International Transaction Journal of Engineering, Management, & Applied Sciences & Technologies

http://www.TuEngr.com, http://go.to/Research

Detecting Urban Change of Salem City of Tamil Nadu, India from 1990 to 2010 Using Geospatial Technology

Shanmugam Tamilenthi[a*] and Rajagopalan Baskaran[a]

[a] *Department of Earth Sciences, Tamil University, Thanjavur, INDIA*

ARTICLEINFO

Article history:
Received 10 January 2011
Received in revised form
08 March 2011
Accepted 08 March 2011
Available online
09 March 2011

Keywords:
Urbanization,
IRS-LISS III,
Change detection,
Salem city, India

ABSTRACT

Unplanned city growth is an indicator of rapid industrialization, which usually reduces the quality of the environmental health of a region - sometimes disastrously. Monitoring provides the planners and decision - makers with required information about the current state of development and the nature of changes that have occurred. The study on development of urban lands and the changes in the land use and land cover in Salem city, Tamil Nadu has been monitored by using IRS LISSII III(1991)and IRS-LISS III 2010) satellite data, the Town and Country Planning map(1994) and Survey of India Topo-sheets (1972) with limited field checks. This study highlights the changes in urban development.

Mapping of the urban changes in the study area have been interpreted in view of developing urban land with different classes.

1. Introduction

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

*Corresponding author (**S. Tamilenthi**). Tel/Fax: +91-9095169124. E-mail addresses: rst_tamil2006@yahoo.com. ©2011. International Transaction Journal of Engineering, Management, & Applied Sciences & Technologies. Volume 2 No.2. ISSN 2228-9860 eISSN 1906-9642. Online Available at http://TuEngr.com/V02/183-195.pdf

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 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 are labor 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).

2. Geography of the Study Area

The study area Salem city is situated in Salem District of Tamilnadu, India. (Figure 1). The town is surrounded by hills on all sides: the Nagaramalai to the north, the Jarugumalai to the south, the Kanjamalai to the west, and the Godumalai to the east. It is divided by the river Thirumanimuthar. The fort is the oldest part of the town. The study area covers a part of toposheet of Survey of India No.58 I/2 (1:50,000,1972), 11° 39′ 0″ to 11.65N and 78.16 to 78° 9′ 36″ E. Salem Corporation consists of 60 wards categorized under 4 Zones namely Suramangalam Zone, Hasthampatty Zone, Ammapet Zone, Kondalampatty Zone with 91.34 (sq.km). It is 278m above Mean Sea Level. The soil types of the study area are red non-calcareous and red calcareous soils.

The average annual rainfall is 363.5mm. The temperature is generally very high during summer and it ranges from 20° to 37.9°. According to 2001 census, the total population of the Salem town is about 30, 16,346 of which 12, 79,846 are workers and the rest are non-workers. The area has a good transport system of road network and is well connected with the adjacent cities namely Banglore, Chennai, Trichy and Coimbatore. It also has good communication facilities.

*Corresponding author (**S. Tamilenthi**). Tel/Fax: +91-9095169124. E-mail addresses: rst_tamil2006@yahoo.com. International Transaction Journal of Engineering, Management, & Applied Sciences & Technologies. Volume 2 No.2. ISSN 2228-9860 eISSN 1906-9642. Online Available at http://TuEngr.com/V02/183-195.pdf

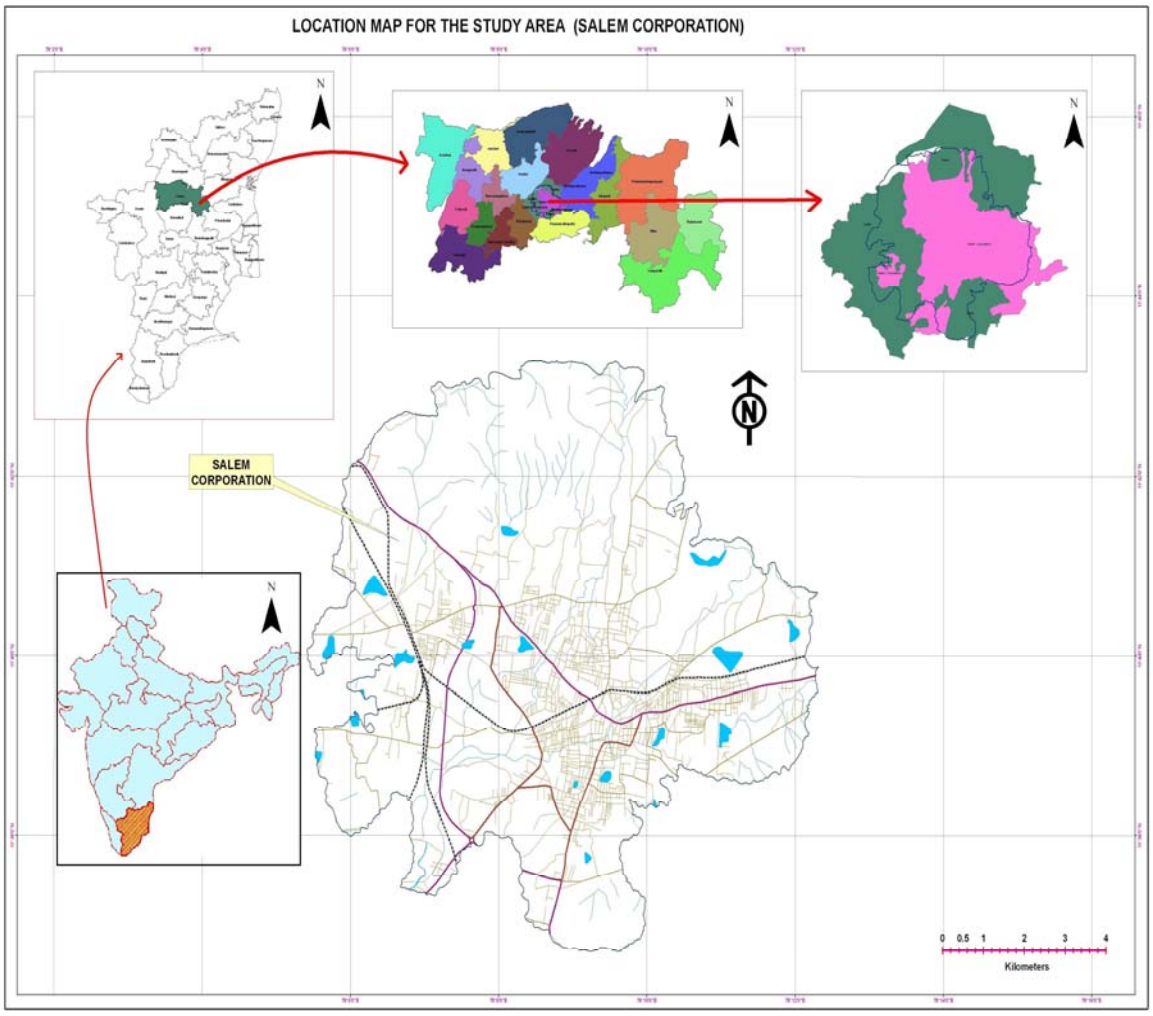

Figure 1: Location map of Salem Corporation.

3. Materials and Methods

Santos et al. (1981) and Welch (1982) stated that *it is important that the planning for the growth of cities and to study the growth tendencies in its relation to the physical environment". In this frame, conventional techniques, i.e. the analysis and interpretation of aerial photography have demonstrated its' applicability to map urban areas.* The use of remote sensing techniques together with Geographic Information Systems(GIS), became more and more fundamental instruments for the analysis of urban phenomena and to obtain relevant information for the physical planning of the territory, as shown in works by Vieira & Kurkdjian (1993), Valerio Filho(1998).The objective of this paper is to monitor the dynamics of urban growth using remote sensing technique with the softwares ArcGIS 9.3 and Eradas 9.2 to record the changes and analysis of other components NDVI and PCA.

The IRS- LISS-III(28.5 x 28.5,1991), IRS LISS III (23.5x23.5,2010)images were used for this study. Different types of urban land use categories were transferred on the standard base map prepared from SOI toposheet (1972) and maps obtained from Town and Country Planning, Salem. The changes in land use and land cover were finalized on the basis of ground verification with the help of town map of Salem.

The data were interpreted visually and analysed through computer techniques. The satellite images were interpreted by elements of image interpretation such as shape, size, tone, texture, pattern, site and association. (Campbell 1983).

4. Image Analysis

4.1 Land use / Land cover.

To achieve this study the two different land-covers and land use classes were analysed. These values quantify the percentage change in each land cover category. The change 'from-to' makes post classification change detection so unique. The other task is the detection of the urban expansion as described in the post classification change detection processes.

In order to determine the "urban sprawl" the two images for 1990 and 2010 were classified as shown in figures 2 and 3. It is clear that the sprawl is towards the sub urban area. The result imply that, the land cost and the industries around Salem city may be the attracting force for most people to acquire a residence closer to this vicinity as result of many socio-economic reasons.

The results indicate a moderate growth of towns in the study area. The town is recorded with moderate to fast urban growth. This was owing to the industrial concessions given to peripherals and fringe areas and backward regions. Town expansion is attributed to the commercial and industrial activities. The intra regional variations in growth are mainly associated with acceleration of economic activity, transportation network, administrative and government interventions.

*Corresponding author (**S. Tamilenthi**). Tel/Fax: +91-9095169124. E-mail addresses: rst_tamil2006@yahoo.com. International Transaction Journal of Engineering, Management, & Applied Sciences & Technologies. Volume 2 No.2. ISSN 2228-9860 eISSN 1906-9642. Online Available at http://TuEngr.com/V02/183-195.pdf

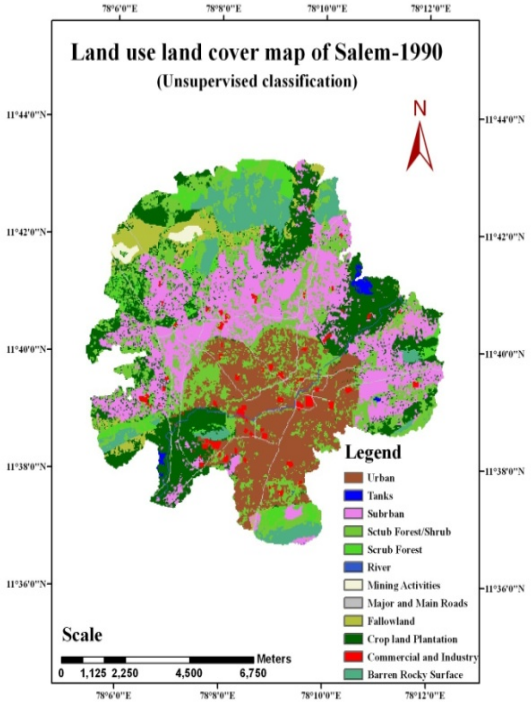

Figure 2: Land use land cover-1990.

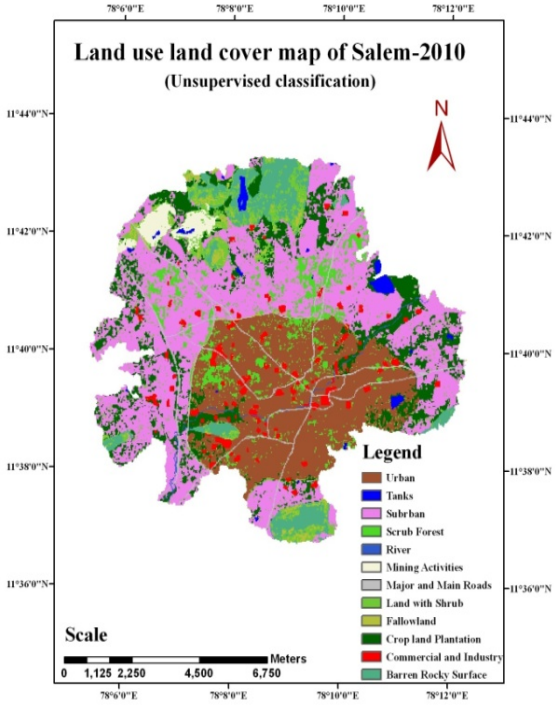

Figure 3: Land use land cover-2010.

4.2 Change detection

An important aspect of change detection is to determine what is actually changing to what i.e. which land use class is changing to the other. This information will reveal both the desirable and undesirable changes and classes that are "relatively" stable overtime. This information will also serve as a vital tool in management decisions. This process involves a pixel to pixel comparison of the study year images through overlay.

In terms of location of change, the emphasis is on built-up land. The map in Figure 4 shows this change between 1990 and 2010. The observation here is that there seem to exist a growth away from the city center due to high land value, closer to new bus stand. New industries emerge depending on the raw material which could be by the road and railway station accessibility.

The bar chart Figure 5 and Table 1 shows the changes within the various land-cover classes which explain the trend of the changes.

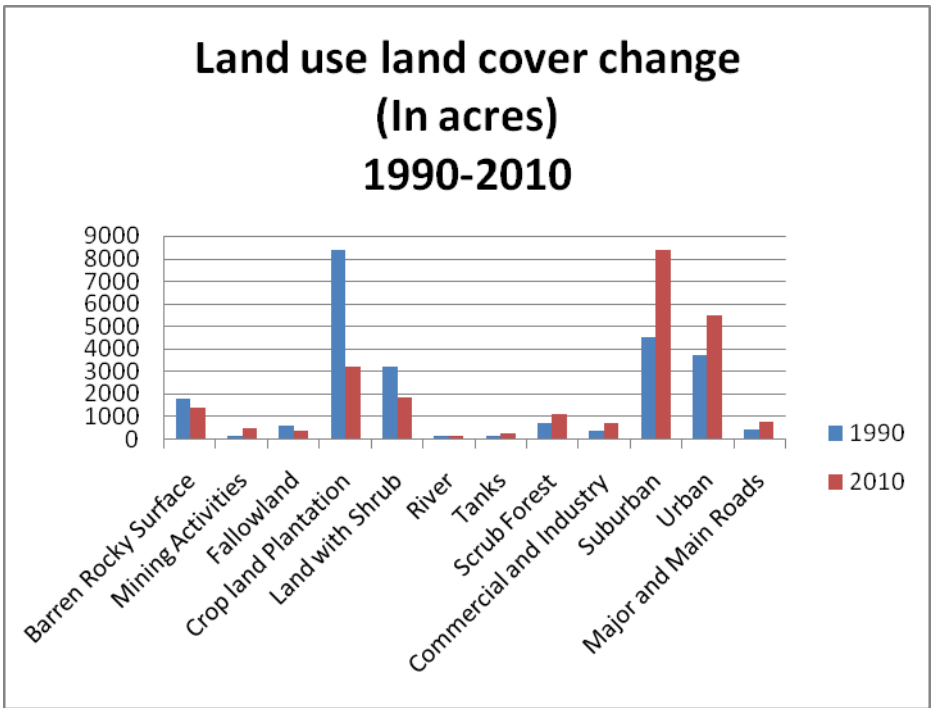

Figure 5: Land use land cover change 1990-2010.

Table 1: Land use land cover change 1990-2010.

Class	1990 (In acres)	2010 (In acres)	Changes (In acres)	Change (%)
Barren Rocky Surface	1700.877	1392.86	308.017	18.11
Mining Activities	184.3655	471.9222	287.557	155.97 (+)
Fallowland	1032.802	359.3903	673.4117	65.21
Crop land Plantation	4548.867	3210.494	1338.373	29.41
Land with Shrub	5120.645	1846.768	3273.877	63.92
River	88.73561	87.17884	1.55677	1.69
Tanks	111.4199	252.1959	140.776	126.12 (+)
Scrub Forest	943.3996	1095.073	151.673	16.01 (+)
Commercial and Industry	343.3779	710.3295	366.952	106.70 (+)
Suburban	5534.744	8368.501	2833.76	51.19 (+)
Urban	4012.674	5466.41	1453.73	36.21 (+)
Major and Main Roads	397.6423	758.4338	360.792	90.68 (+)
	24019.55	24019.55	0.00	

*Corresponding author (**S. Tamilenthi**). Tel/Fax: +91-9095169124. E-mail addresses: rst_tamil2006@yahoo.com. International Transaction Journal of Engineering, Management, & Applied Sciences & Technologies. Volume 2 No.2. ISSN 2228-9860 eISSN 1906-9642. Online Available at http://TuEngr.com/V02/183-195.pdf

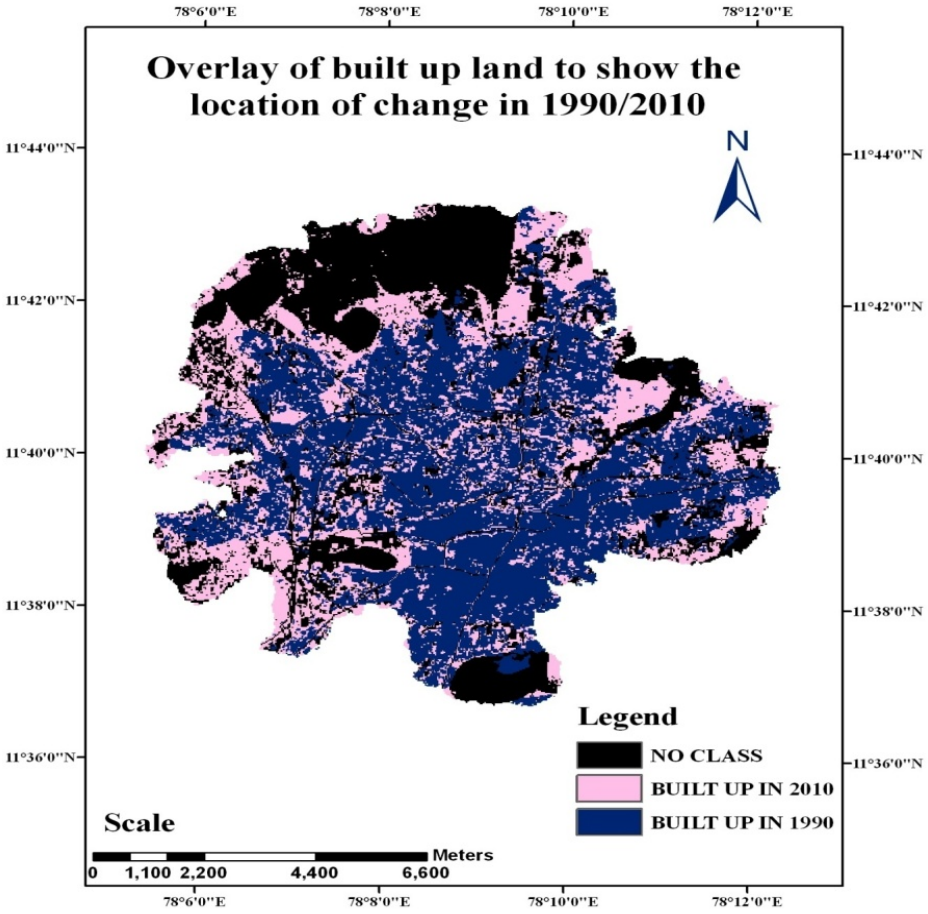

Figure 4: Location of change 1990-2010.

4.3 Performance of NDVI

It can be seen from its mathematical definition that the NDVI of an area containing a dense vegetation canopy will tend to have positive values (say 0.3 to 0.8) while clouds fields will be characterized by negative values of this index.

There is a clear indication (Figures 6 and 7) that water cover and existing urban/bare areas did not change and such have zero or a very lower value. The brighter areas which represent change in vegetation are as a result of evolution of urban/bare areas. The NDVI differencing hence is vital in identifying changes in urban areas by investigating the changes in the vegetation cover. (As is the case when the NDVI is calculated directly on the basis of raw measurements)

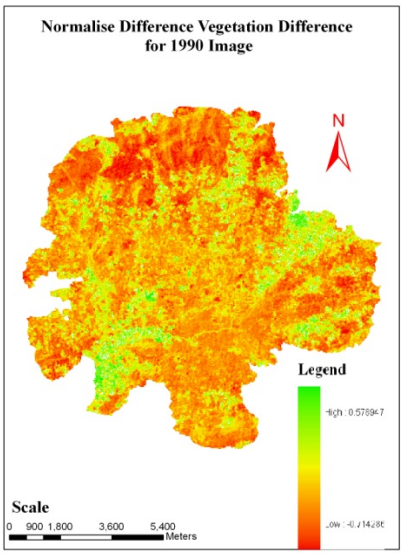

Figure 6: NDVI for 1990.

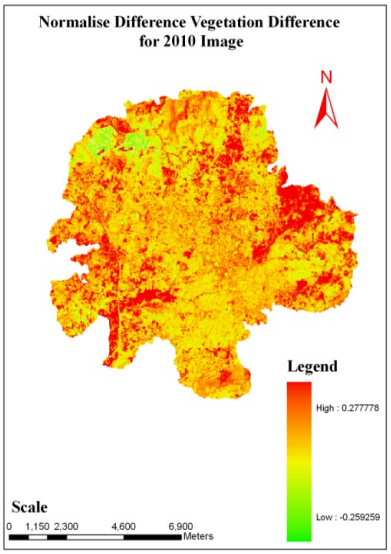

Figure 7: NDVI for 2010.

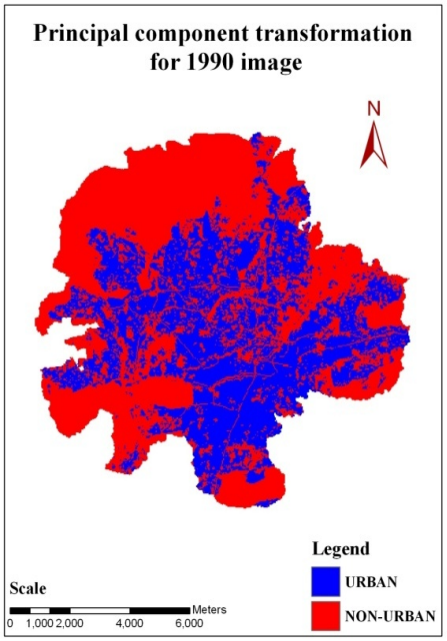

Figure 8: Principal component analysis-1990.

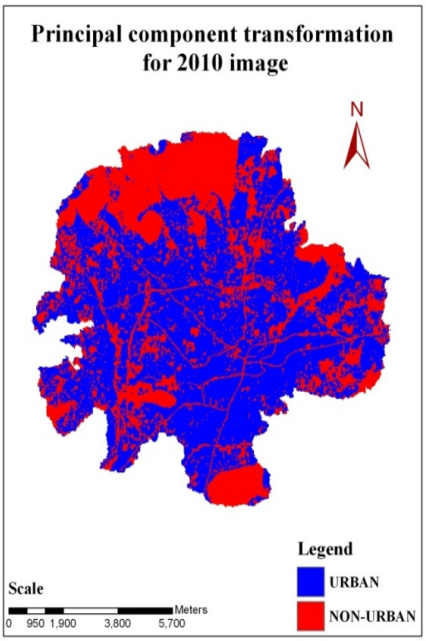

Figure 9: Principal component analysis-2010.

*Corresponding author (**S. Tamilenthi**). Tel/Fax: +91-9095169124. E-mail addresses: rst_tamil2006@yahoo.com. Volume 2 No.2. ISSN 2228-9860 eISSN 1906-9642. Online Available at http://TuEngr.com/V02/183-195.pdf

4.4 Principal Component Analysis (PCA)

In Figures 8 and 9, the pink areas represent urban/bare areas in 1990 &2010. This is because in the PCA analysis of the image, urban areas have a high reflectance values than any other land-cover/land-use category. The other areas are represented by dark blue colour.

From Figures 8 and 9, the PCA has proven to be a good technique in identifying the new urban area that has evolved within the decade. The new urban area evolved is also an indication that there has been lost of vegetation within the two periods.

5. Results and Discussion

5.1 Expansion of Salem city

The rural migration and small industry activity in the Salem town is parallel with the urban expansion, which became the dominant characteristic of the spatial organization. This characteristic can be seen both in the increase of urban population as well as at the territory occupied by these activities. Being so, it is necessary to know the features and effects of urbanization to understand the significance of this phenomenon and also to gather information for urban and regional planning.

Land use is the management of land to meet human needs and human activities which are directly related to land. It is not simply any human activity but must be functionally linked to the land on which it takes place. The vegetation (natural or planted) or human constructions (buildings, etc.) that cover the earth's surface is known as land cover. These two definitions imply that human activities contribute to changes in the land use and land cover types. Data on land use and cover are obtained from four different sources namely census data, remotely sensed data, ground observation data and administrative data as cited by Young and Anthony (1994). Before an in-depth analysis can be made on these changes, there is the need for the available data to be processed. The multi-spectral satellite data was processed into informational classes which are the land use and land cover types. From figures 4, 8 and 9 it is clear that a lot of changes have taken place in the land use and land cover types.

The urban area of Salem has increased tremendously within the two decades. The overall percentage of increase within the decade is about 36.21% and 51.19% Urban and sub urban

respectively.

There has been an increase in major and minor roads with 90.68% in order to facilitate the urban with the state and central government initiation. There has been an increase in the area with 155.97% to dedicate to mining activities with a great demand of minerals in and around the district. The analysis reveals that the crop land and plantation part has been decreased with 29.41% as the result of migration of rural people, working community occupancy and educational institution due to the high land value and Government policy. There has been a decrease in Barren rocky surface and Fallow land with 18.11% and 65.21% with occupancy of educational institutions, and expansion and emergence of small scale industries. On the part of water resources, the width of the river on the average seems little decreased (1.69%). It might be due to the climatic or seasonal variation in rainfall. The number and area of the tanks in the study region shows an increase of about 126.12 % due to the pressure of urban need satisfied by the state government aided tank development programmes.

6. Conclusion

The urban area of Salem has increase tremendously within the two decades. This resulted from rural-urban migration. Salem is one of the most developing cities in Tamilnadu, India and most of the major education institutions, industries and factories etc are located and up coming here.

As a result, rural-urban migration has been characterizing in Salem. The overall percentage increase within the decade is about 36.21% and 51.19% Urban and sub urban respectively. There has been an increase in the commercial and industrial activity as the part of urbanization with 106.70% of it is drawn from barren and rocky surface. There has been an increase in the vegetated field for farming purposes and social forest with government initiation with16.01% in 2010 and decrease in Shrub 63.92% in2010 in the part of settlements.

The results of this study were based on Image classification and its interpretation .The mapping of the urban development of Salem town shows the development of urban lands had

*Corresponding author (**S. Tamilenthi**). Tel/Fax: +91-9095169124. E-mail addresses: rst_tamil2006@yahoo.com. International Transaction Journal of Engineering, Management, & Applied Sciences & Technologies. Volume 2 No.2. ISSN 2228-9860 eISSN 1906-9642. Online Available at http://TuEngr.com/V02/183-195.pdf

brought changes in other part of the city as well. The interpretation of multi-date satellite and other data helped in the preparation of urban sprawl map of the study area. The study of the spatial growth of the city over the years has revealed that the built-up area has spread along main transportation corridors in a radial pattern viz. Namakkal, Dharmapuri, Attur and Erode.

The decrease in agricultural area is due to conversion of urban land use or discontinuation of agricultural lands. The Barren land has been reduced considerably. Similar studies can be under taken for other cities also to estimate the quantum of damage caused to the environment by urbanization.

7. Acknowledgements

Authors are highly thankful to Director, National Remote Sensing Agency, Hyderabad and the Director, Town and Country Planning Office, Salem for their kind help in providing reference data and valuable suggestions. A very special thank you is due to Felix Mutua for insightful comments, helping clarify and improve the manuscript.

8. References

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 Geoinformation Technology Applications for Resource and Environmental Management in Africa. Pp 143-172

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

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.

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

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

Santos,A.P.;Foresti,C.;Novo,E.M.L.M.;Niero,M.;Lombardo,M.A. (1981).Metodologia de interpretação de dados de sensoriamento remoto e aplicações no uso da terra.São José dos Campos,INPE.61 (INPE-2261-MD/016).

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.

Vieira,I.M.;Kurkdjian,M.L.N.O. (1993).Integração de dados de expansão urbana e dados geotécnicos como subsídio ao estabelecimento de critérios de oupação em áreas urbanas. In: SIMPÓSIO BRASILEIRO DE SENSORIAMENTO REMOTO, 7. Curitiba, PR.Anais. Curitiba.v. 1,.163-171.

Valerio Filho,M. (1998).Técnicas de Sensoriamento remoto e geoprocessamento aplicadas ao planejamento regional. VI Simpósio Nacional de Controle de Erosão. Presidente Prudente, São Paulo.CD-ROM.

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,19-21 September 1990, (Nottingham: Remote Sensing Society), 433-437.

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

Young, Anthony, Feb. (1994), Towards an international classification of land use, Consultancy report to UNEP/FAO, page 6. Visited on 11/11/2007 from URL:http://www.fao.org/ag/agl/agll/landuse/docs/young1994.doc

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.

Shanmugam Tamilenthi is a Research Scholar, PhD at Department of Earth science, Tamil University, Thanjavur, India under the guidance of Dr.Rajagopalan Baskaran. He received his Master degree from Madurai Kamaraj University, Madurai. He finished M.phil from Bharathidasan university, Trichy. He is interested in urban geography and remote sensing.

Dr. Rajagopalan Baskaran, Professor and Head, Department of Earth Science, Tamil University, Thanjavur, India. He is holding additional position as Research Coordinator, Ocean & Atmospheric Science and Technology Cell (OASTC)(Autonomous body supported by the Ministry of Earth Sciences, Govt. of India) Tamil University, Thanjavur, India. He is specialized in Geochemistry and coastal management.

Peer Review: This article has been international peer-reviewed and accepted for publication according to the guideline given at the journal's website.

*Corresponding author (**S. Tamilenthi**). Tel/Fax: +91-9095169124. E-mail addresses: rst_tamil2006@yahoo.com. International Transaction Journal of Engineering, Management, & Applied Sciences & Technologies. Volume 2 No.2. ISSN 2228-9860 eISSN 1906-9642. Online Available at http://TuEngr.com/V02/183-195.pdf