American Journal of Geophysics, Geochemistry and Geosystems
Vol. 1, No. 2, 2015, pp. 37-51
http://www.aiscience.org/journal/aj3g

Land Use and Land Cover Change of Salem City in Tamilnadu, India Using Remote Sensing and GIS

Tamilenthi S.[1, *], Arul P.[2]

[1]Dept. of Geography, Kalinga University, Raipur, India
[2]Dept. of Geography, Govt. Arts College (Auto), Salem, India

Abstract

There has been rapid change in the land use and land-cover types in Salem city in Tamilnadu, India in the past 37 years. The major change is the conversion of agriculture and forest lands into urban areas mostly in an un-planned manner making urban sprawl characterizing the urban change dynamics. Land use change has been the reason for many social, economic and environmental problems in Salem city, the capital city of Salem district over the past decades. This has engaged the researchers to find out possible measures to address and monitor this phenomenon. The principal aim of this research was to apply remotely sensed data, geospatial tools to detect, quantify, analyze and detect the urban land use changes of Salem city. Salem is a city is bound between the latitude 11° 39 ` to 11° 65`N and longitude 78° 16` to 78° 9`E. It covers an aerial extent of 12 4 sqkm. The ultimate objective of the research is to detect the land use/land-cover change of Salem city from 1973 to 2010. Satellite images of Salem city at different periods, 1973 and 2010 were analysed. The software programs that have been used in this study to process, quantify, analyze and change detection are ArcGIS 9.2, ArcMap and ERADAS 9.3.The change detection procedure, however it was able to identify the areas of significant change. The seasonal variations of two satellite images used in the analysis affected the spectral resolution which subsequently affected the change detection process. Because of the variation of the temporal resolution and other environmental factors, the same land cover class can have different radiance values between the images. Post-classification comparison change detection was conducted to reveal the areas that have changed over the period of 37 years. In this method, the from-to-change informational classes were available. The results revealed drastic growth of urban areas and reduction of Barren Rocky Surface, Fallow land, Crop & Plantation, Land with Shrub and River.

Keywords

Urban Change, Urban Sprawl, Land Use & Land Cover and Salem City

Received: May 8, 2015 / Accepted: May 14, 2015 / Published online: June 12, 2015

1. Introduction

The history of urban growth indicates that urban areas are the most dynamic places on the Earth's surface (Yikalo H. Araya and Pedro Cabral, 2010). In India as well as in most developing countries, the excessive growth in population and the increased trend towards urbanization have led to many evils such as haphazard growth of industries, unplanned housing and utility networks, conversion of precious agricultural and forest land into urban land etc. Urban Land is one of the important resources provided to man by which necessary human activities are performed. Accurate and up to date information about the urban land is indispensable for scientific planning and management of urban resources of an area taking into consideration the potentials and the constraints to the environment. The rational planning and

* Corresponding author
E-mail address: rst_tamil2006@yahoo.com (Tamilenthi S.)

management of urban is possible through the regular survey of the land use helps in delineating land suitable for various activities and to detect the land use changes (Adeniyi and Omojola,1999).Conventional ground methods of land use mapping (Chains to measure distances ,Old mechanical Theodolites, Vernier Theodolites, Paper maps etc) are labour intensive, time consuming and are done relatively infrequently. These maps soon become outdated with the passage of time, particularly in a rapid changing environment. The monitoring of changes and time series analysis is quite difficult with traditional method of surveying. In recent years, satellite remote sensing techniques have been developed, which have proved to be of immense value for preparing accurate land use / land cover maps and monitoring changes at regular intervals of time. In case of inaccessible region, this technique is perhaps the only method of obtaining the required data on a cost and time – effective basis. (Olorunfemi, 1983).

The Indian Remote Sensing (IRS) Linear Imaging Self-Scanning Sensor (LISS) provides high ground resolution and specified spectral resolution data for detailed studies of urban land use and for monitoring land use changes. This study was undertaken for mapping the unplanned development of the Salem town. This will provide up to date information to the planners so as to fill up the gap between urban growth and information collection process.

The fundamental problem involved in producing accurate land use maps of urban areas arises from the fact that urban areas are complex assemblages of a disparate set of land cover types including man-made structures, vegetation and water bodies – each of which has different spectral reflectance characteristics. In visual analyses of remotely sensed images the spatial pattern of these land cover types is often used to distinguish between categories of urban land use. For example, their particular mixture of buildings, roads, grass and trees can often recognize residential areas; by contrast parkland is primarily composed of grass and trees (Barr, 1992 and Tonjes 1999).

Recently, several studies have attempted to use the spatial mixing of land cover types within urban areas as a means of mapping land use. The various forms of (per-pixel) spatial reclassification techniques applied to an initial (land cover) segmentation of urban areas were those of Whitehouse (1990) and Barnsley et al.(1991).

The study conducted on land cover change detection pilot study of the Washington D.C. area. Seventy-five change-detection techniques and variations were systematically tested and evaluated using both visual and statistical methods. The initial results suggest that the automated scatter-gram controlled regression normalized image differencing and normalized difference vegetation index (NDVI) differencing outperform most other change-detection techniques. However, more testing of the data is needed in geographically diversified regions (Yuan et al. 1998).

Many organizations have attempted to provide a definition, but it turns out that the definition depends on that organization's perspective, usually polarized between a pro-growth and an anti-sprawl viewpoint.

1.1. Land Use and Land Cover Types

The various land use and land cover categories in Salem are listed below:

1) Agricultural land which consist of shrub land, grass/herb, dense/grass fallow.2) Forest consisting of closed forest, open forest and reserve forest 3) Urban areas.4) Bare land.5) Water bodies.6) Unclassified lands.

1.2. Research Hypothesis and Questions

This study is based on the hypothesis that there have been considerable urban land use changes in the study area. It also tests two research assumptions:

1) It is possible to use Remote Sensing and GIS tools to study urban growth analysis.

2) There is a significant urban land use changes and urban sprawl in the study area during the 37 years period.

In order to assist the analysis, the following research questions will also be posed:

3. Have there have been major changes in the urban environment of the study areas?

4. What was the spatial extent of the land cover change and where was the highest rate of changes?

5. What were the major deriving forces for the changes?

1.3. Aims and Objectives

The principal aim of this research was to apply remotely sensed data, geospatial tools to detect, quantify, analyze, and forecast urban land use changes.

The following were also some of the specific objectives of the research:

1. Quantify and investigate the characteristics of urban land use over the study area based on the analysis of satellite images.

2. Identify whether there have been and will be significant urban land use changes.

3. To analyze the land use and land cover pattern for the specific periods.

4. To detect land use and land cover pattern for the study period.

5. Analyze the specific issues of the urban environment and put forward a recommendation or set of recommendations that may form the basis for a sound solution for sustainable land management.

1.4. Significance of the Study

One of the major impacts of urban land cover dynamics is a shrinking amount of cultivated land through the development of infrastructures and various developments projects. Therefore, urban land use change studies are important tools for urban or regional planners and decision makers to consider the impact of urban sprawl. The results of this study would provide information relevant to contribute in the environmental management plans and improve urban planning issues. It is also expected to:

1) Provide information on the status and dynamics of the urban land use of the area and the use of remote sensing from satellite imagery for such analysis for planners. Assist environmentalist, regional (urban) planners, and decision makers to consider the potential of geospatial tools for monitoring and planning urban environment.

2) Provide elements for long term bench-mark monitoring and observation relating to resource dynamics.

3) Provide a base line for eventual research follow-up, by identifying specific and important topics that should be considered in greater detail by those interested in the area. Urban sprawl and growth information are relevant to variety of people, agencies etc. for decision making. Among these users are both government and non- governmental agencies. Some of these potential users are town and country planners, urban planners, statisticians, environmental agencies, land owners etc.

2. Study Area

Salem District is one of the land locked Districts in Tamilnadu. It is bounded on the North by Dharmapuri district, on the South by Namakkal district, on the West by Erode district and, on the East by Villupuram district (Fig.1). The district has 4 Revenue divisions, one corporation and 3 municipalities. There are 20 Panchayat unions in the district as on 1996-97. Salem is a city and a corporation in Salem district in the Indian state of Tamil Nadu, located in the north central part of the southernmost state of India. It is the 5th largest Municipal Corporation and Urban agglomeration in Tamil Nadu next to Chennai, Coimbatore, Madurai and Trichy. (Wikipedia)

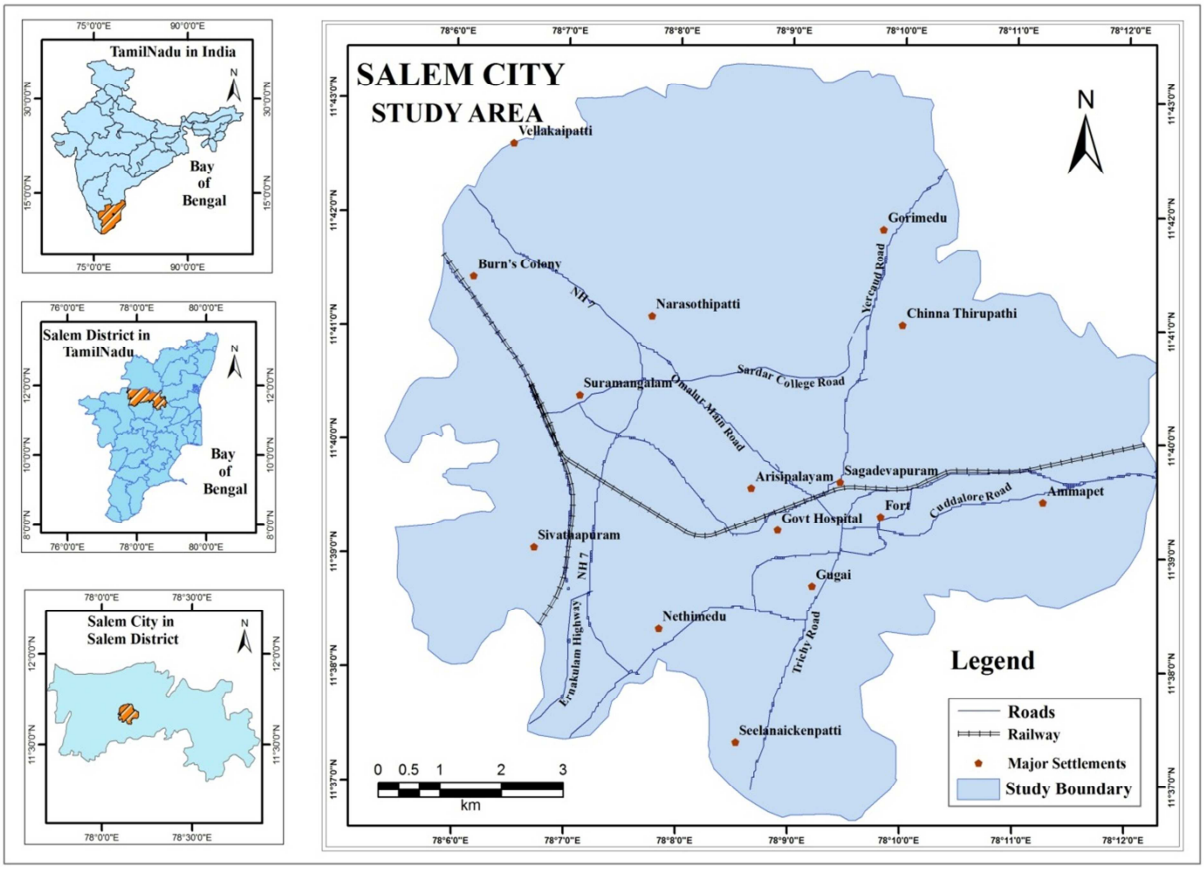

Fig. 1. Location map of the study area.

The city is surrounded by hills on all sides: the Nagaramalai to the north, the Jarugumalai to the south, the Kanjamalai to the west, and Godumalai to the east. It is divided by the river Thirumanimuthar in the main division. The fort area is the oldest part of the town.

3. Research Design

In order to detect areas that have changed as a result of the expansion of the urban, the procedures as shown in the flow chart were followed. The first thing to consider is the processing of the remotely sensed data to extract change information. Basically, the main processes involve are pre-processing (geometric registration and radiometric correction), followed by image classification, change detection and finally assessing the statistical accuracies of the classification in change detection process.

Flow chart for the methods employed

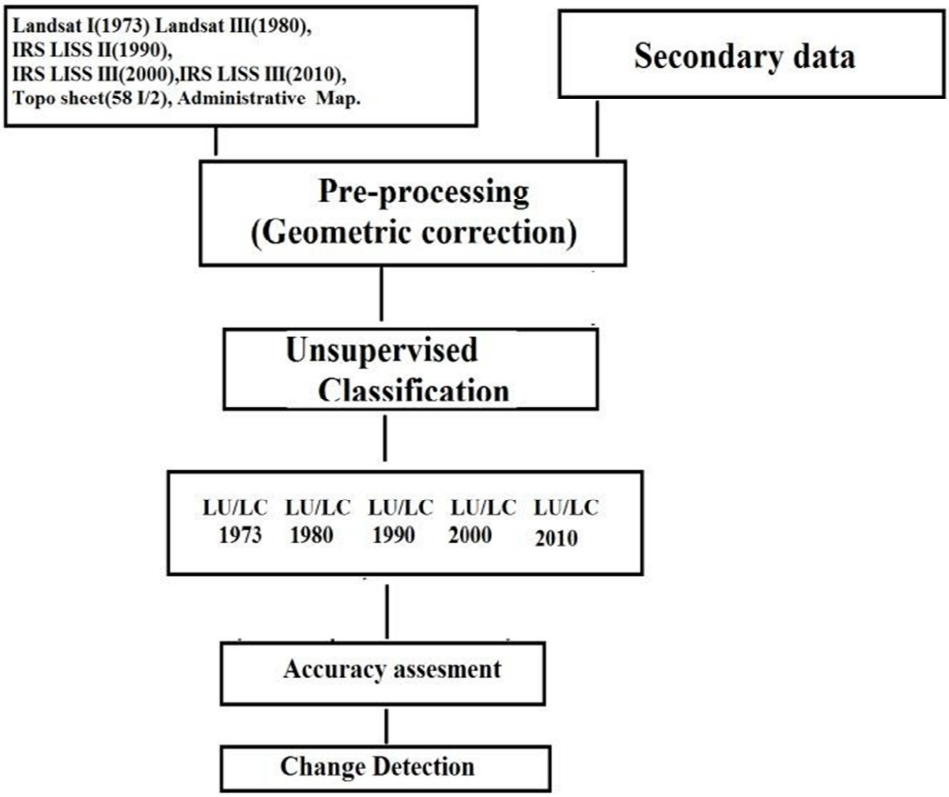

Fig. 2. Flow chart for methodology employed in digital change detection.

Table (1). Data Source.

Sl. No	Sensor	WRS: Path/Row	Resolution	Year of production	Source
1	Landsat 1 Panchromatic RBV,MSS	154/52	57X57	1973	glcf
2	IRS LISS III (P6)	101/65	23.5 x 23.5	2010	NRSC
3	Topographic map	58 I/2	1:50,000	1972	GSI, India.
4	Administrative Map of Salem corporation	11°39′ to 11°.65′N & 78°.16 to 78° 9′36″E	1:1,000	2010	Town planning Office, Salem

3.1. Sources of Data

For this study Landsat satellite images of salem city were acquired for five Epochs; Landsat 1973, and LISS-III 2010. The Epochs of 1973 is obtained from Global Land Cover Facility (GLCF) an Earth Science Data Interface, while that of 2010 was obtained from National Remote Sensing Centre, Hyderabad. The Landsat data were acquired from the global land-cover website at the University of Maryland, USA, URL; http://glcfapp.umiacs.umd.edu:8080/esdi/index.jsp. The

satellite data were different resolutions but these all converted into 30m spatial resolutions.

It is also important to state that Salem city and its environs which were carved out using the local government boundary map and Salem city Administrative map was also obtained from Salem corporation office. Topographic map at a scale of 1:50,000 for 1972. The data were acquired from the Survey Department, Chennai, India.

3.2. Tools Used in the Study

The software programs have been used in this study to process, quantify, analyze and model the spatial dataset. For the preliminary data processing, extracting the study area and mosaicing satellite images, ERADAS 9.3 and Arc GIS 9.2-version was used.

4. Analysis

The data sets were analyzed with following ways for this study:

The ultimate objective of the research is to detect the land use/land-cover change of Salem city from 1973 to 2010. Satellite images of Salem city at different periods 1973,1980,1990,2000 and 2010 were analysed.

4.1. Land Use and Land Cover for 1973

The land use and land cover pattern based on unsupervised classification for 1973 is given below table(2.3).The highest level occupied was crop and plantation are of 8630.03 acres with 35.92% and the lowest level occupied was tanks area of 84.28 acres with 0.35%.

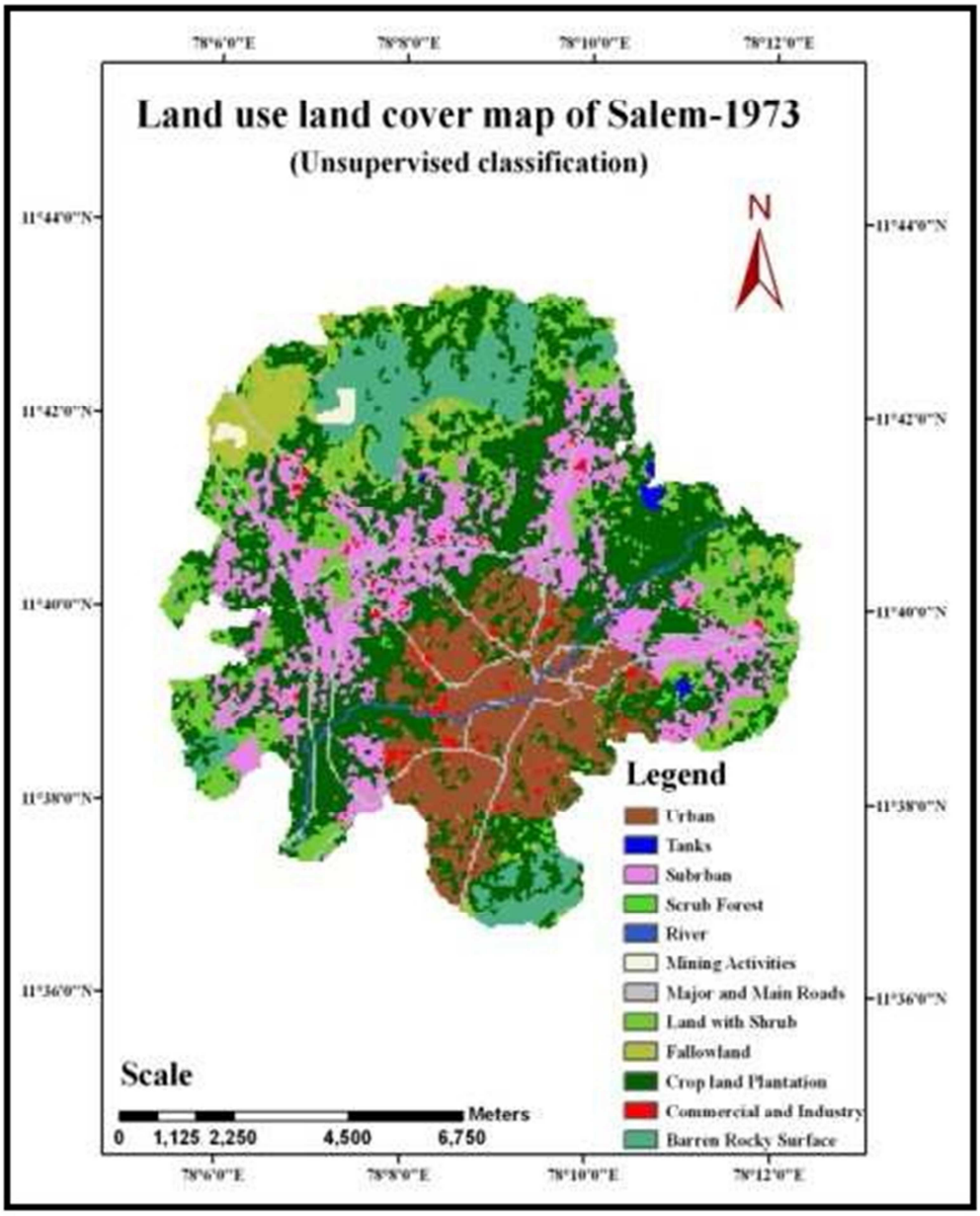

Fig. (3). Land use map of Salem, 1973.

Table (2). Land use and land cover for 1973.

Class	Land cover in 1973 (Acres)	Area (%)
Urban	3409.98	14.19
Sub-urban	4037.35	16.80
Com.& Industry	291.78	1.21
Roads	336.50	1.40
Mining activities	128.54	0.53
Crop & Plantation	8630.03	35.92
Land with shrub	3186.66	13.26
Scrub forest	501.05	2.08
Fallow land	1139.55	4.74
Tanks	84.28	0.35
River	196.49	0.81
Barren rocky surface	2080.28	8.66
Total	24019.55	100

The urban area occupied an area of 3409.98 acres with 14.19% in and the sub-urban area was 4037.35 acres with 16.80%. The commercial and industrial activity as covered with 36.22 acres of 1.40%.It was 128.54 acres with 0.53% to dedicate mining activities for the great demand of minerals in and around the district.

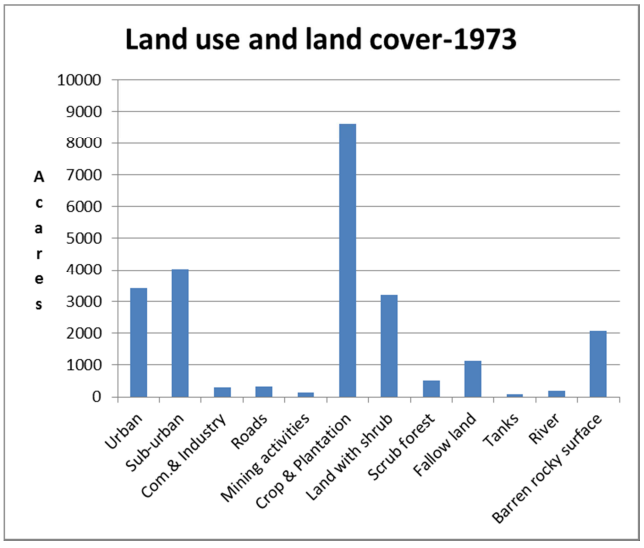

Fig. (4). Land use and land cover for 1973.

The analysis reveals that the crop land and plantation part was 8630.03 acres with 35.92 % and the land with shrub area was 3186.66 acres with 13.26%.The scrub forest was occupied 501.05 acres with 2.08 % and the fallow land was 1139.55 acres with 4.74%.

The area occupied for the tank it was 84.28 acres with 0.35% in 1973 and the river occupied area is 196.49 acres with 0.81%.The Barren and rocky surface land occupied area was 2080.28 acres with 8.66%(Fig.4& 5).

4.2. Land Use and Land Cover for 2010

The land use and land cover pattern for 2010 is given below table(6.3).The highest level occupied was Sub-urban area of 8368.50 acres with 34.84 % and the lowest level occupied was river area of 67.17 acres with 0.27%.

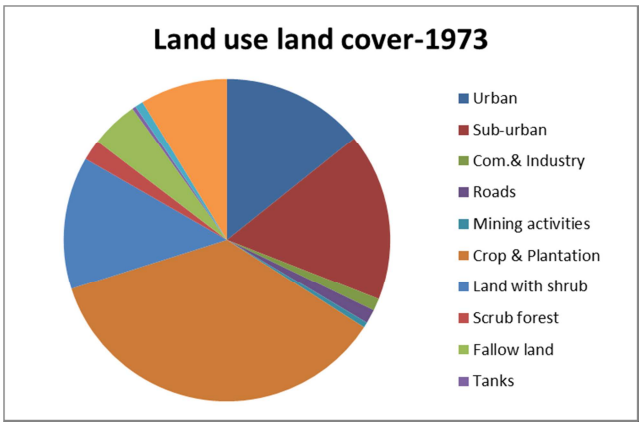

Fig. (5). Pie-chart- Land use and land cover for 1973.

Table (3). Land use and land cover for 2010.

Class	Land cover in 2010 (Acres)	Area (%)
Urban	5466.41	22.75
Sub-urban	8368.50	34.84
Com.& Industry	710.32	2.95
Roads	758.43	3.15
Mining activities	471.92	1.96
Crop & Plantation	3210.49	13.36
Land with shrub	1846.76	7.68
Scrub forest	1095.07	4.55
Fallow land	359.39	1.49
Tanks	272.19	1.13
River	67.17	0.27
Barren rocky surface	1392.86	5.79
Total	24019.55	100

The above table reveals for the land use and land cover pattern for 2010 the Salem city. The urban area occupied an area of 5466.41 acres with 22.75% in and the sub-urban area was 8368.50 acres with 34.84%. The commercial and industrial activity occupied is 710.32 acres with 2.95% and the roads covered with 758.43 acres of 3.15 %. It is 471.92 acres with 1.96 % to dedicate mining activities for the great demand of minerals in and around the district.

The analysis reveals that the crop land and plantation part was 3210.49 acres with 13.36% and the land with shrub area was 1846.76 acres with 7.68 %. The scrub forest is occupied 1095.07 acres with 4.55 % and the fallow land is 353.39 acres with 1.49 %.

The area occupied for the tank it was 272.19 acres with 1.13% and the river occupied area is 67.17 acres with 0.27%. The Barren and rocky surface land occupied area was 1392.86

acres with 5.79% (Fig.7 & 8).

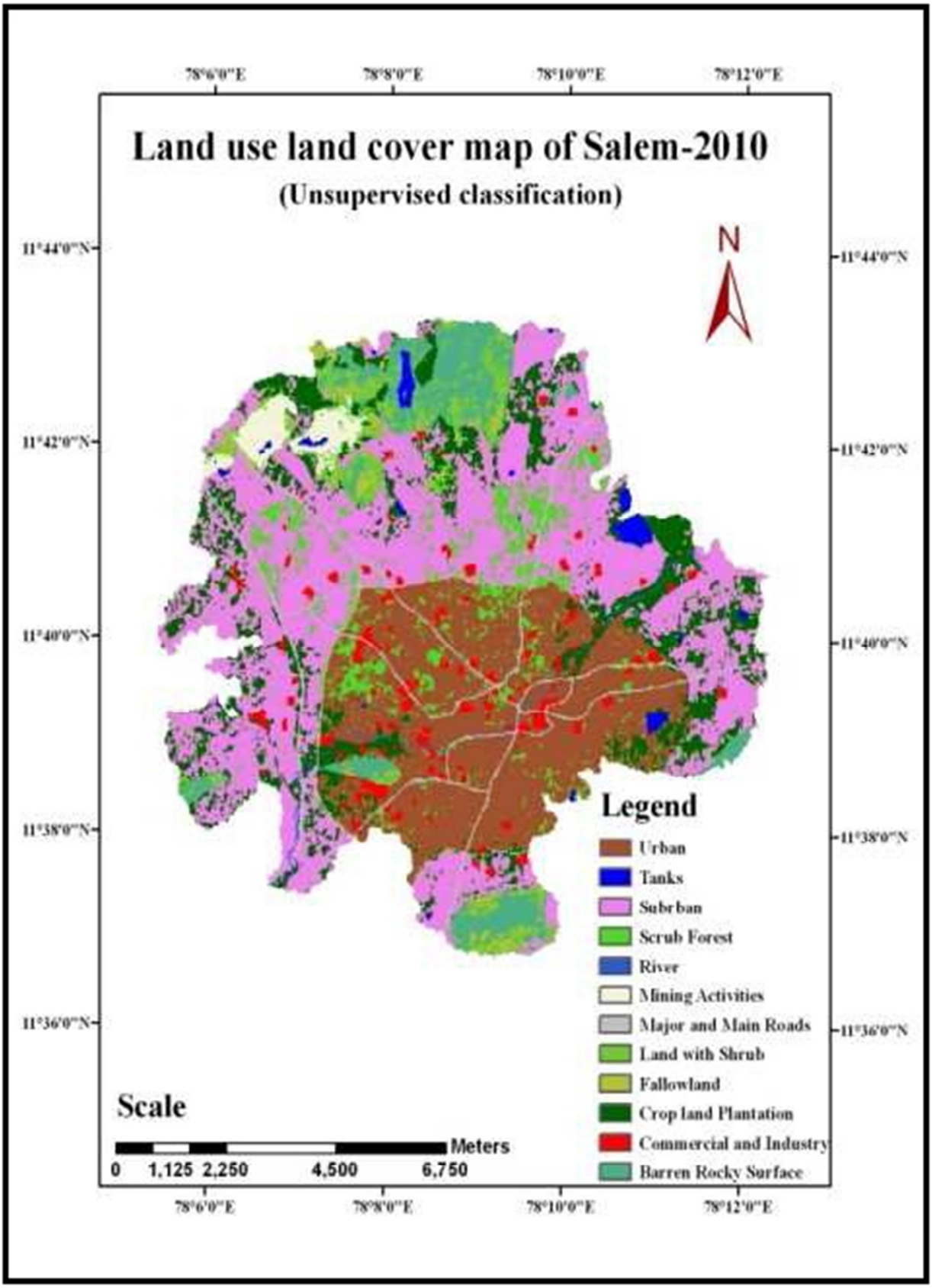

Fig. (6). Land use map of Salem,2010.

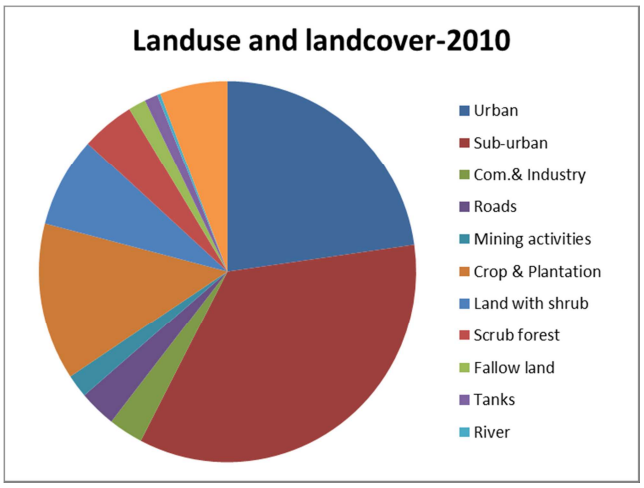

Fig. (7). Pie-chart- Land use and land cover for 2010.

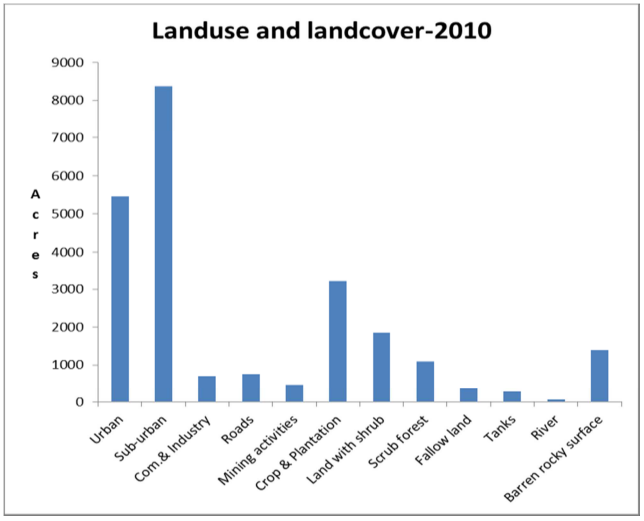

Fig. (8). Land use and land cover for 2010.

Table (4). Land Use and Land Cover from 1973 to 2010.

Class	1973 (Acres)	1980 (Acres)	1990 (Acres)	2000 (Acres)	2010 (Acres)
Urban	3409.98	3715.77	4012.67	4249.65	5466.41
Sub-urban	4037.35	4570.85	5534.74	6989.6	8368.5
Com.&Ind ustry	291.782	337.15	343.37	649.17	710.32
Roads	336.5	372.73	397.64	492.16	758.43
Mining Activities	128.544	139.08	184.36	262.38	471.92
Crop Plantation	8630.03	8346.04	4548.86	3501.6	3210.49
Land with Shrub	3186.66	3143.37	5120.64	4288.81	1846.76
Scrub Forest	501.05	669.4	943.39	1014.34	1095.07
Fallow land	1139.55	735.65	1032.8	736.34	359.39
Tanks	84.287	92.094	119.41	203.82	272.19
River	196.49	128.52	80.73	71.38	67.17
Barren Rocky Surface	2080.28	1768.48	1700.87	1559.84	1392.86
Total	24019.6	24019.6	24019.6	24019.6	24019.6

4.3. Land Use and Land Cover Change 1973-2010

The land use and land cover changes are detected from the images of 2000 and 2010. The changes are given below in change detection map (fig.7.9 & table 7.7&7.8) and this clearly reveals the changes have taken during this period. The change detection procedure, however it was able to identify the areas of significant change. The seasonal variation of the two satellite images used in the analysis affected the spectral resolution which subsequently affected the change detection process. Because of the variation of the temporal resolution and other environmental factors, the same land cover class can have different radiance values between the images. It can be concluded from the resulting statistics that the image-to-image change detection was more accurate that the post-classification comparison.

Table (5). Land use and land cover change for 1973-2010.

Class	1973 (Acres)	2010 (Acres)	Area change (1973-2010) (Acres)	Change (%)
Urban	3409.98	5466.41	2056.42	+60.30
Sub-urban	4037.35	8368.50	4331.14	+107.27
Com.& Industry	291.78	710.32	418.54	+143.44
Roads	336.50	758.43	421.92	+125.38
Mining Activities	128.54	471.92	343.37	+267.12
Crop Plantation	8630.03	3210.49	5419.54	-62.79
Land with Shrub	3186.66	1846.76	1339.90	-42.04
Scrub Forest	501.05	1095.07	594.01	+118.55
Fallow land	1139.55	359.39	780.16	-68.46
Tanks	84.28	272.19	187.90	+222.93
River	196.49	67.17	129.31	-65.81
Barren Rocky Surface	2080.28	1392.86	687.42	-33.04
Total	24019.6	24019.6	-	-

(+ Increase, - Decrease)

4.4. Urban

The urban area was occupied with 3409.98 acres and 5466.41 acres in 1973 and 2010 respectively. The total change of urban areas with built-up was 2056.42 acres with the increase of 60.30% in 37 years of period. The peripherals and urban fringe have turned as urban and hence urban area is extended.

4.5. Sub-Urban

The sub-urban area was 4037.35 acres in 1973 and it had increased to 8368.50 acres in 2010 with the change of 4331.14 acres in 37years with increase of 107.27%. The growth of Sub-urban area is except in the northern part the city and particularly leaving the mining area, all other area

concentrated.

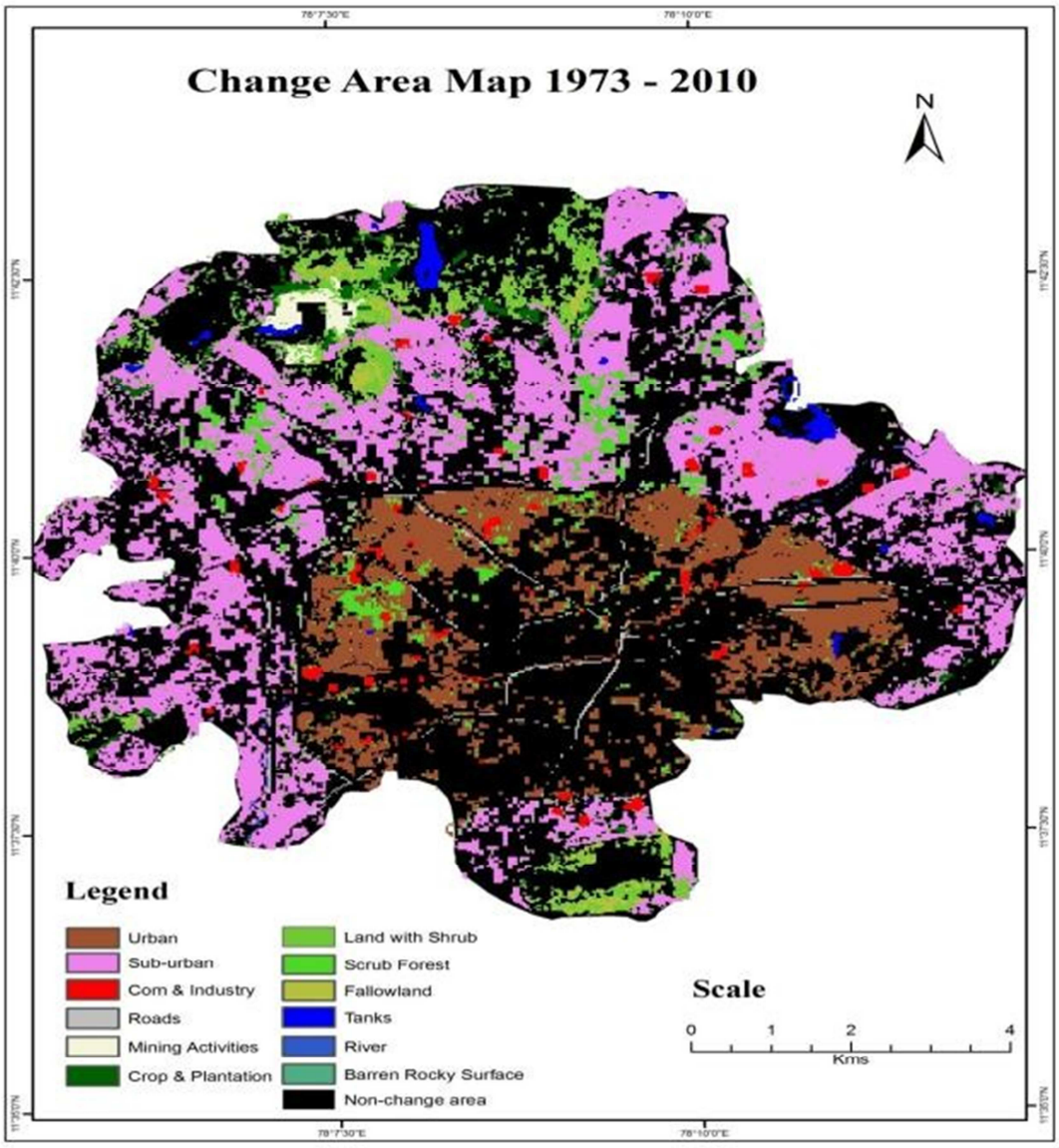

Fig. (9). Change detection 1973-2010.

4.6. Commercial and Industry

There has been increased in the Commercial and industrial activity as the part of urbanization. The area occupied was 291.78 acres and 710.32 acres in 1973 and 2010 respectively with the increase of 418.54 acres and it increase of 143.44%. Urban or core area of the city has occupied more commercial and industrial complexes in urban areas than sub-urban areas.

4.7. Roads

There has been increased in roads with area of 421.92 acres with 125.38% during the period of 1973 and 2010. It was occupied 336.50 acres in 1973 and in 2010 and it has reached to 758.43 acres. During this decade 2000-10 national highway is widened with six lane track under the prime ministers plan. The number of service roads for national highway is also constructed as the result it is found the increase of road area.

4.8. Mining Activities

It has been increased during the period of 1973 - 2010 it is 343.37 acres with highest rate of 267.12% among the classification to dedicate the mining activities for the great demand of minerals in and around the district. It was occupied 128.54 acres in 1973 and in 2010 it is 471.92 acres. This increase is found that the same mining area is extended due to mining activities and hence the area is increased.

4.9. Crop Land and Plantation

The analysis reveals that the crop land and plantation part has been decreased with 62.79% and it was 8630.03 acres in

1973 and in 2010 it was 3210.49 acres with the total change of 5419.54 acres as the result of migration of rural people, working community occupancy and educational institution establishments. These are cause of high land value and government policy. The area includes in this category are Arisipalayam, Narasothipatti, Vellakaipatti, Gorimedu, Chinnathirupathi area and Seelanaickenpatti area.

4.10. Land with Shrub

It has been decreased in the land with shrub area of 1339.90 acres with 56.94% which was occupied 3186.66 acres in 1973 and in 2010 and it was 1846.76 acres. The area includes in this category are Northern of city bound, Seelanaickenpatti area and the way to Mellur road.

4.11. Scrub Forest

The analysis reveals that the scrub forest was occupied 501.05 acres in 1973 and in 2010 it was 1095.07 acres with the increase of 594.01 acres with the high rate of 118.55% during this period. This found around the Seelanaickenpatti and northern of city peripherals.

4.12. Fallow Land

The table reveals that the fallow land had decreased 780.16 acres with 68.46 % and it was occupied 1139.55 acres in 1973 and in 2010 it was 359.39 acres during this period. This category is mostly found in between Vellakaipatti and Gorimedu.

4.13. Tanks

The part of the tank occupied area was increased of 187.90 acres with the high rate of 222.93%.The actual area was 84.28 acres in 1973 and in 2010 it was 272.19 acres. The increase is due to the pressure of urban need which leads the state government aided constructions were set up more tanks. This is mostly found in Ammapeti, Udyapatti, Chinnathirupathi, Narasothipatti and Burns colony.

4.14. River

The analysis reveals that river occupied area is 196.49 acres in 1973 and it was only 67.17 acres in 2010.The actual change area is 129.31 acres of decrease with 65.81%. The area of decrease is cause of urban occupancy.

4.15. Barren Rocky Surface

It has been decreased with an area of 687.42 acres of 33.04% from 1973 to 2010.The occupied area was 2080.28 acres in 1973 and it was 1392.86 acres in 2010. The change area is occurred due to new educational institutions and emergence of small scale industries too. This category area includes are Vellakaipatti, North of Burns colony, West Gorimedu and Chetichavadi area.

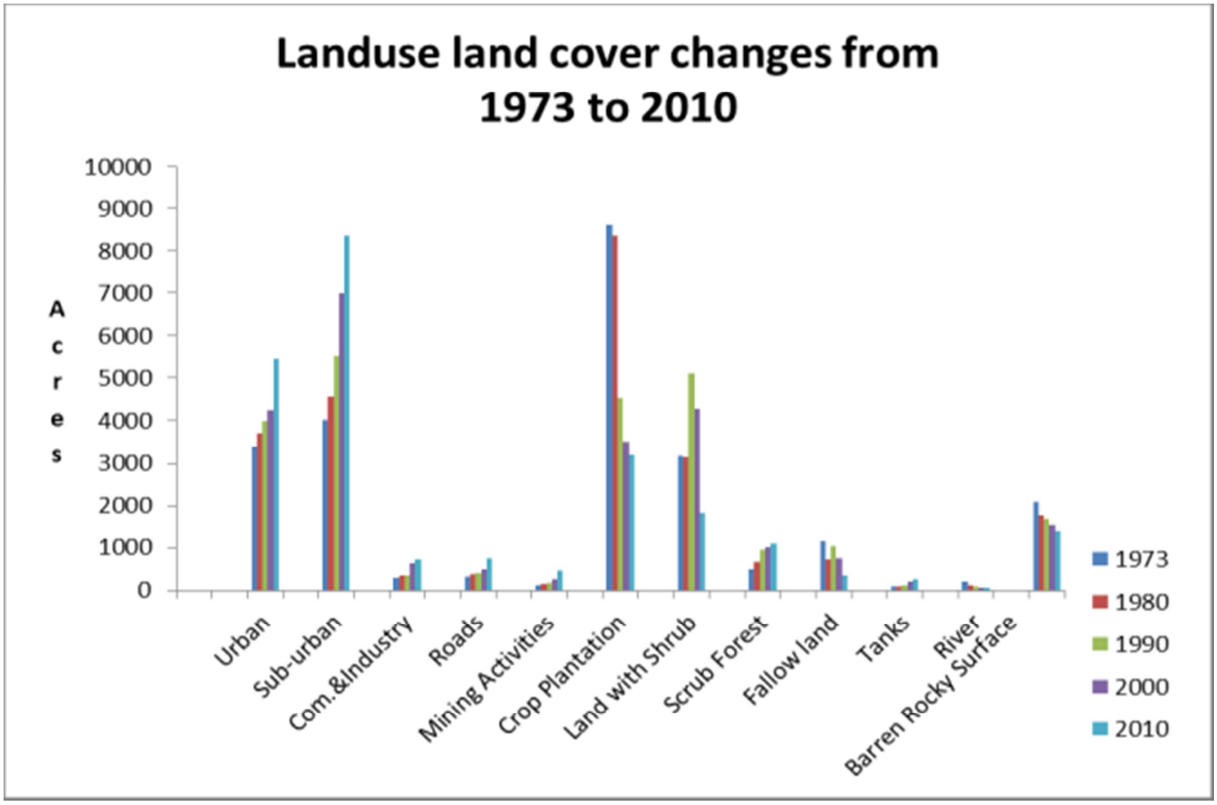

Fig. (10). Bar diagram-Land use land cover Changes from 1973 to 2010.

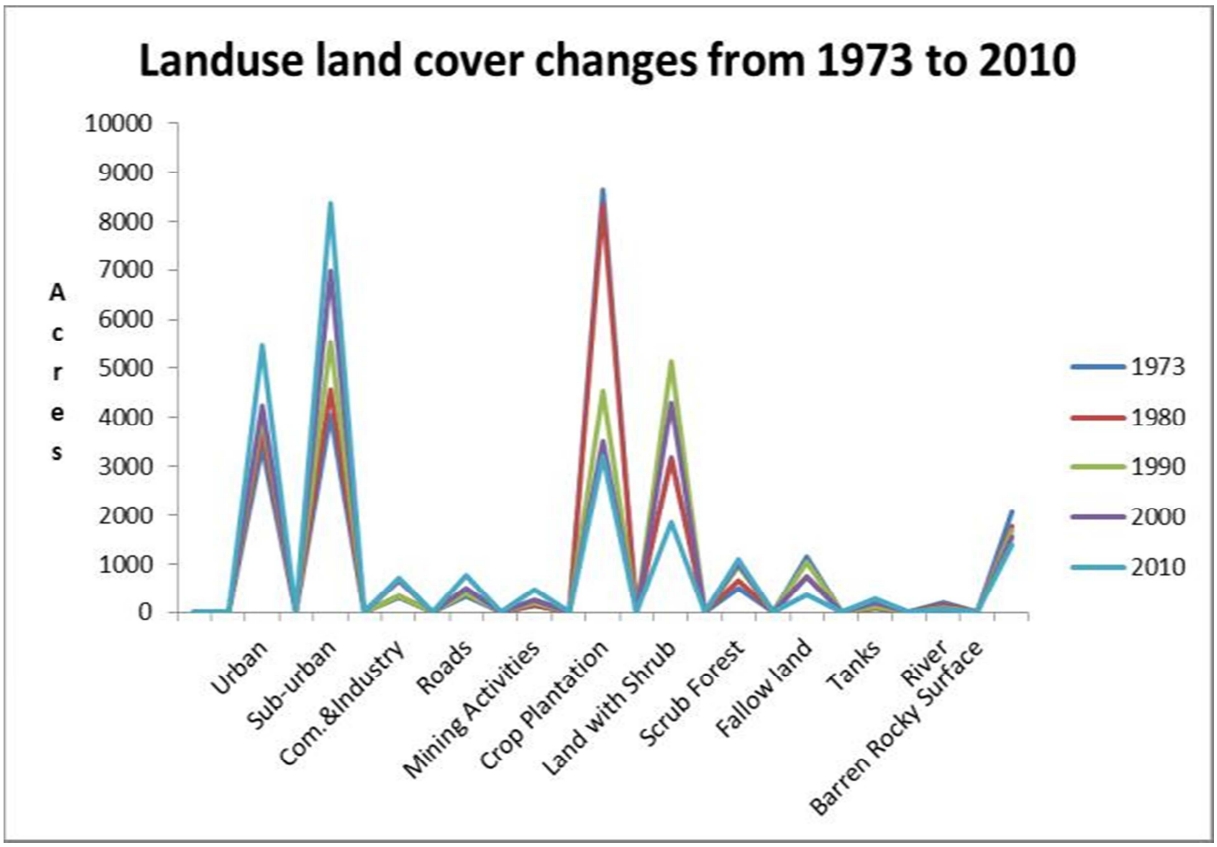

Fig. (11). Trend of Land use land cover Changes from 1973 to 2010.

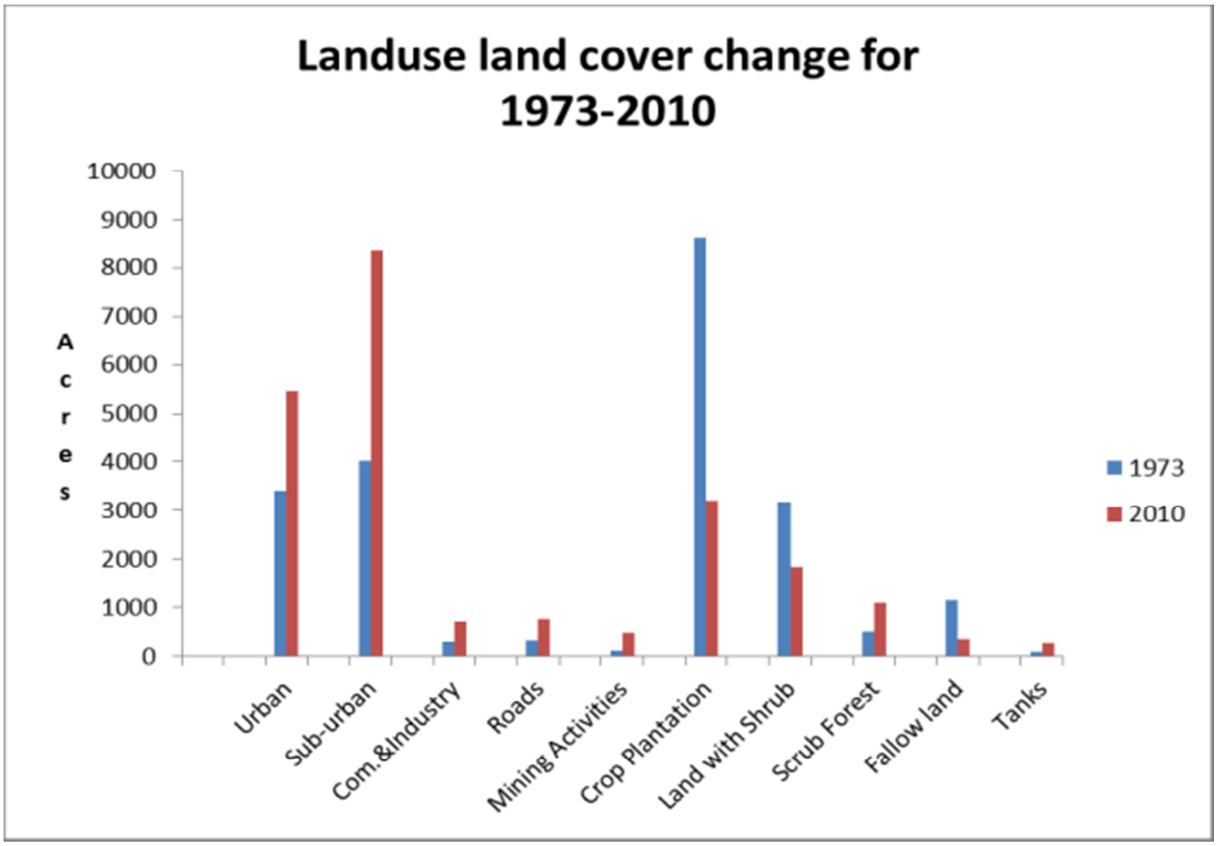

Fig. (12). Land use land cover Change for 1973- 2010.

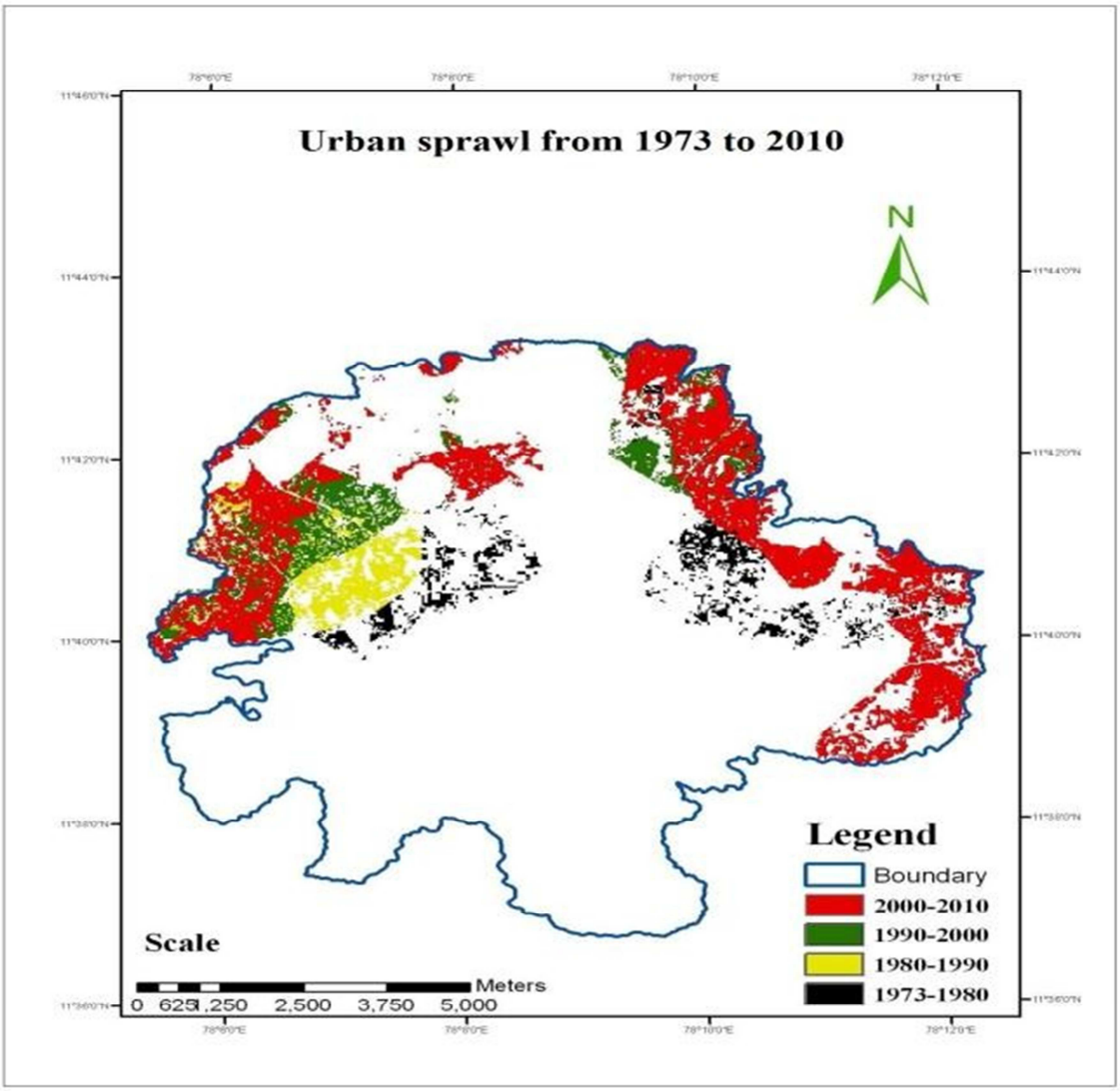

Fig. (13). Urban sprawl from 1973 to 2010.

Change detection technique of post classification comparison (indirect method) and image-to-image comparison change detection (direct method) were employed. In the indirect method, both supervised and unsupervised classifications were performed. The Unsupervised classification proves to be better than the supervised classification with accuracies of 98%, 99%, 98.33%, 98.67% and 98.67% for 1973, 1980, 1990, 2000 and 2010 classified images are respectively. Post-classification comparison change detection was conducted to reveal the areas that have changed over the period of 37 years. In this method, the from-to-change informational classes were available. The results revealed drastic growth of urban areas and reduction of Barren Rocky Surface, Fallow land, Crop & Plantation, Land with Shrub and River.

4.16. Urban Sprawl from 1973 to 2000

It clearly reveals from the figure (8.5) that the expansion of city with different clusters sprawled from North West to north and till north east. It appears like Arc shape covering the areas are Engineers colony, East railway colony, West railway colony, Sunder nagar, Solam pallam, Gorimadu, Jaya nager, Verma Garden, Chinna gollapatti, N.G.O. Colony, Thathampatti, S.K Town ship, Dharmanagar, Kennady nagar, Palaniyappa nagar, Tata colony, Arthanari nagar Rail way police quarters, Subramaniya nagar, Ramalinga nagar, Vellakal patti. Periya gollapatti, Chinna thirupathi, SCCB Colony, Johnsonpet, Kumarasamy patti and Kamarajar nagar

Swarnapuri, SIDCO Industrial Estate, Narasothipatti, Jagir Ammapalayam, Suramangalam, Mayyanur and Burns colony the black colour cluster 1973-80 of now became a core of the city which was the clusters of urban fringe and out of core city. In the same yellow and green colour represented for 1980-1990 and 1990-2000 respectively, now it has become core or adjacent to core of the city (Fig 13).

Finally the red colour represented in the figure is for the recent decade of 2000-2010 and its sprawl of urban. In which

it is noticed that the northern part of the city extended from north to north- east formed the cluster witnessing the recent growth of the city. This made the increase of living cost and land cost. So the urbanization of Salem city is mainly towards the north direction due to good transport facility, sufficient space for housing, institutions and industries, Extension services of buses with increased number of frequency, business extension counters and nearer to the producers of agricultural products so as to get the commodities at the reasonable price. Besides these, the migrant from villages and other parts of people who choose for their residents and urban labours like to reside in the peripherals of city as the result of their low wage or salary which could not allow them to stay within the core city. This is evident that Ammapalyam area to Ayothipattan the formation of linear settlement and expansion of Ayothipattanam block in short span of time.

5. Conclusion

Land use and land cover change dynamics has been one of the topics when dealing with spatial dynamics. Salem corporation of Tamilnadu, India has increased in size and population as a result of many social-economic factors notably urbanization and industrialization.

The ultimate objective of the research is to detect the land use/land-cover change of Salem city from 1973 to 2010. Satellite images of Salem city at different periods 1973 and 2010 were analysed. The software programs that have been used in this study to process, quantify, analyze and change detection are ArcGIS 9.2, ArcMap and ERADAS 9.3.

The change detection procedure, however it was able to identify the areas of significant change. The seasonal variation of the two satellite images used in the analysis affected the spectral resolution which subsequently affected the change detection process. Because of the variation of the temporal resolution and other environmental factors, the same land cover class can have different radiance values between the images. It can be concluded from the resulting statistics that the image-to-image change detection was more accurate that the post-classification comparison.

Change detection technique of post classification comparison (indirect method) and image-to-image comparison change detection (direct method) were employed. In the indirect method, both supervised and unsupervised classifications were performed. Post- classification comparison change detection was conducted to reveal the areas that have changed over the period of 37 years. In this method, the from-to-change informational classes were available. The results revealed drastic growth of urban areas and reduction of Barren Rocky Surface, Fallow land, Crop & Plantation, Land with Shrub and River.

Recommendations

Based on the findings of this study the following observations have been made as recommendations:

1) There is likely going to be crowdedness brought by compactness in Salem by 2020. This situation will have negative implications in the area because of the associated problems of crowdedness like crime and easy spread of diseases. It is therefore suggested that encouragement should be given to people to build towards the outskirts through the provision of incentives and forces of attraction that are available at the city center in these areas.

2) After the initial reduction in crop; and, land with shrub, fallow land, river area and barren and rocky surface between 1973 and 2010, the city has witnessed a steady growth in this class and indeed, may continue in this trend in future. For this projection to be realistic, it is suggested here that a deliberate attempt should be made by the city corporation and the state government to achieve this, since this will lead to many social crimes.

3) Land use land cover changes have both favorable and unfavorable impacts. In order to get comprehensive, pragmatic and scientific measures to monitor this phenomenon, interdisciplinary approaches should be employed. Geographic information system and Remote sensing technologies are versatile tools which cannot be ignored in monitoring land use and land cover change. However, the availability of these technologies is not just enough but there is the need for an accurate processing of remotely sensed data as any error introduced into the image processing procedure will propagate to the final analysis. It is recommended that different image processing techniques should be employed in order to compare the results and to detect mistakes in the analysis. For urban change detection testing, different combinations of indices and sensors could also be of interest. Improving the classification process is also interesting area of further investigation. The bare open fields caused false urban changes and these could be minimized by using more frequent data covering growth seasons.

4) Real estate business should be abolished and it should be operated by the respective state government which would help the people to buy the land at the actual cost and affordable price.

5) To avoid the more land occupancy, transport congestion and commuters congestion in the city limit the multi-storied buildings are to encouraged for shopping malls at reasonable distances.

6) Industrial and its allied activities should be prohibited within the city so that it would move to outskirts along with its workers so as to get additional space for other important administrative offices could be established within the city.

7) New satellite town to be established southern side of city so as to distribute the concentrations of population is equal in throughout the city.

8) High taxes to be levied for the core of the urban so as to discourage for further growth within this limit.

9) 'Villas' to be encouraged in the outskirts of city or peripherals

and fringes in order to occupy mass population in a particular place.

10) One who wish to sell the land has to obtained land value certificate along with registration documents to report to registering authority and the same to be paid by the buyer through the authority too, which will be monitored with appropriate authority so as to get everyone individual house/own house and avoid the spread of slums.

11) Common market centers, Malls and central market for selling of agricultural products to be set, so as to avoid the commuters of small vendors and business travelling in the peak hours and to also avoid congestion in and around old bus stand.

12) Government official complexes and their quarters, new housing board units and existing to be shifted when the life of the building comes to an end. So that there is a space for other necessary amenities.

13) It is recommended that different image processing techniques should be employed in order to compare the results and to detect mistakes in the analysis. For urban change detection testing, different combinations of indices and sensors could also be of interest. Improving the classification process is also interesting area of further investigation.

Land use and land cover change have both favorable and unfavorable impacts. In order to get comprehensive, pragmatic and scientific measures to monitor this phenomenon, interdisciplinary approaches should be employed. Geographic Information System and Remote sensing technologies is versatile tool which cannot be ignored in monitoring land use and land cover change. However, the availability of these technologies is not just enough but there is the need for an accurate processing of remotely sensed data as any error introduced into the image processing procedure will propagate to the final analysis.

Application of Remote sensing and GIS was found helpful in quantifying past and present resources so that appropriate planning could be made for the future. It is therefore assumed that future development activities will cause much unfavorable environment in the urban. Hence the present study surely will help the planners to take appropriate steps to have healthy growth of Salem city.

Acknowledgement

My sincere thanks to Dr. S. Ramalingam, Director, Institute of Remote Sensing, Anna University, Chennai for his assistance in providing necessary data and relevant materials. I am very much thankful to K. Chandra Mohan, Madurai Kamaraj University, Madurai and Vasanth Kumar, Project Assistant, Institute of Remote Sensing, Anna University, Chennai for his useful and supportive role in the preparation of maps and their support in this research work.

References

[1] Adeniyi P.O and Omojola A. (1999) Landuse landcover change evaluation in Sokoto –Rima Basin of North Western Nigeria based on Archival of the Environment (AARSE) on Geo information Technology Applications for Resource and Environmental Management in Africa. 143-172.

[2] Barr, S. L. (1992). Object-based Re-classification of High Resolution Digital Imagery for Urban Land-Use Monitoring. International Archives of Photo-grammetry and Remote Sensing (ISPRS, Washington, D.C.1992). Vol. XXIX, Part B7, Commission VII, 969- 76.

[3] Barnsley, M.J., Barr, S. L., and Sadler, G. J. (1991) Spatial Re-classification of Remote Sensed Images for Urban Land Use Monitoring. Proc. Spatial Data 2000, 17-20 September1991, Oxford University, (Nottingham: Remote Sensing Society), 106-117.

[4] Campbell, James B (1983) "Mapping the Land Aerial Imagery for Land Use Information" Resource Publications in Geography, Association of American Geographers, Washington D.C.

[5] http://en.wikipedia.org/wiki/Salem,_Tamil_Nadu.

[6] Olorunfemi J.F (1983). Monitoring Urban Land – Use in Developed Countries – An aerial photographic approach, Environmental Int.9,27 – 32.

[7] Tonjes, R., Growe S., Bucker J. and Liedtke C.–E. (1999).Knowledge-Based Interpretation of Remote Sensing Images Using Semantic Nets. Photogrammetric Engineering & Remote Sensing, 65, 811-821.

[8] White house, S. (1990). A spatial land use classification of an urban environment using high resolution multispectral satellite data.Proc.16th Ann. Conf. Remote Sensing Society, Remote Sensing and Global Change, University Collage Swansea,19-21September 1990,(Nottingham: Remote Sensing Society), 433-437.

[9] Welch, R., (1982). Spatial resolution requirements for urbans studies. International Journal of Remote sensing, 3(2): 139-146.

[10] Yikalo H. Araya and Pedro Cabral (2010) Analysis and Modeling of Urban Land Cover Change in Setúbal and Sesimbra, Portugal, Remote Sensing, 2010, 2, 1549-1563.(http://www.mdpi.com/journal/remotesensing)

[11] Young, Anthony, Feb. (1994), Towards an international classification of land use, Consultancy report to UNEP/FAO, page 6.from URL: http://www. fao.org/ag/agl/agll/ landuse/docs/ young 1994. doc.

[12] Yuan, D., and Elvidge, C. (1998). NALC land cover change detection pilot study: Washington D.C. area experiments. Remote Sensing of Environment, 66, 166-178.