The influence of changes in Land Use/Land Cover (LULC) on Land Surface Temperature in Ramanathapuram coast and Assessment of Urban Heat Island, using remote sensing and GIS

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Abstract

Due to marine and terrestrial processes, the land use/land cover features of the Ramanathapuram coastal area noticed dynamic changes. Sometimes the anthropogenic activities and nature also governed such changes. Landuse/Landcover analysis is an essential parameter for the climate change studies in coastal region. Similarly, the analysis of land surface temperature (LST) and the severity of Urban heat island (UHI) also factored for assessing its influence on climate changes. In this study, Remote sensed Landsat satellite data from 2000 to 2020 is very well used to identify the relation between LULC and LST. Advance tools in GIS (Geographic Information Systems) softwares is used to integrate the results. The findings strongly indicate that the built-up area is increasing every year. In the year 2000, the build-ups are noted with 8km² and it was increased to 44 km² in 2020. In addition, the LST of the year 2000, 2005, 2010, 2015, and 2020 radiates a maximum temperature of about 30°C, 29°C, 30°C, 30°C, and 27°C, respectively. The highest radiance temperature is observed in barren land; the UHI analysis also points towards increased urban activities. The temperature is comparatively high in an urbanised area, and its UHI values range from very Strong to moderate heat island.

1 Introduction

Land use / Land cover has an regular impact on the climatic condition. Since the climatic condition has changed and human influence, there has been a change in the coastal environment (Velsamy, S et al., 2020). Analysing Land use-land cover for several decades is an excellent method to figure out the changes on the land surface. The significance of studying LULC and its consequences are essential for natural resource planning and sustainable environmental management (Lambin et al., 2000; Read and Lam et al., 2002). Coastal dynamics impact a variety of physical, climatic, and biological aspects (Nithu Raj et al.2019). Recent analyses using geospatial techniques are pretty beneficial for analysing various spatial changes in the land surface. The ability of satellite-based data is now a commonly accepted tool for LULC mapping (Saadat et al. 2011; Yuan et al. 2005; Herold et al. 2003; Lambin et al. 2003; Hathout et al. 2002). In the last few decades, geospatial technology has been used for LULC mapping and climate change research. (Wu et al. 2018; Lv et al. 2018; Jin et al. 2017; Sekertekin et al. 2017; Phiri and Morgenroth et al. 2017). The gradual change of the landscape through various forms of land usage is seen worldwide (Geist et al. 2001). Land use/coverage is also dictated by environmental factors, elevation, geographical structure, slope, socioeconomic, and technological context, which often influences land-use trends (Rai et al. 1994). Urbanisation, Population growth and industrialisation, and have a rapid impact on LULC (Voogt et al. 2003). LULC has a significant role in environmental transition (Lambin et al. 1999). Natural ecosystems will be disrupted, including biodiversity, water, and radiation budgets. (Guzha et al. 2018; Kiruki et al. 2017; Yang et al. 2017; Lambin and Meyfroidt 2011; Riebsame et al. 1994).

LST is a significant climatic variable for estimating decadal climate variations. It is a strong indicator for understanding surface temperature (Schneider and Hook, 2010). The LST details are used for various atmospheric studies (Dousset et al., 2011; Luvall et al., 2015). The LST analysis was helpful to understand the influence of greenhouse gases, which tend to raise the temperature and the chances to melt polar ice caps. It will be increasing sea levels and floods. The radical changes in LST are due to the shift in rainfall

pattern, which affects the entire surface of the vegetation (Rajeshwari et al., 2014). Urban climate, evaporation, hydrology and vegetation analysis are just a few of the applications for LST (Hansen et al. 2010; Kalma et al. 2008; Weng et al. 2004; Arnfield, 2003; Su et al. 2002; Kogan et al. 2001; Bastiaanssen et al. 1998). The radiative temperature from the earth reflecting radiative energy is known as land surface temperature. It will help to understand the temperature fluctuation on the land. It's commonly used to monitor droughts. (Anderson et al., 2011; Hain et al., 2011). The reflecting radiance of each surface feature is different. So, LULC and its changes are highly influencing the land surface temperature. Various Natural and anthropological factors tend to change in the LULC of an area. As it changes, the climate of the region will also show variations. As a result, the study is receiving more attention these days for quantifying the magnitude of the LST on a regional basis. (Norman and Becker et al. 1995). Remote sensing satellite data is widely used these days for LST estimation using thermal data (Rajeshwari et al., 2014). Now, due to the free availability of the data, the usage of this data type is increased.

The term "urban heat island" refers to a region where noticeably higher temperature than the surrounding areas due to human influences. The temperature in an urban area is substantially greater than in an underdeveloped or rural area nearby. Nowadays, construction activities have increased demand for residential, commercial, and industrial purposes (Buyadi et al., 2013). During 1950, only 30% population lived in urban areas (Essa et al. 2012). According to India's 2011 census, the country's urban population has grown dramatically in the recent two decades (Pandey & Seto et al. 2015). The percentage of people living in cities has increased significantly. Between 2010 and 2050, India's urban population is expected to grow by more than 500 million people, according to UN estimates. The growth of the city's population compelled the area's construction to expand. Hence it will damage the vegetation cover in the land for making the structures to urbanisation. It leads to increased structured sites and decreased green cover in cities (Rahman et al. 2013; Rahman et al. 2012; Shahmohamad et al. 2011; Rahman et al., 2007). Urbanisation will transforms vegetation into a structured area and mainly within the boundaries of the agricultural land surrounding them (Pandey & Seto, 2015). The temperature of the land surface will rise if vegetation is reduced and barren land is increased. (Kumar et al. 2012).

The city's climate is influenced by the green thermal system, which improves selective absorption and reflection of incident radiation while also managing latent and reactive heat transfer (Owen et al. 1998; Nichol et al. 1996; Gallo et al. 1995; Carlson et al. 1994). Vegetation is an essential part of the world and has a multidimensional role across all the physical elements (Rao & Puntambekar et al., 2011). Green space is a must-have in any city since it contributes to a healthy urban environment and a healthy way of life. It will keep the urban regions' natural and environmental attractiveness (Chen et al. 2006). The Green vegetation in the earth improves the quality of air and reduces biodiversity conservation. It will reduce the violence of UHI and a significant contributor to environmental sustainability (Senanayake et al. 2013; Colding et al. 2007; Kühn et al. 2006; Gaston et al. 2005; Pauleit et al. 2000; Bolund et al. 1999). The increase in urban heat island (UHI) in metropolitan regions is caused by a reduction in plant cover and an increase in the built-up part, resulting in a degradation of the environmental condition in industrial areas (Mallick et al. 2013). Earth's surface temperature influences the planet's physical, chemical, and biological properties (Becker et al., 1990). The relationship between built-up land, vegetation cover, and the LST was investigated by (Badarinath et al.

2005). Several studies have found a clear link between LST, built-up, and green cover as a result of urbanisation. (Kumaret al. 2012; Weng et al. 2004).

Landsat satellite data is beneficial to analyse the historical and recent changes in different types of land cover, (Galford et al. 2008; Seto et al. 2002; Woodcock et al. 2001; Coppin et al.1996; Jensen et al. 1995). Its spatial and spectral coverage has continuous measurement up to the near-nadir (Woodcock & Strahler et al., 1987).

2 Materials And Methods

2.1 Study Area

Ramanathapuram coastal part of Tamil Nadu, India's coastline region has taken for the study. It is situated between the geographic coordinate's 78°45'E and 79°20' E longitudes, as well as the latitudes of 9°05' N and 9°30' N, at 3 meters above mean sea level. There are 21 unpopulated coral islands situated within a 10 km radius from the coastal belt of Ramanathapuram. More than 30,000 fishermen live in this area, and various large- and small-scale industries present for the economic sustain of people. The study has carried out in a 468 km² area, over the coastal villages viz. Kalimankund, Ervadi, Mayakulam, Keelakarai, Kanjirangudi, Periapattinam, Karan, Rettaiyurani, Pudumadam, Tiruppulani, Nochiyurani, Sattakonvalsai, Enmanamkondan, Nagachi, Attangarai, Alagankulam, Terbhogi, Pirappanvalsai Athyuthu, Chitrakkottai, Devipattinam, Pathanendal, Mandapam, Pamban, and Rameswaram (Fig. 1).

2.2 Data Used

Landsat (OLI, ETM+, and TM) was used to figure out LULC, LST, and UHI mapping. It helps in the detection of changes in the research area. Landsat-7 ETM + and Landsat-4 TM images have 60 m spatial resolution, while Landsat-8 have a spatial resolution of 30 m. The data was taken from the website of USGS Earth Explorer. The satellite data taken for the study are precise and practically cloud-free. To map LULC from remotely sensed digital data, a supervised digital image classification technique can be applied. (Thomas et al., 1987; Campbell et al., 1987). Visual analysis and supervised classification are carried out using the false-colour composite (FCC) during the investigation. The Thermal Infrared (TIR) of the Landsat satellite data series is highly useful for estimating ground radiative energy using the Radiative Transfer Equation (RTE).

2.3 Image Processing and Classification

Data accuracy is fundamental for mapping and identifying the changes in the land surface. Every satellite data contains both radiometric and geometric errors. Correction of these errors is essential for the generation of the data with significant levels of location precision. The data were taken to GIS using an input tool. The multi-date Landsat satellite and the Toposheets were taken to GIS. Image pre-processing methods in GIS platforms. The registration of data, geometric and radiometric calibration were used to process the data. These methods help reduce data errors and enhance the quality of the spatial data. The multi-date satellite data retrieved were pre-processed using techniques for enhancing the images. This includes strip detection and restorement, image processing, and topographical correction. When using distinct ancillary data of

different sources or formats, evaluation is essential before integrating it into a classification procedure. Multiple source data needs strong data rectification for a classification algorithm. Digital images were processed and co-registration is done to standardise data using ERDAS image processing software. LULC mapping is an image classification method in remote sensing. It categorises the land feature based on the pixel values of satellite data. The study helps to identify the physiographic changes and able to predict hazardous regions.

Landsat imagery (TM, ETM+, and OLI) used for LULC mapping of the year 2000, 2005, 2010, 2015, and 2020 to identifying changes in the study region. LULC can mapped from digital satellite data through a supervised image classification process (Campbell et al. 1987; Thomas et al. 1987). Visual analysis and supervised classification are carried out using the false-colour composite (FCC) during the analysis. Image classification technique in GIS software, usually pair all similar pixels in an image into land cover groups (Kiefer et al. 1994). The maximum likelihood classifier calculates the variance and covariance of the spectral response patterns in the category while categorising an unknown pixel. As a result of its statistical properties, it is regarded as one of the most accurate image classifiers. The study area is classified into Ten main classes (Table 1): Water bodies, Saltpan, Plantation, Sand/ Sandy beaches, Barren land, Mangrove, Shrubland, Lagoon, Tidal Flat, and Built-up Land.

Table 1
Land use and Land cover classifications and Description

Sl. No	Land Use Type	Description
1	Plantations	Commercial horticulture plantations, orchards and tree cash crops
2	Built-up Land	Land covered with buildings and other man-made structures
3	Water bodies	Areas with surface water, either impounded in the form of ponds, lakes, reservoirs or flowing as streams, rivers, etc. Can be either fresh or salt-water bodies
4	Mangrove	Evergreen forests in the intertidal areas. These forests are dense and dominated by halophytic plants
5	Sand/ Sandy Beaches	White colour sand deposited and beach sediments
6	Salt Pan	Land covered with salt and minerals
7	Barren land	Exposed soil, sand, rocks, or snow and never have more than 10% vegetated cover during any time of the year
8	Shrubland	Zone of soft, moist land, intermittently or permanently filled by sand and mud, mostly vegetated by shrubs and trees,
9	Lagoons	Shallow region of waterbody separated from sea
10	Tidal Flat	Intertidal zones where sediments accumulated by tidal action

The Thermal Infrared (TIR) satellite data collection from Landsat is extremely valuable for estimating ground radiative energy using the Radiative Transfer Equation. The research area's land surface temperature is calculated using a thermal infrared band. Climate Change, Evapotranspiration, Hydrological Cycle, Vegetation, Urban Atmosphere, and Natural Investigation Assessment are just a few examples of applications where LST is commonly used. (Hansen et al. 2010; Weng, 2009; Kalma et al. 2008; Weng et al. 2004; Arnfield et al. 2003; Voogt et al. 2003; Kogan, 2001; Bastiaanssen et al. 1998). Land surface temperature (LST) is one of the essential elements influenced by surface energy (Karnieli et al. 2010; Kustas et al. 2009; Anderson et al. 2008; Zhang et al. 2008; Brunsell et al. 2003).

2.4 Accuracy Assessment

Accuracy is an essential for LULC classification process. It decides whether the reference data and categorised data are acceptable. (Tso et al. 2005). The accuracy assessment is done with 50 field-collected ground truth locations. Then it has validated with the classified result of land use/land cover 2000, 2005, 2010, 2015, and 2020 in ArcGIS. Finally the similarity has been determined between ground truth locations and land use / landcover classes.

2.5 Retrieval of Brightness Temperature

2.5.1 Conversion of DN – Radiance

The pixel values in a satellite data dependent on its resolution, are referred to as DN. It conveys information regarding the spectral reflectance of the object. The primary stage in performing a fine spectral analysis for the study is to convert DN values into spectral radiance using the following computation.

$$L_{\lambda} = M_L \times Q_{cal} + A_L - O_i,$$

Here, M_L is the multiplicative rescaling factor for each band, Q_{cal} is Band 10 in an image, A_L is the additive rescaling factor for each band, and O_i is Band 10 correction (Barsi et al. 2014).

2.5.2 Conversion- Radiance to At-Sensor Temperature

It involves converting Digital Numbers (DN) into reflection in terms of brightness. The TIRS band is converted from the spectral radiation to brightness temperature (BT) using the following equation,

$$BT = \frac{K_2}{\ln \left[\frac{K_1}{L_{\lambda}} + 1 \right]}$$

Here BT is effective while calculating satellite temperature in Kelvin for obtaining the results in Celsius, K_1 and K_2 are calibration constants, and L_{λ} is spectral Radiance (USGS, 2013).

2.6 Urban Heat Island Intensity

To determine the Urban Heat Island, the relative radiative temperature was calculated using the land surface temperature as the average for each year. The formula used for the calculation of UHI is given below (Xu et al. 2013; Zhang et al. 2012)

$$UHI_n = \frac{T_n - T_{mean,2000}}{T_{mean,2000}}$$

Where,

UHI is Urban Heat Island in the year (n),

T_n is the temperature of the year (n).

T_{mean} is the land surface temperature of the year 2000

UHI was categorised as Green Island (UHI Range > 0), Weak heat island (UHI Range 0–0.005), Strong heat island (UHI Range 0.005–0.010), Stronger heat island (UHI Range 0.010–0.015), Strongest heat island (UHI Range 0.015–0.020), Violent heat island (> 0.020)

3. Results And Discussion

3.1 Land use/Land cover Changes 2000 and 2020

The analysis was carried out for 2000, 2005, 2010, 2015, and 2020. There are 10 number of land use-land cover classes are observed and classified: Built-up Land, Plantation, Barren land, Sand/ Sandy Beaches, Water bodies, mangroves, Saltpan, Scrubland, lagoon, and Tidal flat. The results are given in (Table 2), and spatial maps are given in Fig. 2 (a-e).

Table 2
Land Use and Land Cover Changes between 2000 and 2020

Classes	2000	2005	2010	2015	2020
	Area km ²	Area km ²	Area km ²	Area km ²	Area km ²
Built-up Land	8	19	31	35	44
Plantation	67	89	68	68	73
Barren land	201	162	218	220	222
Sand/ Sandy Beaches	127	145	85	85	82
Water bodies	16	15	23	23	21
Mangrove	1	1	0.8	0.97	0.5
Saltpan	1	2	3	3	7
Shrubland	12	11	13	12	9
lagoon	16	12	14	14	13
Tidal flat	1	1	1	1	1

An overall result shows that Barren land is highly dominated class in the area. The northern and southern area is coastal region. So, sand/sandy beaches become the Second dominantly occupied landcover feature. The sand/sandy beaches become decreased from 127km² in 2000 to 82km² in 2020. The third dominant one is Plantations. The plantation was increased from 67 km² in 2000 to 73km² in 2020. It covered near the Vaigai river basin. Plantain and coconut trees are mostly cultivated in the region—the residential area primarily dominated in the central part of Rameswaram island. The residence is increasing every year. During the year 2000, the build-ups are noticed with 8 km². While in 2020, the area covered with 44 km² of built-up land. The Saltpans increased from 1km² in 2000 to 7 km² in 2020. It is mainly seen in the northern corner of Rameswaram island and near the coastal region of Sethuhukarai and Atangarai villages. The area of water bodies increased from 16 km² in 2000 to 21km² in 2020. However, Shrubland decreased from 12km² in 2000 to 9km² in 2020. Similarly, Mangroves in this region fell from 1km² in 2000 to 0.5 km² in 2020. Mangroves are mostly covered in the Devipatinam region.

The degree of acceptance between reference data and classified data is tested during accuracy evaluation, an important aspect of the image classification procedure. The land use and land cover accuracy studies were carried out for the ten classes with 50 ground control locations for each class (500 points). In the year 2000, the results show an overall accuracy of 90% and Kappa coefficient of 89%. It seems the higher amount of matching with classified map and ground location is shown in (Table 3). The user's accuracy of 89% was noticed for Barren Land (BL), 90% for Built-up Land (Bu), 75% for Lagoon (La), 100% for mangroves (Ma), 89% for Plantation (Pl), 100% for Salt pan, 100% for Sand /sandy beaches, 73 % for Shrub Land, 100% for Tidal Flats and 100% for water bodies.

Table 3
Accuracy Assessment of Land Use and Land Cover _ 2000

Class	BL	Bu	La	Ma	PI	Sp	SB	SL	TF	WB	Total	User's Accuracy (%)
BL	8	0	0	0	1	0	0	0	0	0	9	89
Bu	0	9	0	0	0	0	0	1	0	0	10	90
La	1	0	9	1	0	0	0	0	1	0	12	75
Ma	0	0	0	8	0	0	0	0	0	0	8	100
PI	0	1	0	0	8	0	0	0	0	0	9	89
Sp	0	0	0	0	0	8	0	0	0	0	8	100
SB	0	0	0	0	0	0	9	0	0	0	9	100
SL	1	0	1	0	0	0	0	8	0	1	11	73
TF	0	0	0	0	0	0	0	0	9	0	9	100
WB	0	0	0	0	0	0	0	0	0	9	9	100
Total	10	10	10	9	9	8	9	9	10	10	85	
Producer's Accuracy (%)	80	90	90	89	89	100	100	89	90	90		
Overall Accuracy = 90%												
Kappa coefficient = 89%												

Accuracy assessment for the year 2005 results in an overall accuracy of 94%, Kappa coefficient of 93% (Table 4). The user's accuracy of 82% was noticed for Barren Land (BL), 91% for Built-up Land (Bu), 100% for Lagoon (La), 100% for mangroves (Ma), 100 % for Plantation (PI), 89% for Salt pan, 100% for Sand /sandy beaches, 90% for Shrub Land, 100% for Tidal Flats and 90% for water bodies.

Table 4
Accuracy Assessment of Land Use and Land Cover _ 2005

Class	BL	Bu	La	Ma	PI	Sp	SB	SL	TF	WB	Total	User's Accuracy (%)
BL	9	0	1	0	0	0	0	1	0	0	11	82
Bu	0	10	0	0	1	0	0	0	0	0	11	91
La	0	0	8	0	0	0	0	0	0	0	8	100
Ma	0	0	0	8	0	0	0	0	0	0	8	100
PI	0	0	0	0	9	0	0	0	0	0	9	100
Sp	0	0	0	1	0	8	0	0	0	0	9	89
SB	0	0	0	0	0	0	9	0	0	0	9	100
SL	0	0	0	0	0	0	0	9	0	1	10	90
TF	0	0	0	0	0	0	0	0	9	0	9	100
WB	0	0	0	1	0	0	0	0	0	9	10	90
Total	9	10	9	10	10	8	9	10	9	10	88	
Producer's Accuracy (%)	100	100	88.8889	80	90	100	100	90	100	90		
Overall Accuracy = 94 %												
Kappa coefficient = 93 %												

Accuracy assessment for the year 2010 results in an overall accuracy of 95%, Kappa coefficient of 94% (Table 5). The user's accuracy of 90% was noticed for Barren Land (BL), 100% for Built-up Land (Bu), 82% for Lagoon (La), 100% for mangroves (Ma), 90 % for Plantation (PI), 100% for Salt pan, 100 % for Sand /sandy beaches, 100% for Shrub Land, 100% for Tidal Flats and 100% for water bodies.

Table 5
Accuracy Assessment of Land Use and Land Cover _ 2010

Class	BL	Bu	La	Ma	PI	Sp	SB	SL	TF	WB	Total	User's Accuracy (%)
BL	9	0	0	0	0	0	1	0	0	0	10	90
Bu	0	9	0	0	0	0	0	0	0	0	9	100
La	1	0	9	0	1	0	0	0	0	0	11	82
Ma	0	0	0	10	0	0	0	0	0	0	10	100
PI	0	1	0	0	9	0	0	0	0	0	10	90
Sp	0	0	0	0	0	10	0	0	0	0	10	100
SB	0	0	1	0	0	0	9	0	0	0	10	90
SL	0	0	0	0	0	0	0	9	0	0	9	100
TF	0	0	0	0	0	0	0	0	9	0	9	100
WB	0	0	0	0	0	0	0	0	0	9	9	100
Total	10	10	10	10	10	10	10	9	9	9	92	
Producer's Accuracy (%)	90	90	90	100	90	100	90	100	100	100		
Overall Accuracy = 95%												
Kappa coefficient = 94%												

Accuracy assessment (2015) results reveal that in an overall accuracy of 94%, Kappa coefficient 93% (Table 6). The user's accuracy of 90% was noticed for Barren Land (BL), 90% for Built-up Land (Bu), 90% for Lagoon (La), 100% for mangroves (Ma), 90 % for Plantation (PI), 100% for Salt pan, 100 % for Sand /sandy beaches, 90% for Shrub Land, 100% for Tidal Flats and 90% for water bodies.

Table 6
Accuracy Assessment of Land Use and Land Cover _ 2015

Class	BL	Bu	La	Ma	PI	Sp	SB	SL	TF	WB	Total	User's Accuracy (%)
BL	9	0	0	0	1	0	0	0	0	0	10	90
Bu	0	9	0	0	0	0	0	0	0	1	10	90
La	0	0	9	0	0	0	1	0	0	0	10	90
Ma	0	0	0	9	0	0	0	0	0	0	9	100
PI	0	1	0	0	9	0	0	0	0	0	10	90
Sp	0	0	0	0	0	10	0	0	0	0	10	100
SB	0	0	0	0	0	0	9	0	0	0	9	100
SL	0	0	1	0	0	0	0	9	0	0	10	90
TF	0	0	0	0	0	0	0	0	10	0	10	100
WB	0	0	0	1	0	0	0	0	0	9	10	90
Total	9	10	10	10	10	10	10	9	10	10	92	
Producer's Accuracy (%)	100	90	90	90	90	100	90	100	100	90		
Overall Accuracy = 94%												
Kappa coefficient = 93%												

Accuracy assessment for the year 2020 results in an overall accuracy of 87%, Kappa coefficient 86% (Table 7). The user's accuracy 100% was noticed for Barren Land (BL), 91% for Built-up Land (Bu), 83% for Lagoon (La), 100% for mangroves (Ma), 100 % for Plantation (PI), 100% for Salt pan, 100 % for Sand /sandy beaches, 90% for Shrub Land, 100% for Tidal Flats and 100% for water bodies.

Table 7
Accuracy Assessment of Land Use and Land Cover _ 2020

Class	BL	BU	La	Ma	PI	Sp	SB	SL	TF	WB	Total	User's Accuracy (%)
BL	9	0	0	0	0	0	0	0	0	0	9	100
Bu	0	10	0	0	1	0	0	0	0	0	11	91
La	1	0	10	0	0	0	1	0	0	0	12	83
Ma	0	0	0	10	0	0	0	0	0	0	10	100
PI	0	0	0	0	9	0	0	0	0	0	9	100
Sp	0	0	0	0	0	10	0	0	0	0	10	100
SB	0	0	0	0	0	0	9	0	0	0	9	100
SL	0	0	0	0	0	0	0	10	0	0	10	100
Tf	0	0	0	0	0	0	0	0	10	0	10	100
WB	0	0	0	0	0	0	0	0	0	10	10	100
Total	10	10	10	10	10	10	10	10	10	10	97	
Producer's Accuracy (%)	90	100	100	100	90	100	90	100	100	100		
Overall Accuracy = 87%												
Kappa coefficient = 86%												

Overall accuracy assessment study reveals that 91% accuracy is matched with the ground for all the years above. That indicates a higher amount of matching. However, producer accuracy for all years of all classes is also above 85% accuracy. It means during the pixel-based classification, more than 85% of classes correctly matching with the ground points, and less than 15% of pixels are incorrectly classified. Hence the land use and land cover results have been verified with an accuracy assessment method.

3.2 LST Changes between 2000 and 2020

The land surface temperature was calculated using the thermal band of Landsat satellite data sets from 2000 to 2020 and GIS software. The overall findings show that the highest temperature was noticed in 2000 (26°C), and the lowest temperature was noticed in 2005 (15°C). During the year 2000, 2005, 2010, 2015, and 2020, radiates a maximum temperature of about 30°C, 29°C, 30°C, 30°C, and 27°C respectively (Table 8). The Spatial maps were prepared, and it is shown in Fig. 3 (a-e). The lowest LST (18–22°C) was noticed over the area covered with water bodies such as rivers and lagoons, where the wetness is present in the study area. The highest temperature was recorded mostly on barren land and built up-land. The spatial details of GIS output are graphically shown in (Fig. 4)

Table 8
Spatial distribution results of Land Surface Temperature (2000–2020)

2000		2005		2010		2015		2020	
Temp (°C)	Area (km ²)	Temp (°C)	Area (km ²)	Temp (°C)	Area (km ²)	Temp (°C)	Area (km ²)	Temp (°C)	Area (km ²)
18–22	33	09–10	64	17–22	48	20–23	79	15–16	12
22–24	37	10–14	115	22–24	68	23–24	114	16–19	52
24–26	96	14–16	106	24–25	182	24–25	81	19–22	113
26–27	164	16–21	100	25–26	104	25–26	111	22–24	173
27–30	137	21–29	83	26–30	66	26–30	85	24–27	119

3.3 Relationship between LULC and LST

The radiative temperature from the reflecting radiative energy of the earth's surface is known as land surface temperature. The reflected radiance of every feature on the land surface has its characteristics. Therefore, Changes in land use/land cover (LU / LC) impact land surface temperature. The LU / LC of an area tends to alter due to many natural and anthropological variables. As it changes, the local climate of the region will also show variations. Hence, the study considers quantifying the magnitude of the LST based on a regional scale (Norman and Becker 1995).

The Contribution Index (CI) will vary in between Negative to Positive values. A positive CI value indicates the effect of that specific land feature on increasing surface temperature. A negative CI value represents the influence of land features to stabilise or decrease the surface temperature.

The CI value of Built-up land increased from – 0.006 in 2000 to 0.003 in 2020. For the Plantation, CI increased from – 0.055 in 2000 to -0.020 in 2020. CI of Barren land decreased from 0.010 in 2000 to -0.117 in 2020. In Sand/Sandy Beaches, CI decreased from 0.103 in 2000 to 0.088 in 2020. For the waterbodies, CI decreased from – 0.036 in 2000 to -0.061 in 2020. CI of Mangroves decreased from 0.003 in 2000 to 0.000 in 2020. For the Saltpan region, CI decreased from – 0.001 in 2000 to -0.031 in 2020. In the scrubland, CI increased from – 0.041 in 2000 to -0.005 in 2020. CI value of lagoon increased from – 0.079 to -0.021 in 2020. In the Tidal flat region, CI increased from – 0.011 in 2000 to 0.000 in 2020. In the study area, the Highest positive contribution index (CI) noted in Sand/ Sandy beaches because it covers a larger area of bare soil and lacks vegetation cover. Similarly, Land Surface Temperature is also high in this region. Those covered by plantation, waterbodies, salt pan, shrubland, lagoon, and Tidal flats negatively contributed. It indicates that vegetation or wetness in these regions makes a stabilising or cooling effect over these regions (Fig. 5 and Table 9).

Table 9
Contribution Index between LULC and LST

Classes	2000	2005	2010	2015	2020
Built-up Land	-0.006	0.104	-0.023	0.019	0.003
Plantation	-0.055	-0.526	-0.041	0.106	-0.020
Barren land	0.010	0.275	-0.012	-0.426	-0.117
Sand/ Sandy Beaches	0.103	-0.225	0.010	0.270	0.088
Water bodies	-0.036	-0.036	-0.004	0.011	-0.061
Mangrove	0.003	-0.001	-0.0002	0.0002	0.000
Saltpan	-0.001	0.010	0.003	-0.009	-0.031
Scrubland	-0.041	0.074	-0.001	-0.001	-0.005
lagoon	-0.079	0.196	-0.008	-0.035	-0.021
Tidal flat	-0.011	0.005	-0.001	0.002	0.000

3.4 Intensity of Urban Heat Island

The study area is between moderate to very strong heat islands. As per the study in 2000, 466.2 km² (99.6%) of the total study area is under a Very Strong heat island. In 2005, 169.5 km², 36% area under Moderate heat island, 139.7km² area was strong heat island, 83.4km² area very strong heat island and 72.6km² area under weak heat island. During 2010, the maximum area of 463.8 km² (99.1%) came under a Very Strong heat island. There was an increase in land surface temperature noted during this year. In 2015, 456 km² (97%) came under a Very Strong heat island. In 2020, about 356 km² (76%) came under a very strong heat island and 102.1 km² on a strong heat Island. The overall result is given in Table 10, and the variation is graphically plotted in (Fig. 6). The study reveals that climatic elements such as rainfall, land surface temperature, and construction activities have a significant role in the changes of the Urban heat island.

Table 10
UHI Affected Area in km²

Class	2000	2005	2010	2015	2020
	Area (km ²)	Area (km ²)	Area (km ²)	Area (km ²)	Area (km ²)
Green Island	-	-	-	2.9	-
Very weak heat island	-	2.7	-	-	0.2
Weak heat island	-	72.6	-	-	0.4
Moderate heat island	-	169.5	-	-	8.8
Strong heat island	1.8	139.7	4.2	9.0	102.1
Very Strong heat island	466.2	83.4	463.8	456.0	356.5
Violent heat island	-	-	-	-	-

Conclusion

The impacts of LU change on LST and UHI intensity were determined for the coastal area of Ramanathapuram and its environs in this study. Detailed Land use and Land cover studies have done for about 21 years, starting from 2000 to 2020. Ten land use-land cover classes are observed and classified: Built-up Land, Plantation, Barren land, Sand/ Sandy Beaches, Water bodies, mangroves, Saltpan, Scrubland, lagoon, and Tidal flat. An overall study concludes that Barren land is the dominant feature in the study area. The other predominant land use is Sand/ Sandy Beaches. The third dominant one is Plantations. The residential area mostly dominated in the central part of Rameswaram island. The Accuracy assessment shows that the classified images have more than 85 % accuracy with the ground for all the land use/ landcover classes. The land surface temperature study concludes that the mean temperature was highest in 2000 (26°C) and least in 2005 (15°C). During the years 2000, 2005, 2010, 2015, and 2020, the study area radiates a maximum temperature of about 30°C, 29°C, 30°C, 30°C, and 27°C. In a barren land, it indicates about 24⁰C -27⁰C, the highest temperature was found in this region.

The correlation study between land use/land cover (LU / LC) and land surface temperature indicates that both the parameters are related. The changes in land use and land cover makes fluctuations in ground surface temperature. In the study area, the significant contribution of warming comes from Sand/ Sandy beaches due to their wide coverage. Sand/ Sandy Beaches' contribution index has a significant change in CI value from 2000 to 2020. The area covered by plantation, waterbodies, salt pan, shrubland, lagoon, and Tidal flats had a negative contribution

The Urban Heat Island study concludes that area between moderate to very strong Heat Islands. The study concludes that climate elements such as rainfall, terrestrial, surface temperature, and construction activities play a significant role in the island's urban heat changes.

Declarations

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Author contribution Gurugnanam Balasubramanian: Writing of original draft, formal analysis. Methodology. Glitson Francis Pereira: Software handling and writing of the original draft. Bairavi Swaminathan: Data curation Software handling. Santonu Goswami: Investigation. Saroj Choudhury: writing of review and editing, investigation

Availability of data and material The research depended on Landsat satellite data obtained through the Earth Explorer website, which is open to the public.

Code availability Software: ArcGIS 10.5, Erdas Imagine.

Ethics approval Not applicable.

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Figures

Figure 1

Study Area

Figure 2

(a - e) Spatial distribution of Landuse/Landcover (2000-2020)

Figure 3

(a - e) Spatial distribution of Land Surface Temperature (2000-2020)

Figure 4

Spatial distribution of Landuse/ Landcover Vs Year

Figure 5

Contribution of LULC types and their changes to LST

Figure 6

Urban Heat Island variations in per cent