli district. By using this method to estimate the numerical values of various parameters like agricultural lands ,built-up lands, fallow lands, natural vegetation , scrub without scrub lands water bodies sandy area and so on. To fit the function to the set data of the above said parameter and to characterize the statistical properties of the estimates, the increase or decrease, the rate of increase or decrease and the trend and the change that follow have been found out to the highest possible perfection. Least square method (LSM) has been very useful in this as it can modulate the importance of each observation in the final solution.

Finally, the 1990, 2000 and 2010 landuse and landcover data have been compared and analyzed and there will be drastic changes in landuse and landcover categories. Thus it is understood clearly that agricultural land, natural vegetation and water bodies show a downward spiral of decrease in area where as fallow land, built-up land, and scrub without scrub lands and sandy areas go on increasing. In 2010 Agriculture land was 2088.48 sq.km, Built-up land I and II were 316.16sq.km and 359.37sq.km, Fallow land was346.91sq.km, Natural vegetation was 492.52sq.km, Water bodies were 367.42sq.km, Scrub without scrub land was 247.03sq.km and sandy area was165.23sq.km.Built-up –I and Built-up land –II land having the highest increase compared to 271.09 sq.km & 315.65 sq.km in 1990, was increased to 316.16sq.km & 359.37 sq.km in 2010. In 1990 Agriculture land cultivation was 2257.31sq. km, and it was decreased to 2088.48sq.km in 2010.In 2020, the area of agricultural land will be decreased to 2010.98sq.km as per the estimation. It has been estimated that in 2020 the area of built-up land-I will be 338.12 sq.km and Built-up land –II will be 381.11sq.km.

The last twenty year period shows many drastic changes in agriculture land particularly these lands are converted to Real Estate lands. The real estate land included Government offices, Educational institution, industries and settlements. The major reasons for these changes are increase in population, climate change and socio economic development activities.

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