Chapter 15
Geospatial Technology for Analysing the Dynamics in Microclimate with Special Reference to Land Surface Temperature of Tropical Cities: A Case Study

K. P. Shimod, T. K. Prasad, V. Vineethkumar, R. Akhil, and G. Jayapal

Abstract The environmental implications of aggravating urbanisation associated with the alteration of landscape are of grave concern of urban planners now. This crisis is acute in many regions in the world, especially in the highly populated tropics. Urban geographers and planners are centring on climatically receptive designs to reduce undesirable microclimates. It demands scientific studies to address the problems related to the ill effect of unplanned developmental activities in the city. This study is an attempt to examine the spatio-temporal changes in the land use and land cover especially the built-up area and their impact in the land surface temperature (LST). Landsat imageries of 2000, 2010 and 2020 have been used to estimate the LULC, LST, NDVI and NDBI. The chapter shows that there is a remarkable increase in the built-up area and the land surface temperature for the last two decades. The mean temperature in the district was 26.76 °C in 2000, 28.54 °C in 2010 and 30.38 °C in 2020. The study suggests that it is necessary to have more focus on policies which will give more emphasis to urban greenery or urban forest concept in the upcoming years in order to reduce the land surface temperature in the district.

Keywords Microclimate · Land surface temperature (LST) · Normalised differential built-up index (NDBI) · Normalised differential vegetation index (NDVI) · Urbanisation

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Introduction

The rapid rate of urban growth and population pressure on land keep on altering the physical environment and resulting significant increase thermal environment of urban areas (Li et al. 2010). Urbanisation is the change from rural to urban, and its impact on environment has been widely assessed and studied for an effective resource management. Urbanisation has led to change in land use land cover especially in the peri-urban area frequently due to the rapid economic development. The process of urbanisation leads to the increasing in atmospheric as well as surface temperature and air quality in different ways to form urban heat island (Shimod et al. 2022a). This has a direct impact on human life and comfort, air pollution, energy management, climatic changes and urban planning policies (Fallmann et al. 2016). These changes can be ideally spotted and observed using the remote sensing images as they are comparatively up to date and provide a synoptic view of the area. The land surface temperature (LST) retrieved from the thermal band of satellite sensor provides scientific support to evaluate if the urban development is amenable with the environmental sustainability (Fan et al. 2010). Land use land cover changes have different kinds of environmental implications and the process of urbanisation which leads to the conversion of natural land cover to man maid land use has an immense impact on the urban climate. The decrease in the land surface temperature leads to the increases in albedo of the built-up surface, (Baldinelli et al. 2017) but the air temperature is not followed by same trend. The urban studies required accurate spatial information to observe the dynamics in land use land cover and the surface temperature (Xu 2011). Remote sensing products in the form of aerial photographs and satellite images provide data over a large area and are usually converted into useful information. Suitable image processing techniques and statistical analysis are used to extract the spatial parameters which are useful for detecting changes in urban extend as well as the thermal statistics. In several studies, different types of analysis are used to find out the relation between urban land use change and LST. These studies state that there is a direct impact of land use change in the variation of land surface temperature. When the area becomes urbanised, there will be an excess number of buildings for administration, industrial and residential purpose and transportation routes which will lead to increase in the temperature in and around the built-up regions (Prasad and Jishnu 2022; Jayalakshmy et al. 2021). The vegetative covers of regions are replaced by concrete materials in the urban area, and the density of vegetative cover will be reduced in its density and which will make the environment hotter. This will significantly increase the temperature of surface and affect the land use pattern. Hence, it is essential to understand the correlation between different land use land cover types and land surface temperature.

Knowledge of what others have found out in the related field of study and how they have done is a significant concern of a researcher. The different methodologies adopted by scholars like Slonecker et al. (2001), Dash et al. (2002), Jiang et al. (2006), Yuan and Bauer (2007), Mallick et al. (2008), Lu (2011a; 2011b), Sastry et al. (2013), Orhan et al. (2014), Chithra et al. (2015), Ivan and Benedek (2017), carried out studies in relation with different aspects and impacts of urbanisation especially in the field of land surface temperature, differential vegetation index, built-up index, etc. These kinds of research practice with remotely sensed data have involved interest since the 1970s and proved that, it is proficient in fetching out the trend and variations of results from time to time.

The studies on land surface temperature have received worldwide attention because of its importance and timely advancement and new innovations in different filed of urban studies. These kinds of studies related to LST can also provide useful awareness in many sorts of analysis like that of urban heat island, drought, forest fire monitoring and detection of thermal anomalies related to earthquakes (Wan 1999). This chapter discusses the changing land surface temperature over different period in the study area and its effects on different land use land cover in the district from 2000 to 2020.

Methodology

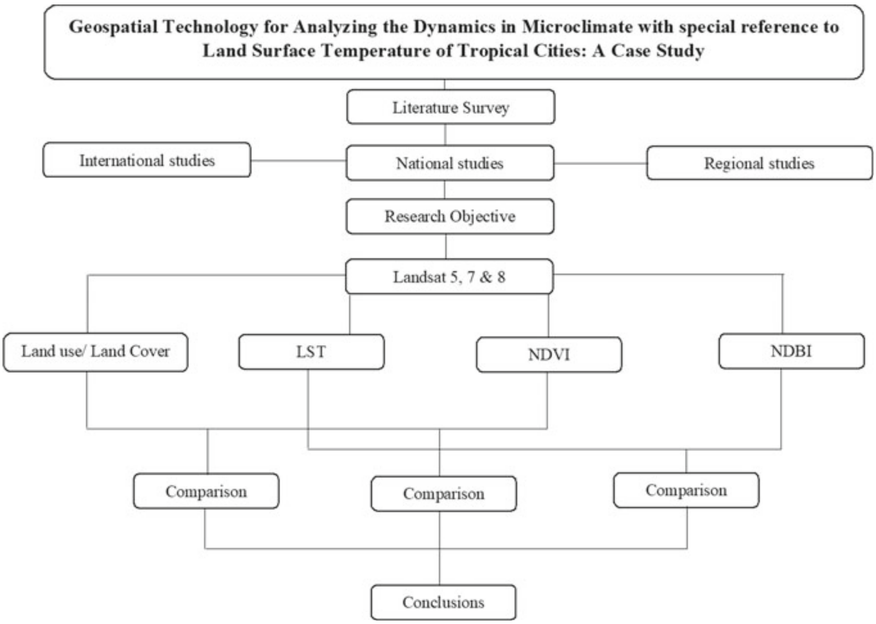
This study was carried out with the help of Geographical information system and remote sensing. Different time periods Landsat images (2000, 2010, 2020) were obtained from the official website of United States Geological Survey (USGS). These images are used for the calculation of different indices, i.e. LST, NDVI and NDBI. The location of the area under investigation falls in the Landsat path 145 and row 52 with UTM 43N WGS 1974.

Data Processing and Analysis

Cloud-free Landsat images downloaded from USGS for the years 2001, 2010 and 2020. The images were downloaded based on the percentage of cloud cover. As per the meta data, all the three images for the years 2001, 2010 and 2020 cloud cover are less than 20%.

ArcGIS 10.4 and ERDAS IMAGINE 2014 were used for data processing and analysis. The downloaded bands of different satellite images were layer stacked to obtain false colour composite (FCC), and also, processing of images includes geometric correction, unsupervised classification, band rotation and reclassifications and was done in ERDAS software. The output image is processed in ArcGIS platform, and different shapefiles were generated. The extraction of study area from the satellite images is performed using the district boundary shapefile.

Flowchart-methodology



Measurement of Land Surface Temperature (LST)

Many researches carried out studies in the recent years-related deriving LST using satellite data. The technological advancement in geospatial studies allows examining the changes in land surface temperature over different period of time this helps the researchers to make inferences in the relationship between land use changes over LST. In the earlier days, NOAA data was used to obtain LST for regional scale studies because of the resolution of the images attained from the satellite series. Nowadays, the Landsat satellite series, i.e. Thematic Mapper and Enhanced Thematic Mapper Thermal and Landsat 8 OLI Infrared band, has been used for studies in small-scale units.

Normalised Difference Vegetation Index (NDVI), Normalised Difference Built-up Index (NDBI) have also been calculated in order to inspect the correlation between LST. All these indices are calculated using Landsat 5, Landsat 7 and Landsat 8.

Retrieval of Land Surface Temperature

The Landsat images of 2000 which belong to Landsat 5 TM and 2010 of Landsat 7 ETM+ and 2020 of Landsat 8 OLI TIRS have been used for calculating LST. From Landsat 5 and 7, band 6 (thermal infrared band) has been used to calculate LST for 2000 and 2010. From Landsat 8, band number 10 has been used to estimate LST. Band 6 of Landsat 5 and 7 has a spectral range of 10.4–12.5 μm, and Band 10 of Landsat 8 has a spectral range from 10.60 to 11.19 μm. LST calculated from the thermal infrared band undergone radiometric calibration, emissivity and atmospheric correction. Landsat TM, ETM+ and OLI TIR are used for LST calculation.

Study Area

For the present investigation, Kannur District of Kerala (Fig. 15.1) has taken as the study area. Kannur District is typical tropical setting that lies between latitudes 11° 40′–12° 48′ N and longitude 74° 52′–76° 07′ E. The district is bound by the Western Ghats in the east (Coorg District of Karnataka State), Kozhikode and Wayanad district, in the south, Lakshadweep Sea in the west and Kasaragod, the northern-most district of Kerala, in the north.

Kannur District is one of the northern districts of Kerala, with a total geographical area of 2966 km^2 which accounts about 7.64% of the total area of Kerala state. It is ranked as in 6th position in areal extent. As per the 2011 census the total population of the district is about 2,523,003 persons, Kannur District ranks 8th in population among the districts of Kerala. Among the total population, 65.04% lives in the urban area, i.e. 1,640,986 persons. The region accounts 4th rank in the percentage of urban population in the state.

Spatial Pattern of LST

The spatial variation of the land surface temperature has been studied from 2000 to 2020. The values of LST distribution have shown in Fig. 15.2. After the retrieval of LST values from the satellite data using the above-mentioned formula, it shows the changes in the temperature values of last two decades in the district. The temperature range experienced in the district in 2000 is about 19.46–34.07 °C. In 2010, the range has increased to 20.38–36.69 °C. In 2020, the variation is 21.37–38.79 °C. This change in temperature ranges from time to time mainly due to the uneven trend of urbanisation pattern in the district. One of the most noticeable facts that all the Class II and Class III towns in the district are located very close to the major rivers flowing in the district that helped the district in lowering down the temperature up to an

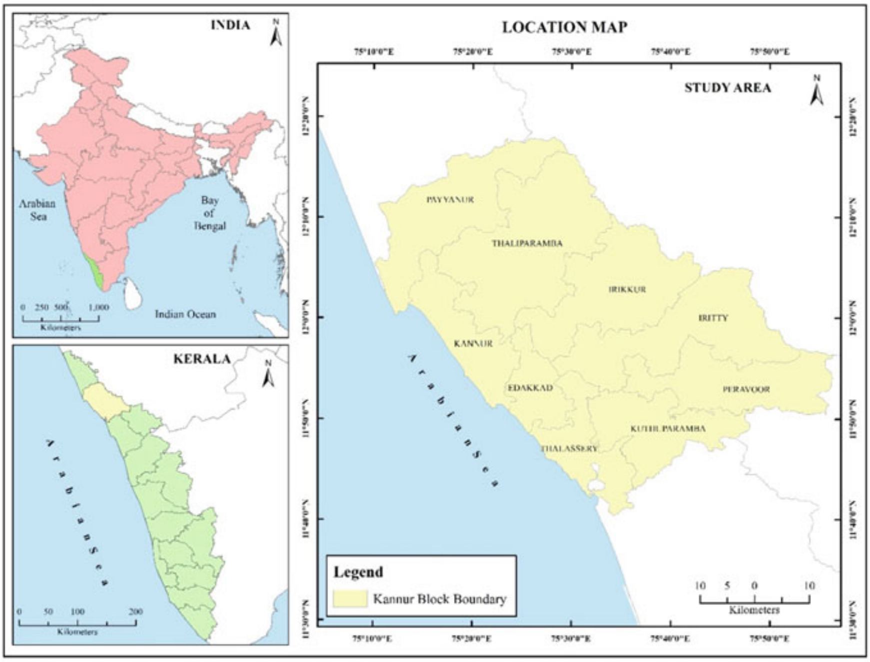


Fig. 15.1 Location map

extent. Even then the intensity of temperature gradually increases in the subsequent years.

The LST map shows colour variation from red to green, where the red shades show the areas recorded with high temperature and intensity or in other term the red decreases with the decrease in temperature. The areas of low temperature are shown with the green colour shades. The red shades mainly correspond to the built-up areas, open spaces such as grounds, construction sites and bare hill slopes. The green shade mainly shows the water bodies, forested tracts and agricultural lands. From this analysis, it has been identified that there is increase in the minimum and maximum temperatures recorded from 2000 to 2020.

Land Cover Type and Land Surface Temperature

There is a significant relation between land use land cover and land surface temperature of a region because change in the land use land cover has a direct impact on the temperature of that region. Different land use land cover types such as water bodies, built-up lands, vegetative covered areas and barren lands are the areas where the heat signature recorded by the satellite images and post-processed using remote

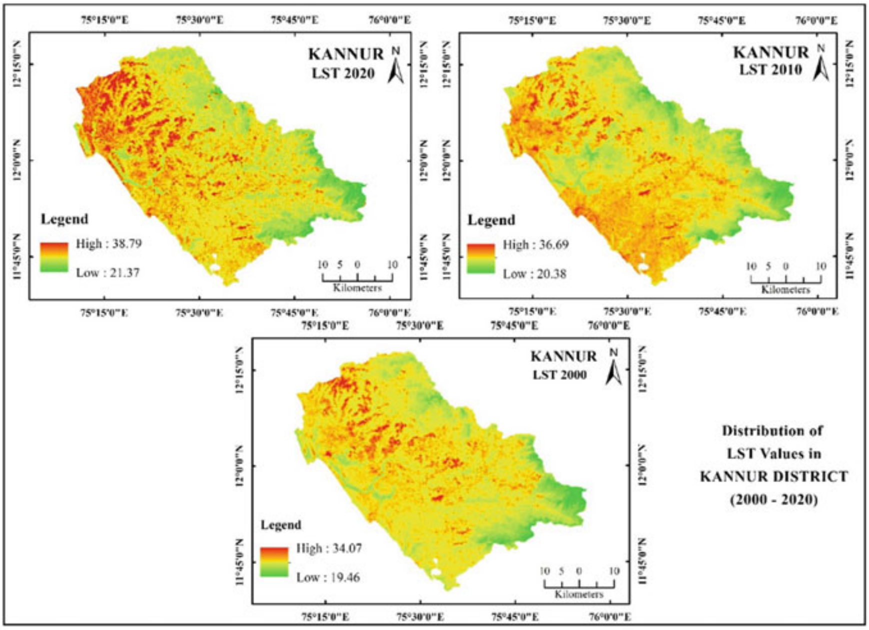


Fig. 15.2 Distribution of LST in Kannur district 2000–2020

sensing (Ibrahim et al. 2016). In the present study, analysis was done to find out the correlation between land use land cover and land surface temperature as well (Rajasekar and Weng 2009). The present study examines the change of temperature over different land use land cover type in the district over two decades, from 2000 to 2020. For that, the land use land over of the district had broadly classified under five categories (Table 15.1), they are vegetation, agriculture, water body, built-up and barren land (Fig. 15.4). Their area in different time period is shown in Table 15.2 and Fig. 15.3.

The temperature has increased in all the land cover type even in the vegetative covered regions and water bodies from 2000 to 2020. This shows the indication

Table 15.1 Land cover description

Land cover	Description
Vegetation	Trees, natural vegetation, mixed forest, grassland, vegetated lands
Agriculture	Agriculture lands, irrigated tracts, crop fields
Water bodies	River, lakes, ponds, canals, low lying areas, marshy land and swamps. seasonal wetlands
Barren land	Fallow land, open space, bare soils and rocky outcrops
Built-up	All Infrastructure-residential, commercial and industrial use, settlements, villages, road network, pavements and other manmade structures

Table 15.2 Land use/land cover types 2000–2020

LULC	2000	%	2010	%	2020	%
Vegetation	1491.8	50.30	1143.71	38.56	879.36	29.65
Agriculture	1259.3	42.46	1582.62	53.36	1783.8	60.14
Water bodies	75.8	2.56	64.82	2.19	52.81	1.78
Barren land	51.8	1.75	38.33	1.29	26.6	0.90
Built-up	87.3	2.94	136.52	4.60	223.43	7.53

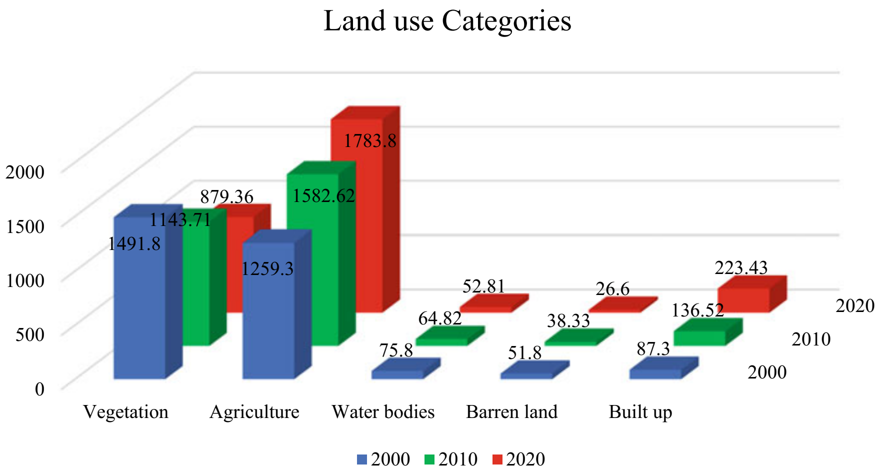


Fig. 15.3 Land use/land cover types 2000–2020

of change in the processes of different developmental activities and increase in the area of built-up. However, the change in the temperature range has more seen in the major cities' centres of the district and along the National Highway passing through the district. Urban areas in the district experience a considerable expansion of imperviousness as a result of the developmental activities of urban infrastructures which eventually leads to increase in surface temperature of that region. These kinds of urban expansion result in the growth of imperviousness surface, and the LST will be severely affected in different land use land cover types of the study area.

Table 15.3 and Fig. 15.5 show the average LST values of different land use classes in the district. Twenty training samples were taken from each land use land cover category to get the average temperature values in each category. The land surface temperature values show an increasing trend in all the five land use categories which is a clear indication of development in the built-up area and other associated infrastructures like that of roads and buildings. The built-up area has recorded the highest amount of temperature in all the three periods taken for the study, and it ranges from 34° to 39 °C. However, all other categories of land use land cover also show increasing trend in temperature but not as same phase with that of the built-up land.

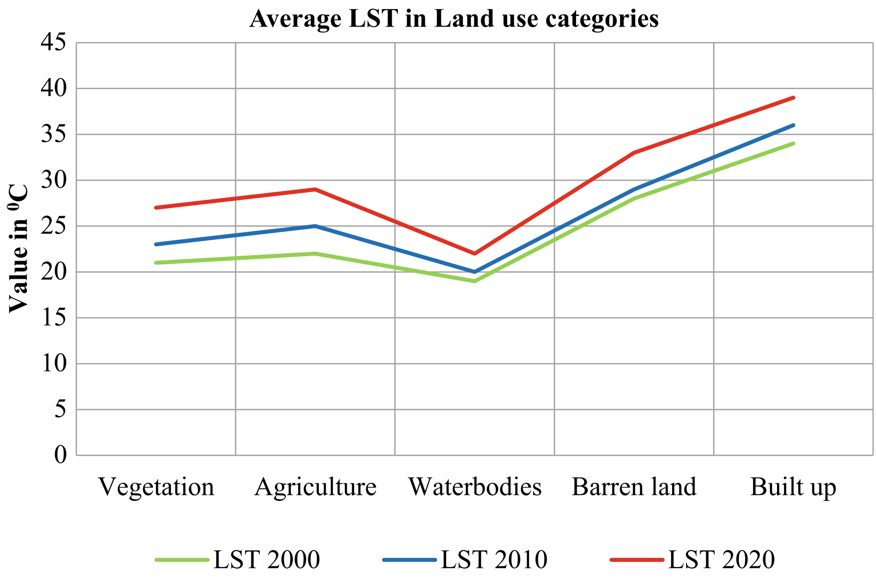


Fig. 15.4 Land use/land cover in Kannur district 2000–2020

Table 15.3 Average LST in land use categories

Land use category	Avg. LST in °C		
	2000	2010	2020
Vegetation	21	23	26
Agriculture	22	25	28
Water bodies	19	20	22
Barren land	28	29	33
Built-up	34	36	38

Vegetation

Vegetative cover in the district is more in the eastern high land regions with compared to the mid-lands and lowlands. High lands of the district are covered with mountain forest in the Western Ghats regions and which borders the district from nearby state. Few areas of the lowland regions are also covered with the vegetative cover in the form of mangrove forest in the river banks of major rivers flowing in the district. The average value of temperature over vegetative cover was 21 °C in 2000 which is slightly increased to 23 °C in 2010 and 26 °C in 2020, which indicates that the surface temperature has affected the vegetative cover over past two decades due to the expansion of land under developmental activities mainly in the built-up and other infrastructural developmental activities. This directly resulted in the increase in temperature of the areas under vegetative cover.

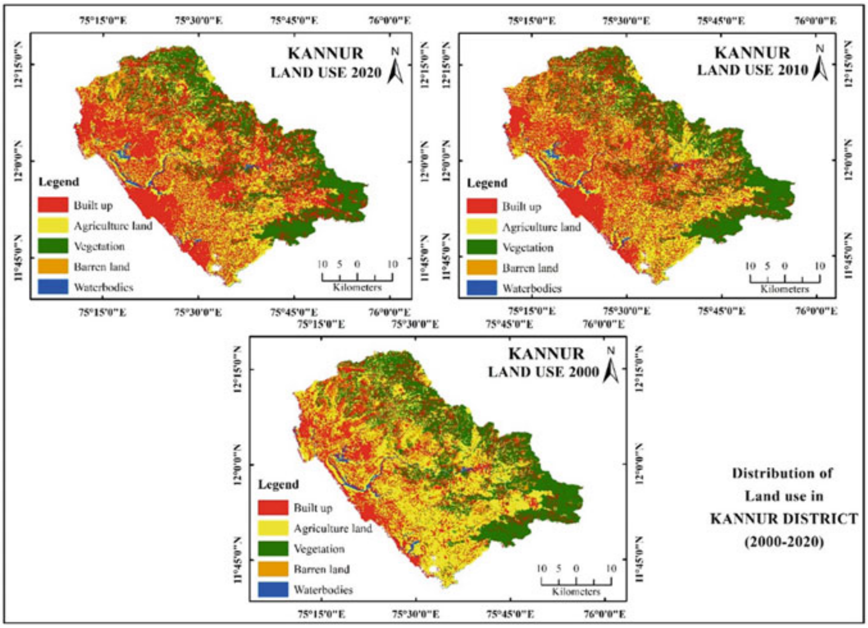


Fig. 15.5 Average LST values in land use categories

Agriculture

The agricultural lands in the study area are mainly come in the mid-land and lowland regions. The district has got a sound base in the agricultural sector. Paddy, coconut, arecanut, pepper, cashew and rubber are the major agricultural crops in this area. Due to these variation in cash crop cultivation and the presence of water content in the irrigated tracts of the paddy fields along with other farming practices agricultural land also shows lesser LST values. In 2000, the average temperature recorded from the agricultural land is 22 °C, 25 °C in 2010 and 28 °C in 2020. Decline in agricultural area and developmental activities in agricultural lands leads to the trend of increasing temperature in the district.

Waterbodies

The waterbodies are characterised with low-temperature values in usual scenario of LST studies. But in this study, due to the urban expansion and infrastructural development lead to the increase of temperature in the waterbodies of the district. Mainly because of all the class I and class II towns in the district are located in the banks of the major rivers. In 2000, the average temperature shown in the water body is 19 °C and slightly increased to 20 °C in 2010. By 2020, the LST has amplified to 22 °C. The waterbodies like Valapatanam, Kuppam and Peruvamba show increasing trend in the temperature values due to the developmental activities and concentration of industries in these river banks. All these reasons lead to the increase of LST values in the waterbodies of the study area in the last two decades.

Barren Lands

The areas of open spaces record different temperature values according to the nature of the land. Because of its absorption and reflection characteristics is different from one another. There was not much imperviousness expansion in 2000 so that the average value of temperature recorded was low and it shows the land surface value as 28 °C. In 2010, it increased to 29 °C and 33 °C in 2020. This shows that the developmental activities are taken over to the open spaces in the study area in order to expand the infrastructural facilities. This resulted in the overall increase in average temperature.

Built-Up

The major land cover type shows high rate of land surface temperature throughout the period. This is mainly due to the large-scale urban developmental activities in the district. The process of urbanisation is a never-ending process and the infrastructural development will be an ongoing process with variations in the intensity which causes fluctuation in the land surface temperature values over the built-up regions in the district. In 2000, the LST values recorded as 34 °C and in 2010 temperature increased to 36 °C by the year 2020 the temperature increased to 38 °C.

Significance of Different Land Cover Indices on LST

Considerable effort has been taken into simplify the process of map making to analyse the different parameters which affect the land use land cover of a particular area and also to find out the changes over different period of time. In this study, three land cover indices were derived to examine the relation between LST and indices and their distribution over the different land cover types in the study area. Among the various indices studied in the district, Normalised Difference Vegetation Index (NDVI) and Normalised Difference Built-up Index (NDBI) correlate strongly with LST.

Normalised Difference Vegetation Index—NDVI

Vegetation is a significant component of global environment and knowledge about the vegetative cover in the surface of the earth is vital to comprehend land–atmosphere relations and their impacts on climate. Changes in vegetative cover in the environment directly influence the surface water and energy budgets by plant transpiration, emissivity, surface albedo and roughness (Aman et al. 1992). The amount of vegetation is usually assessed through the tiny area of the vegetation inhabiting each grid cell (horizontal density) and the leaf area index (LAI), i.e. the quantity of leaf layers of the vegetated part (vertical density). Both photosynthesis and evapotranspiration are managed by these two parameters (Gujman and Jgnatov 1999). The satellite date will deliver a spatial and periodical interpretation of land under vegetation cover. There are numerous spectral vegetation indices developed in the last couple of decades to estimate the vegetation, canopy and biophysical properties such as LAI, biomass and vegetation cover percentage (Huete 1988). Many GIS and remote sensing studies have utilised the vegetation indices to examine and evaluate the properties of the background which are same or the variations are normalised by the particular indices used for the study (Hanan et al. 1991). By estimating the ratio of red and NIR bands from the satellite images, the index of vegetation ‘greenness’ can be calculated. The Normalised Difference Vegetation Index (NDVI) is perhaps the most commonly used indices for calculating vegetative cover. This is calculated using the following formula:

$$\mathrm{NDVI} = \frac{\mathrm{NIR} - \mathrm{RED}}{\mathrm{NIR} + \mathrm{RED}}$$

where NIR is the near-infrared band and RED is the red band.

The output of NDVI values ranges from -1 to $+1$, and the values less than zero do not have any environmental meaning, so the value range of the indices is shortened from 0.0 to $+1.0$.

Higher values obtained from the indices indicate a greater change between red and near-infrared radiation recorded by the satellite sensor. This condition is associated with extremely photosynthetically active vegetation cover. Low NDVI value indicates that there is slight difference between the red and NIR signals received by the satellite sensor. This occurs when there is very low photosynthetic activity, or when there is only a very little reflectance (i.e. NIR reflection is very little in the water).

The NDVI classification creates a single band data. In Landsat 5 and 7, Band 3 and 4 are used to derive NDVI, where Band 3 is the red band in the visible spectrum (0.63–0.69 μm) and Band 4 is the near-infrared (0.76–0.90 μm). In Landsat 8, Band 4 and 5 are used to derive NDVI, where band 4 is the red band (0.64–0.67 μm) and Band 5 is the near-infrared band (0.85–0.88 μm).

Estimation of NDVI for Landsat 5, 7 and 8

Formula for NDVI calculating using Landsat 5 and 7

$$\text{NDVI} = (\text{Band 4} - \text{Band 3})/(\text{Band 4} + \text{Band 3})$$

Formula for NDVI calculating using Landsat 8

$$\text{NDVI} = (\text{Band 5} - \text{Band 4})/(\text{Band 5} + \text{Band 4})$$

Distribution of NDVI Values in Kannur District

The NDVI (Fig. 15.6) value in the district ranges from 0.56 to −0.611 in 2000, 0.533 to −0.42 in 2010 and 0.486 to −0.144 in 2020, respectively. The least value of greenness recorded more in and around built-up area, mainly in the major class towns in the district and the highest values recorded in the agricultural lands. But gradually due to rapid urbanisation, the trend of NDVI gradually decreased to −0.52 in 2010 and further the value of NDVI drop down to −0.144 in 2020.

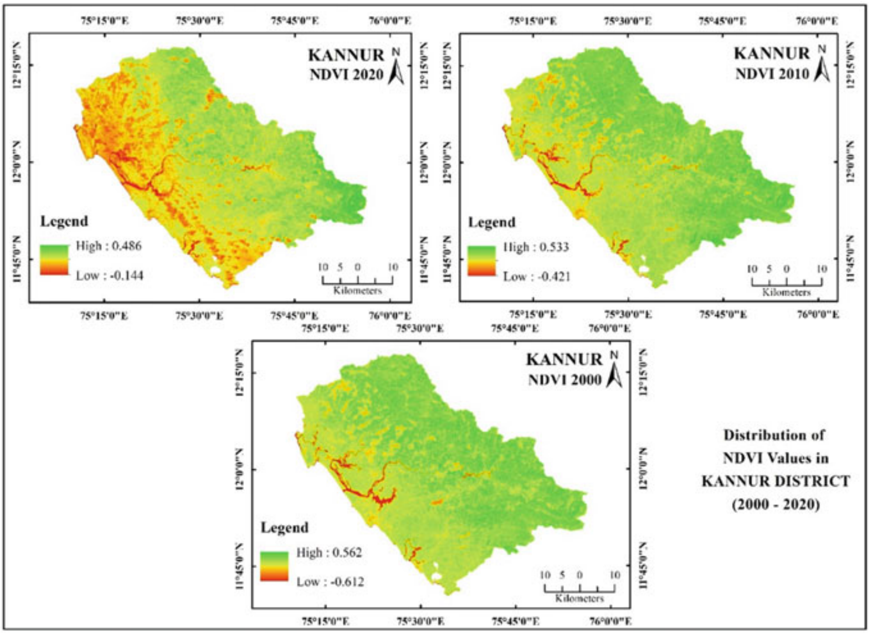


Fig. 15.6 Distribution of NDVI values in Kannur district 2000–2020

Table 15.4 NDVI values over land cover types (2000–2020)

Land use category	Range of NDVI		
	2000	2010	2020
Vegetation	0.41	0.21	0.2
Agriculture	0.15	0.14	0.11
Waterbodies	0.13	0.1	0.09
Barren land	0.09	0.08	0.06
Built-up	0.05	0.04	0.02

Distribution of NDVI Values on Land Use Land Cover

The range of NDVI (Table 15.4) values over different land use land cover in different years indicates the level of the intensity of vegetation in the district from 2000 to 2020. To calculate the level of vegetative cover in each land use land cover type in the district, 20 training sample points have been taken from each land cover types and checked the NDVI values of the same. The average NDVI value from the collected sample points from each land use class, which shows the intensity of vegetative cover during this period.

The intensity of vegetative cover is high in 2000, it is about 0.41. The index value derived from the average values of the sample points taken from all the parts of the district to represent the entire vegetative cover in the district. It is well noted that the high lands regions of the district have recorded the highest greenness value and its decreases towards mid-land and lowland regions of the district. The index values decreased to 0.21 in 2010 and 0.2 in 2020. Agriculture area has an index value ranges from 0.15 in 2000, 0.14 in 2010 and 0.11 in 2020. Waterbodies with 0.13 in 2000, 0.1 in 2000 and 0.09 in 2020. Barren land records the index values of 0.09 in 2000, 0.08 in 2010 and 0.06 in 2020. Built-up land has the lowest index values in last two decades with 0.05 in 2000, 0.04 in 2010 and 0.02 in 2020.

Relationship Between NDVI and LST

To test the relation between NDVI and LST (Fig. 15.7), correlation analysis was carried out for different time periods taken for the analysis. Figure 15.7 shows the NDVI and LST relationship. In 2000, NDVI value ranges from −0.511 to +0.56 and it gradually decreased to −0.42 to 0.533 and later in 2020 the values drastically reduced to −0.14 to 0.48. This has a clear indication of decrease in the vegetation index in the study area. The correlation shows a negative trend between NDVI and LST. When the land surface temperature increases, the vegetative cover decreases and that leads to the increasing of temperature in the district. This shows that this trend will also keep on going in future scenario.

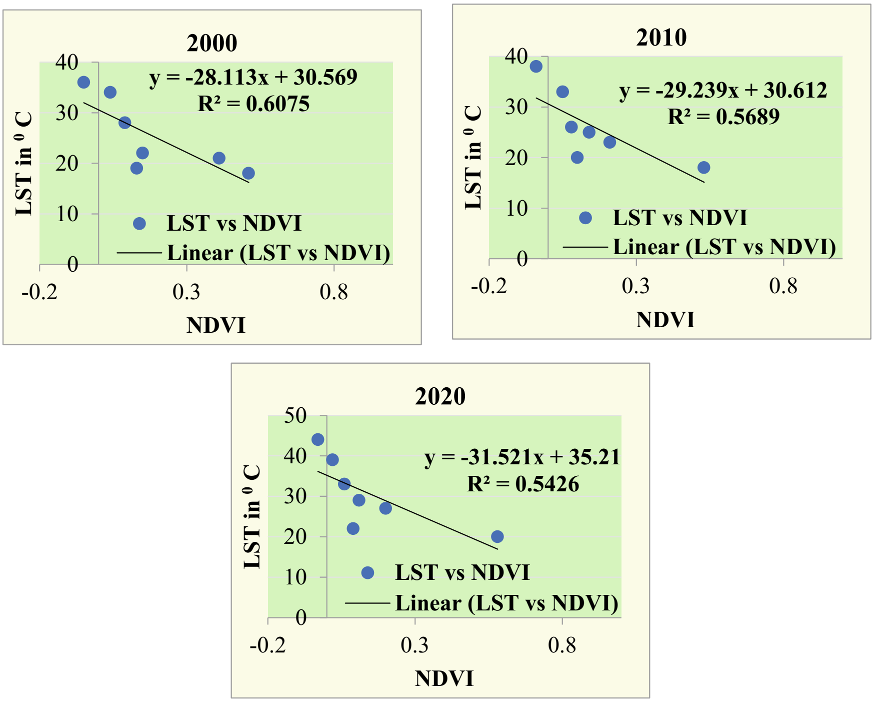


Fig. 15.7 Correlation between LST and NDVI values 2000–2020

Normalised Difference Built-Up Index (NDBI)

This index is used to classify built-up land. NDBI has been used recently as a major indicator to project the extent of built-up land. The output values lie between −1 and + 1. The negative value represents waterbodies, whereas the highest value represents built-up land. The value for vegetation in NDBI is low.

$$\text{NDBI} = \frac{\text{SWIR} - \text{NIR}}{\text{SWIR} + \text{NIR}}$$

Estimation of NDBI for Landsat 5, 7 and 8

Formula for NDBI calculating—Landsat 5 and 7

$$\text{NDBI} = (\text{Band 5} - \text{Band 4})/(\text{Band 5} + \text{Band 4})$$

Formula for NDBI calculating—Landsat 8

$$NDBI = (Band\ 6 - Band\ 5)/(Band\ 6 + Band\ 5)$$

Distribution of NDBI in Kannur District

The NDBI (Fig. 15.8) values of the district for the two decades (2000–2010–2020). In 2000, the values of the built-up indices vary from −0.582 to 0.288, this increased to −0.442 to 0.356 in 2010 and then to −0.337 to 0.439 in 2020. This gives an indication of expansion built-up land, especially in the coastal regions of the district, where the districts major towns are located like that of Thalassery, Kannur and Payyanur. National and State Highway corridors are also showing an increasing trend in the process of urbanisation which is clearly visible in the Taliparamba, Iritty, Irikkur and Sreekandapuram areas. In the last decade, there is a remarkable development in the Mattanur region where the Kannur International Airport (KIAL) is located. This growing trend in the built-up regions of the district will surely keep more phases than the last two decades of urban growth because of the well-connected transportation network. The high land regions of the district are connected with the hill highway which gave people more access to their developmental needs.

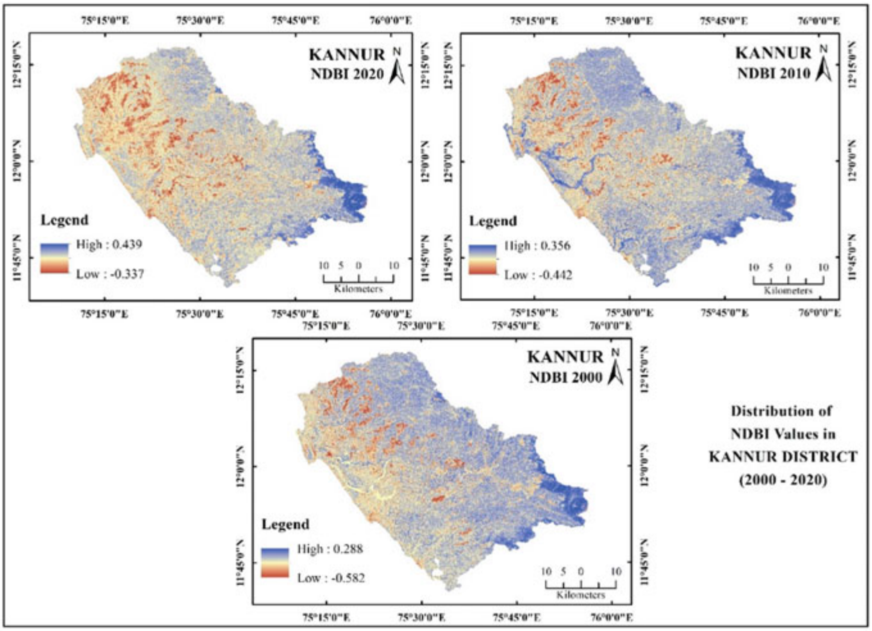


Fig. 15.8 Distribution of NDBI values in Kannur district 2000–2020

Table 15.5 NDBI values over land cover types (2000–2020)

Land use category	Range of NDBI		
	2000	2010	2020
Vegetation	0.16	0.14	0.12
Agriculture	0.12	0.1	0.09
Waterbodies	0.08	0.07	0.04
Barren land	0.19	0.18	0.15
Built-up	0.14	0.18	0.27

Distribution of NDBI Values on Land Use Land Cover

All land use types other than built-up shows a decreasing trend in the index values (Table 15.5). Waterbodies have the lowest index values ranges from 0.08 in 2000, 0.07 in 2010 and 0.04 in 2020. Barren land recorded the highest index values in 2000 (0.19) and 2010 (0.18) and second highest index value in 2020 (0.15). Agricultural area in the district has minimum index value ranges from 0.12 in 2000, 0.1 in 2010 and 0.09 in 2020. Vegetation category has an index value ranges from 0.16 in 2000, 0.14 in 2010 and 0.12 in 2020. But in built-up land cover the index value shows an increasing trend throughout the period with index value range from 0.14 in 2000, 0.18 in 2010 and 0.27 towards 2020.

Relationship Between NDBI and LST

This is the most common and efficient indices used to discriminate built-up from other land use land cover type. Exact mapping of the built-up area is very much necessary to have a well developmental plan or to make urban development strategies. This signifies the importance of knowing relationship between NDBI and LST.

Figure 15.9 shows the correlation between NDBI and LST in the study area for different period of time. It shows a positive relation from 2000 to 2020 values ranges from −0.5 to −0.3 in minimum and 0.2 to 0.4 to its maximum. Thus, it can be said that there exists a strong correlation between NDI and LST in the last two decades. These indices are derived and explained to know their drive on different land use land cover types in the study area. Different studies show that these indices have firm relationship with land surface temperature. Correlation has been conducted to identify the connection between different land cover indices over LST for different period of time (2000, 2010 and 2020) in order to examine their relationship during this time frame.

The study states that there are statistically significant correlations observed and hold over the years in the study area. The correlation between NDVI and LST shows a negative correlation, because when the values of LST getting increased over year the NDVI value gets decreased. This shows that the vegetative cover of the district

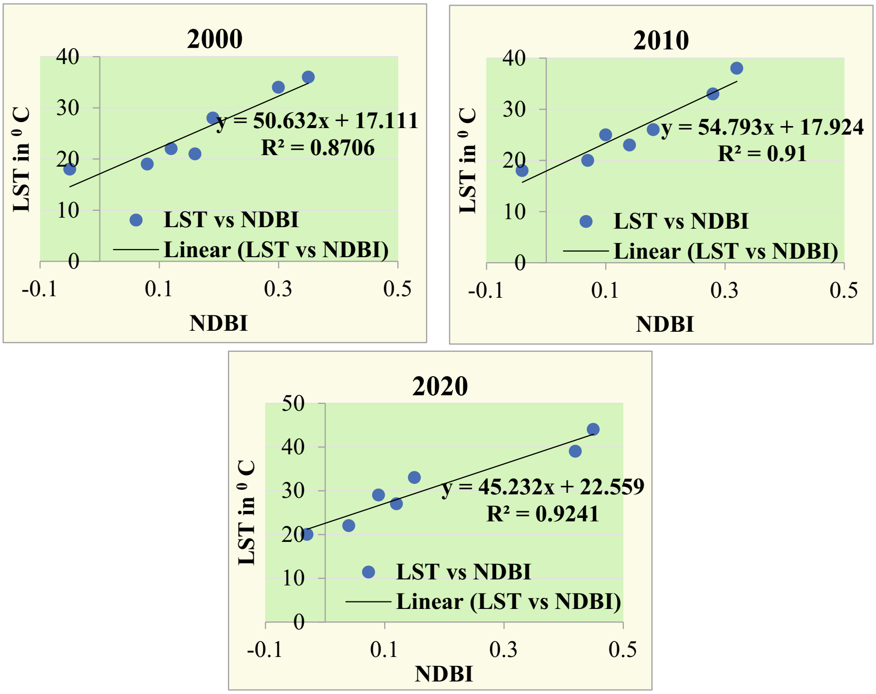


Fig. 15.9 Correlation between LST and NDBI values 2000–2020

is getting reduced from year to year mainly due to the cutting down of vegetative cover for developmental activities. But in the case of NDBI and LST, there exists a positive correlation, due to expansion of built-up area in the district, which has a direct influence on the land surface temperature. Thus, it can be summarised that all these two indices have strong correlation with LST. When NDVI shows a negative correlation or inversely propositional to LST, the NDBI shows a positive correlation or directly propositional to LST.

Conclusion

Urbanisation is a grave reality and is fast progressing in developing countries. In tropical areas, urbanisation is an extreme way that human activities have changed the land cover according to their needs and desire which have made multifaceted impacts on local environment. Urbanisation alters the urban canopy, modifies the radiation, germinate layers of buildings, changes the local land cover and thermal and dynamic characteristics of the underlying surface. The effect of urbanisation on micro-climate of tropics and its adverse effects are yet to be analysed extensively. The present study is an attempt to examine the impact of urbanisation on microclimate from a geographical standpoint. It is obvious from the study that the built-up area shown an increasing trend in the past two decades and which have a direct influence on the increasing of land surface temperature. The increase in the land surface temperature is mostly affected in the class I and class II towns in the district. All these towns are located in the western lowland regions of the district. These townships are well-connected with good transportation facilities; however, it is very much essential to have fast growth of urban infrastructure to address the demand of growing urban population and settlements. Planned development and policies should be adopted to reduce the population pressure on land and also to preserve the greenery, which will consequently help to reduce the land surface temperature. It is the high time where the planning strategies should give more emphasis to adopt environment-friendly approach. In addition, policies should not limit to horizontal management but also it should consider the vertical growth of cities as it influences the local temperature of urban areas.

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