Impact of Land use Land cover Changes on LST; A Case Study from Salem Area, Tamil Nadu using Remote Sensing and GIS

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Abstract

Salem area is one of the store house of various minerals and metals occurrence in India. Because of the mineral potentiality, various mining companies have started exploration and exploitation activities in this region. Therefore, uncontrolled urbanization and industrialization have been developed since a decade onwards. Remote Sensing and GIS are the perfect and efficient tool for the change detection and Land Surface Temperature variation analysis. In this study, multi-temporal data sets have been used to prepare thematic maps like land use land cover, Normalizes Difference Vegetation Index and Land Surface Temperature maps for the year 2001 and 2013. The Land Surface Temperature variation for the year 2001 ranges from 14.39°c to 37.78° C and for the year 2013 it varies from 14.39° to 40.10°C. It has been derived using thermal remote sensing and found nearly about 2.32°C increases in temperature. The Normalizes Difference Vegetation Index value for 2001 ranges between -0.9 and +0.5 and for the year 2013 is -0.08 and 0.13 indicate the vegetation loss over the period of time. Land use Land cover mapping using Landsat data has also been carried for the same period. The total area of built-up land in 2001 and 2013 was 786.11 and 935.17 sq.km respectively. Similarly for the agricultural land in 2001 was 2629.83 sq.km and for 2013 was 2559.48 sq.km. The present study has brought to light significant variation in the land use land cover pattern and its related impact on Land Surface Temperature variation within a short period of time.

Introduction

Land Use Land Cover (LULC) changing information is fundamental for a better understanding of the relationships and interactions between humans and the natural environment. Remote sensing (RS) and GIS data are being used as most important data sources for studies of LULC, Land Surface Temperature (LST) and Normalized Difference Vegetation Index (NDVI) spatial and temporal changes. Multi-temporal RS data sets allow to map and identify landscape changes, giving an effective effort to sustainable landscape planning and management [Dewan et al., 2009]. In particular, by means of the integration of RS and GIS techniques, it is possible to analyze and to classify the changing pattern of LC during a long time period.

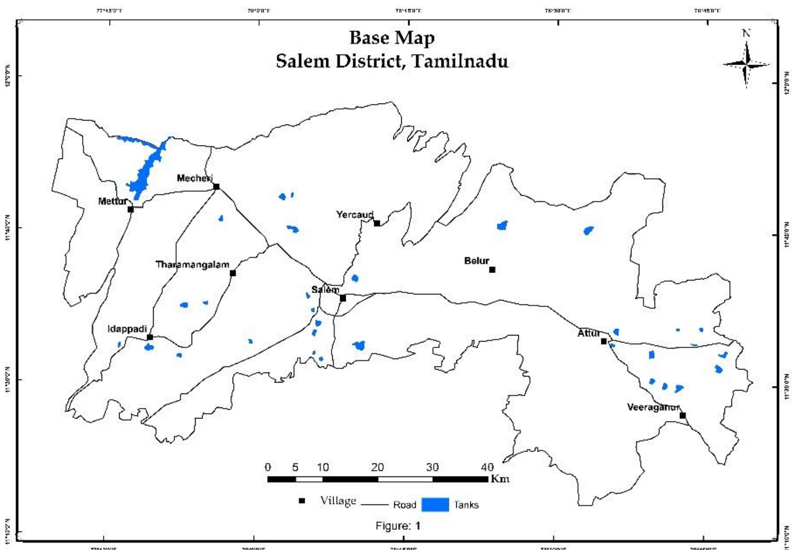
Landsat satellite data sets for the last three decades have been effectively utilized to explore the land cover change detection. [Masek et al., 2000; Yang and Lo, 2002; Yuan et al., 2005] to evaluate built-up expansion and to assess urban morphology changes. The main aim of those studies was the spatio-temporal analysis of land cover dynamics, focusing on urban growth/sprawl phenomenon and loss of rural land.

In the present study, the change detection for the LULC over 13 years have been taken and also it's related temperature variations were calculated. It is further spatially correlated with NDVI. Spatial variations for the land cover change for the year 2001 and 2013 of Landsat data has been taken to consideration for this analysis.

Changes in LULC affect the underlying biotic diversity, soil quality, runoff, and sedimentation rates, the dynamics of which cannot be well understood without knowledge of the land use Land cover change that drives them. LULC changes is one of the most visible results of human's modification of the terrestrial ecosystem, and it has a significant impact on the local, regional, and global environment, Weng et al (2001). Urbanization has been a major force of LULC throughout human history that has had a great impact on climate change (CC). Covered with buildings, roads, and other impervious surfaces, urban areas generally have higher absorption of solar radiation and greater thermal capacity and conductivity, leading to a relatively higher temperature in the urban areas compared with the surrounding rural areas.

LST which is controlled by the surface energy balance, atmospheric condition and thermal properties of the materials on the surface/subsurface rocks, is one of the important parameters in several environmental models, Becker and Li (1990). LST is important for environmental studies and management of the Earth's resources because it determines the effective radiating temperature of the Earth's surface. It is also a major factor in determining the partition of the available energy into sensible and latent heat fluxes. For example, the rate of change of LST is sensitive to the characteristics of the land surface such as soil moisture, land use and vegetation, Gillies et al (1997); Verstraeten et al (2006).

The Study area Salem District is a district of Tamil Nadu state in southern India. Salem is the district headquarters and other major towns in the district include Mettur, Omalur and Attur. Salem is surrounded by hills and the landscape dotted with hillocks. Salem has a vibrant culture dating back to the ancient Salem Nadu ruled by Mazhavar kings. As a district, Salem has its significance in various aspects; it is known for mango cultivation, silver ornaments, textile, sago industries and steel production. As of 2011, the district had a population of 3,482,056 with a sex-ratio of 954 females for every 1,000 males. Salem is one of the biggest cities in Tamil Nadu. (https://en.wikipedia.org/wiki/Salem_district) (Fig-1)

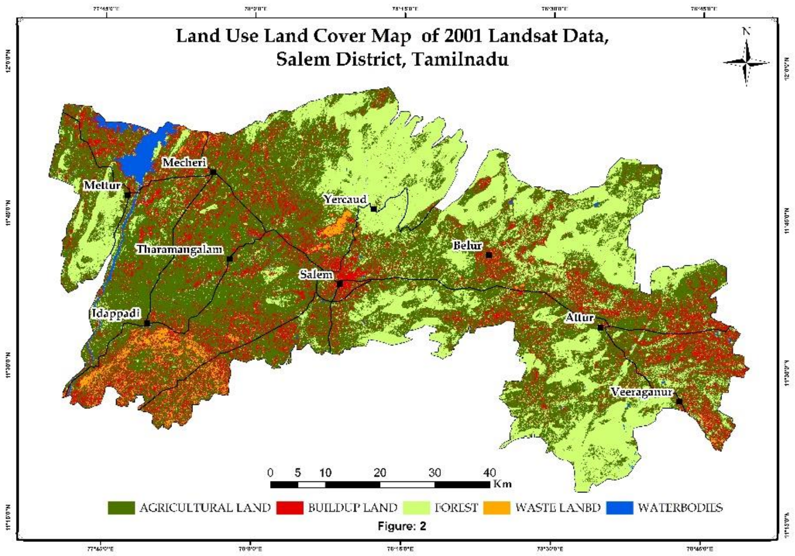


Materials and Methods

In the Present study, 1:50000 scale toposheets were used to prepare base map dated 1969 and Landsat images of years 2001 (ETM) and 2013 (OLI & TIRS) used for LST, LULC and NDVI analysis. Scenes were collected for the summer season and have little or no cloud cover for the study area. All Landsat images were downloaded free of cost from U.S. Geological Survey (USGS) Center for Earth Resources Observation and Science (EROS) via http://glovis.usgs.gov/. All scenes supplied by the EROS Data Center had already been Georeferenced to the Universal Transverse Mercator (UTM) map projection (Zone 44N), WGS 84 datum and ellipsoid. LULC map has been prepared from Landsat 2001 and 2013 FCC data of ETM and OLI. Similarly, LST has been calculated using thermal data obtained from ETM and TIRS. NDVI for the study area has also been generated using ENVI software. Finally all these layer were integrated for correlation and change detection analysis.

Land use Land cover

Land Use Land Cover maps for the period of 2001 and 2013 has been prepared using supervised classification technique (Fig-2 & 3). The total area of built-up land in 2001 and 2013 was 786.11 and 935.17 sq.km respectively. Similarly for the agricultural land in 2001 was 2629.83 sq.km and for 2013 was 2559.48 sq.km. Major changes noticed in these temporal data is crop land.



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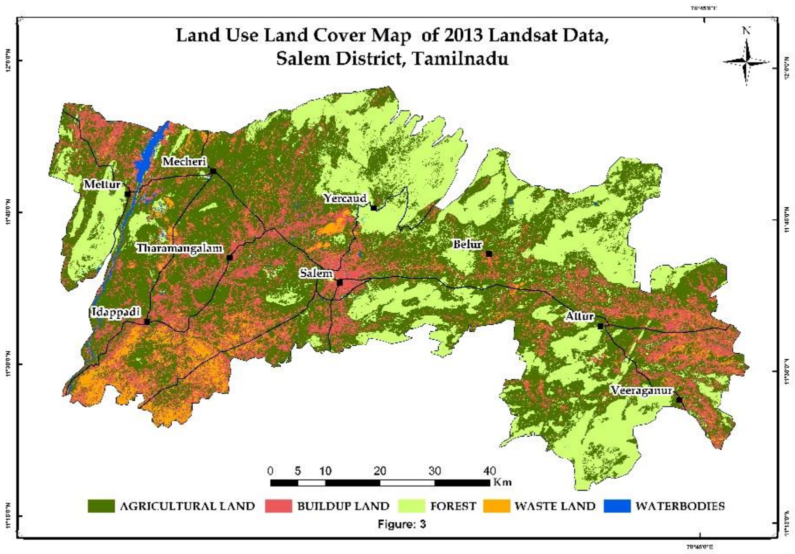


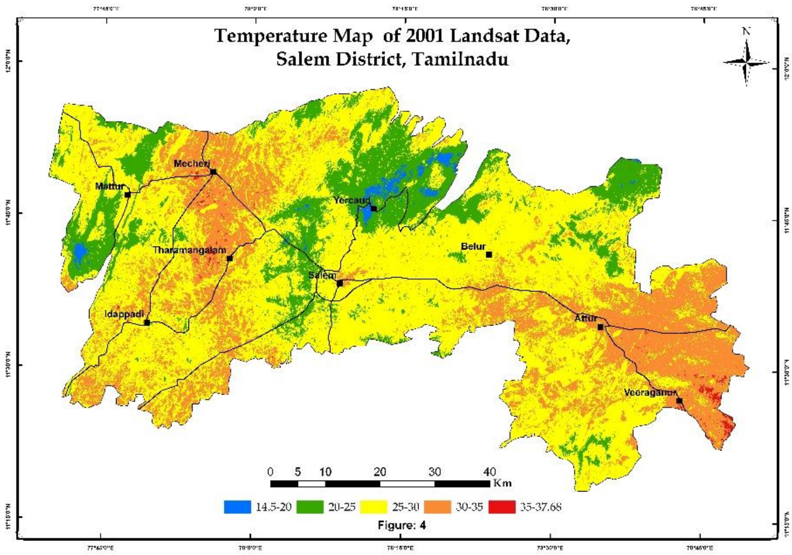
Figure: 3

Temperature Calculation

Conversion of Digital Number (DN) to Spectral Radiance ($L\lambda$) is the first step for the LST derivation. Radiance in TIRS band 10 and 11 (high gain on ETM+) were calculated from its digital numbers (DN) using standard equations by taking the required information from the MTL files given for Landsat 8 in ENVI environment. However, ETM+ band 61 and 62 captures the radiant thermal energy between 10.40 and 12.50 was taken in to ENVI directly to calculate the temperature using Landsat calibration option to convert the DN values to radiance. Further, bandmath has been used to convert temperature kelvin to Celsius. The spectral radiance ($L\lambda$) is calculated using the equation provided by

USGS, 2001, however, the LMAX and LMIN has been replaced by RMAX and RMIN which is taken from Landsat 8 MTL file.

The temperature in Celsius was calculated using the equation, (William Thomson & Aniello et. al, 1995): T (°C) =T-273.13 Where, T (°C) = Temperature in Celsius, T= Temperature in Kelvin, 273.13 = Zero Temperature Kelvin, the LST for the period 2001 and 2013 has shown in (Fig-4 & 5. Higher temperature has been observed in the area covered by settlement and sand while the lower temperature is associated with water body and vegetation. The temporal data have shown significant variations in temperature changes about 2.32° C within the period of 13 years, however, interestingly at some places, temperature has been decreased when compared to 2001 data



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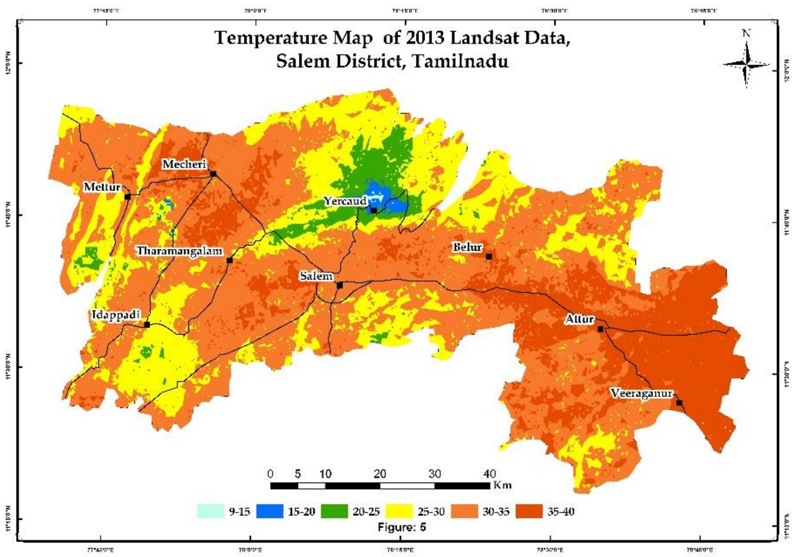
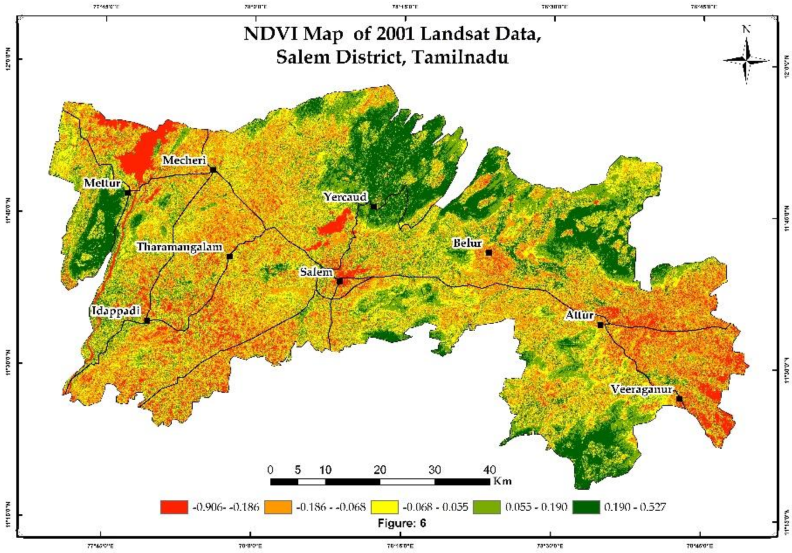


Figure: 5

Normalized Difference Vegetation Index

Vegetation cover monitoring is being successfully and sufficiently verified for the last two decades through Normalized Difference Vegetation Index (NDVI) technique. NDVI calculations are based on the principle that actively growing green plants strongly absorb radiation in the visible region of the spectrum while strongly reflecting radiation in the Near Infrared NDVI value of the pixels varies between -1 and +1 in which the value -1 indicates usually water and the value +1 indicates strongest vegetative growth. The NDVI value for 2001 ranges between -0.9 and +0.5 and for the year 2013 is -0.08 and 0.13 indicate the vegetation loss over the period of time. The NDVI for a pixel is calculated from the following formula, NDVI = NIR-Red / NIR+Red. Where NIR shows Near Infrared band and R shows Red band.



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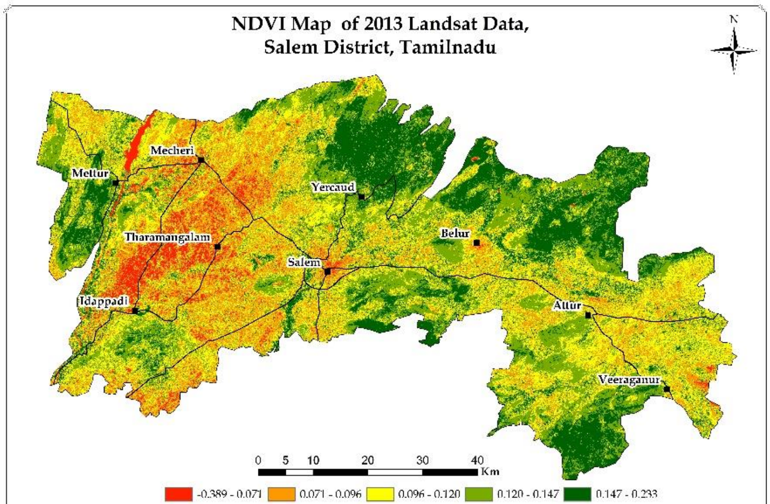

Figure: 7

Visual Interpretation

The output generated from the satellite data were visually interpreted and correlated with one another. Most of the Salem districts shows higher temperature. For the temperature variation analysis, a table has been generated from the attribute table in ARCGIS environment is given below in which temperature area in sq km has been calculated with respect to the temperature class range. The temperature class interval 25 to 30°C shows major variation in the entire Salem district where 3026.61 sq km has been reduced to 1268.22 sq km. Similarly 30-35°C area has been increased double the times in 2013 when compared to 2001. This is mainly due to urbanization and reduce of forest area. Land Use Land Cover map shows that the agricultural, forest and waste land has been decreased however the buildup land is increased. Therefore, the temperature variation i.e LST directly relates the urbanization in the Salem area. Likewise a positive correlation has also been noticed between temperature and NDVI result for the study area.Table-1 & 2.

Table-1: Temperature Variation for 2001 and 2013

Temperature 2001	Area in sq km	Temperature 2013	Area in sq km
No Class	---	9-15	3.24
14.5-20	46.17	15-20	31.41
20-25	804.24	20-25	208.76
25-30	3026.61	25-30	1268.22

30-35	1305.45	30-35	2710.67
35-37.68	19.05	35-40	1078.56

Table-2: Land Use Land Cover Changes for 2001 and 2013		
Name	**Area Sq km 2001**	**Area Sq km 2013**
Agricultural Land	2629.84	2559.49
Buildup Land	786.11	935.18
Forest	1558.15	1438.14
Waste Land	148.84	224.60
Water Bodies	78.74	44.35

Conclusion

Land surface temperature variation for the period of 13 years from 2001 to 2013 has been studied using various parameters like Temperature, Land Use Land Cove and NDVI. All these parameters have correlated and resulted about 2.32° C increase in the temperature. Thermal and Optical Remote Sensing data has been effectively utilized to bring the significant variation in the LST changes. The present study suggest that the un controlled urbanization in the Salem district should be minimized by taking proper action against the migration of village people to the city. Further, mining activities in the Salem area should be taken care and proper afforestation should be implemented after completion of every project work.

References

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