ANALYSIS OF THE RELATIONSHIP BETWEEN URBAN HEAT ISLANDS AND LAND USE BY REMOTE SENSING TECHNIQUES (A CASE STUDY OF COLOMBO DISTRICT, SRI LANKA)

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ABSTARCT

Urban Heat Islands (UHI) can be described as areas that experience high temperature conditions when compare to the surrounding rural areas. UHI is one of primary impacts of Global Warming and there is a high probability of creating UHIs in urban areas. Colombo district represents the 77.6% (1,802,904) of total urban population while it has been developed as the major commercial city.

The main objective of the study was to determine the relationship between urban heat islands and land use (LU) types in study area and specific objectives were to estimate the pattern of Land Surface Temperature (LST) using Land sat 5/8 images, to identify the UHIs in the study area, to identify the different land use types and their thermal properties and to analyze the relationship between temperature and different LU/LC types.

LST was derived using Landsat images of 1997, 2007 and 2017 which were downloaded through USGS website. The software ArcGIS 10.3 version was used to calculate LST and Google Earth Pro software and land use maps developed by Survey Department were used for ground verification. Both Normalized Difference Vegetation Index (NDVI) and Normalized Difference Built Index (NDBI) indices were used for this study to analyze the relationship between UHI and LU/LC types.

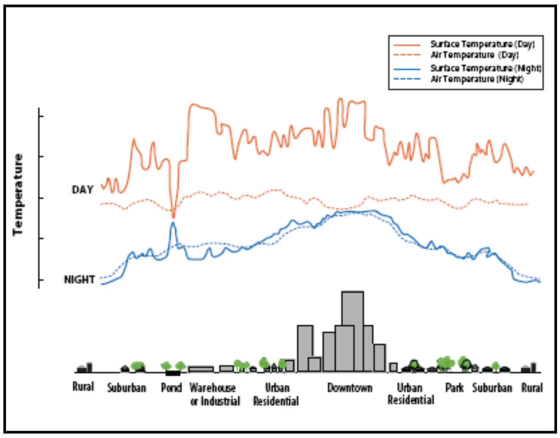
According to the results totally 46.3 km^2 (6.77% from total land area) in Colombo District have been found indications of intensifying UHI effect. Municipal Councils (MC) has highest extent of UHI areas and lower extent of UHIs identified in Pradeshiya Sabhas (PS). The maximum temperature recorded as 31.55^{0}C from an industrial zone located in one of the MCs and minimum temperature was 21.61^{0}C reported from a Rubber land located in PS. Properties of LU/LC in urban areas decide the albedo of the surface that directly relate with urban temperature. The lands which are densely covered with vegetation, water areas and wetlands represented low temperature values while built-up areas represented high temperature values. There was a direct relationship between UHIs and LU/LC. The output of this study can be utilized effectively for sustainable development of urban areas and proper urban planning in future. The public can aware regarding effects of UHIs to minimize impacts and encourage maintaining of green environment. Further it is recommended to do studies on the impacts of UHIs on human health.

1. INTRODUCTION

Urban Heat Island (UHI) can be described as an area that experience high temperature condition when compare to the surrounding rural areas. According to the Unites States Environmental Protection Agency (USEPA) the term of "Heat Island" describes as built up areas that are hotter than nearby rural areas and the annual mean air temperature of a city with 1 million people or more can be 1.8–5.4°F (1–3°C) warmer than its surroundings".

There are two types of UHIs. They are surface and atmospheric urban heat islands. These two types of heat island differ in the ways they are formed, the techniques used to identify and measure them, their impacts and the methods available to mitigate them (Oke, T.R., 1997).

The magnitude of surface urban heat islands varies with seasons, due to changes in the sun's intensity as well as ground cover and weather. As a result of such variation, surface urban heat islands are typically largest in the summer (Oke, T.R., 1982). Warmer air in urban areas compared to cooler air in nearby rural surroundings defines atmospheric urban heat islands. The figure 1 illustrate surface and atmospheric temperature during day and night in several types of land uses both in urban and rural areas.



Global Warming is a major environmental problem that all kind of organisms has been affected at present. UHI is one of the primary impacts of Global Warming. The major cause that affect the formation of heat islands is urbanization process. As a result of that reduction of vegetation cover in urban areas, physical properties of urban surface materials, urban geometry (Sailor, D.J., and H. Fan., 2002), release of anthropogenic heat (Voogt, J., 2002) and polluted air due to human activities and other additional factors such as weather and geographic location are caused to development of UHIs in urban areas.

Figure1. Variations of Surface and Atmospheric Temperatures

2. STUDY AREA:

Colombo District (6.8602° E, 80.0535°N) is the commercial capital of Sri Lanka and located in the Western Province. The boundaries of the Colombo District are included North - Kelani River (Gampaha District), South - Bolgoda River (Kalutara District), West – Indian Ocean and East - Sabaragamuwa Province. The total extent of the Colombo District is 685km^2. Colombo District is divided in to 13 Divisional Secretariat Divisions (DSD) and 13 Local Authorities (LA). The LAs are included 5 Municipal Councils (MC), 5 Urban Councils (UC) and 3 Pradeshiya Sabhas (3).

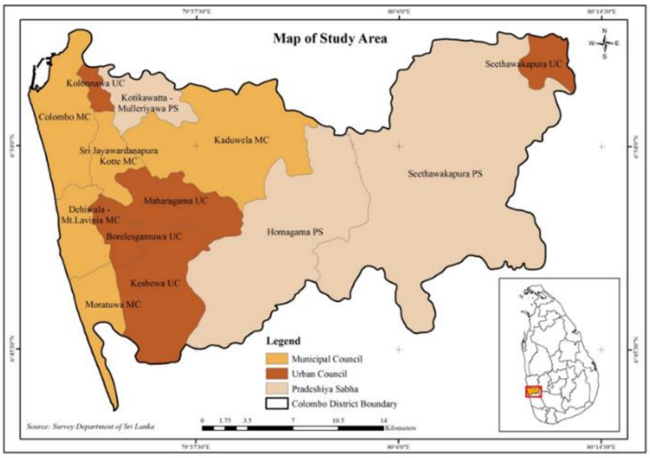
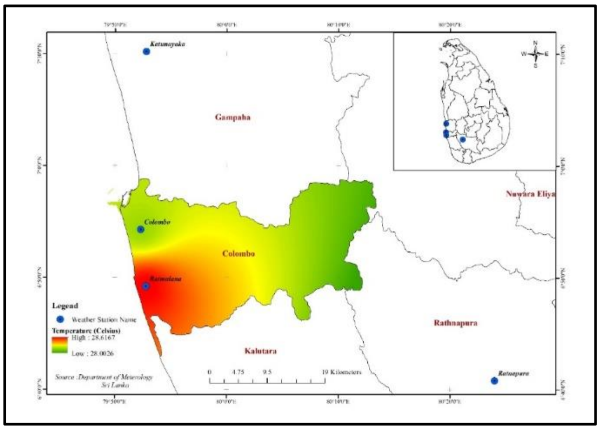


Figure 2. Study area map

Colombo District has mild weather conditions without extremes throughout the year. The maximum temperature is about 31^{0}C during the months of March and April and the minimum temperature is about 22^{0}C. The monsoon seasons are from March to August and from October to January during which time very heavy thunder showers can be expected. The annual rainfall is about 2400 mm. *http://www.colombo.dist.gov.lk, Last updated 09/11/2018)*

Colombo is the most highly populated District in Sri Lanka. According to the Department of Census and Statistics report in 2012 total population of Colombo District is 2,324,349 which represent 78% of urban population and population density is 325 persons/km^2 (Figure 2).

3. METHODOLOGY



Aim of this study is to analyses of the relationship between Urban Heat Islands and Land Use types using Remote Sensing Techniques. As a developing country pre-identification of urban heat islands is very important for well-planned sustainable development. In USEPA identification of UHIs is done by using air temperature measurements which is obtained from meteorological stations, but that method is costly and impracticable in country like Sri Lanka. As Sri Lanka has only limited number of fixed meteorological stations throughout the country. Colombo District has only 2 weather stations (Figure 3). Therefore, spatial resolution is very low of those data. Hence, satellite imagery data were used for this study due to high spatial resolution.

Figure 3. Average annual air temperature distribution in Colombo District, 2017*(Source: Department of Meteorology)*

3.1 Primary and Secondary Data

As primary data freely, available satellite imageries from United States Geological Survey (USGS/NASA) were used for this study. Landsat-5 TM and Landsat-8 OLI/TIRS Operational Land Imager (OLI) & Thermal Infrared Sensor (TIRS) images in 1997, 2007 and 2017 covering Colombo District were downloaded to analysis and identification of Urban Heat Islands. The air temperature data was obtained from Department of Meteorology as secondary data to justify satellite data is more suitable than air temperature data which is obtained from 4 weather stations located inside and near to the Colombo District. Population and housing data were obtain from Department of Census and Statistics. Satellite images were used to calculate Land Surface Temperature, NDVI and NDB. Population and housing data in Colombo District were used to compare with UHI effect. The satellite image date of 13th of January 2017 and time at 10.54 a.m. was used for further analysis of UHI identification while 1997 and 2007 images were used for validation of land surface temperature as well as NDVI and NDBI. Arc GIS 10.3 software was used for the analysis of data and Google Earth Pro software was used for ground observation and verification. The description of the satellite images used for the analysis is shown in table 1.

Table 1. Characteristics of data used

Sensor	Acquisition Date	Time (GMT)	Band	Resolution (m)	Usage
Landsat 5	11/03/1997	9:49 a.m	Band 6	60	To find Land Surface Temperature
			Band 3	30	To find NDVI
			Band 4	30	
			Band 5	30	To find NDBI
Landsat 5	01/02/2007	10:18 a.m	Band 6	60	To find Land Surface Temperature
			Band 3	30	To find NDVI
			Band 4	30	
			Band 5	30	To find NDBI
Landsat 8	13/01/2017	10:54 a.m	Band 10	100*(30)	To find Land Surface Temperature
			Band 11	100*(30)	
			Band 4	30	To find NDVI
			Band 5	30	
			Band 6	30	To find NDBI
			Band 5	30	

3.2 Method

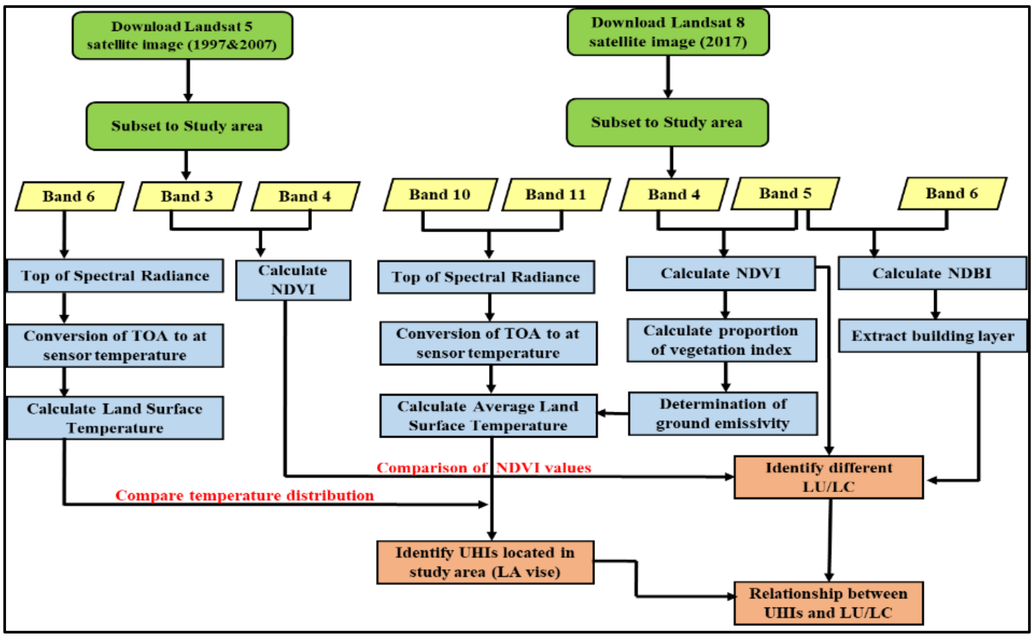


Figure 4. Flow chart of the methodology

3.3 Analysis of data

The retrieval method of LST from the thermal band of an image was done as describes in Landsat 7 Science Data Users Handbook (NASA, 2012). There were two major steps as follows.

- Image Preprocessing and deriving NDVI data
- Deriving the Land Surface Temperature using thermal band data and NDVI data

Before deriving the LST, following conversions were done to preprocess the images.

- Convert DN values to TOA Radiance
- Convert TOA Radiance to Satellite Brightness Temperature
- Average the Satellite Brightness Temperature (Mean of Band 10 & Band 11)
- Deriving the Land Surface Emissivity

(1) Following equation was used to obtain spectral radiance.

$$L_\lambda = MLQ_{cal} + A_L \qquad (1)$$

Where, L_λ is the TOA spectral radiance (Watts/ (m2 * srad * µm)),
ML = Band-specific multiplicative rescaling factor from the metadata (RADIANCE_MULT_BAND_x, where x is the band number)
Q_{cal} = Quantized and calibrated standard product pixel values (DN)
A_L = Band-specific additive rescaling factor from the metadata (RADIANCE_ADD_BAND_x, where x is the band number)

(2) The next step is to convert TOA Radiance to Satellite Brightness Temperature

$$BT = \frac{K_2 - 273.15}{ln\left((K_1/L_\lambda) + 1\right)} \qquad (2)$$

Where, BT is at-satellite brightness temperature (K),
K_1 and K_2 are Band-specific thermal conversion constant from the metadata

(3) Then average the Satellite Brightness Temperature (Mean of Band 10 & Band 11)
Cell statistics tool was used to get the average satellite brightness temperature of Band 10 and Band 11 of Landsat 8 image. As overlay statistic MEAN was selected after adding BT of Band 10 and 11. The averaging of satellite brightness temperature was done only for 2017/01/13 image, because Landsat 8 image have 2 thermal bands.

(4) Using the minimum and maximum NDVI value the Proportion of Vegetation (PV) was estimated by equation (3) (Sobrino et.al. 2004)

$$PV = (NDVI - NDVI_{min} / NDVI_{max} - NDVI_{min})^2 \qquad (3)$$

Where, PV is proportion of vegetation
$NDVI = (R_{NIR} - R_{RED}) / (R_{NIR} + R_{RED})$
R_{NIR} = Spectral Reflectance of the Near-Infrared band
R_{Red} = Spectral Reflectance of the Red band

(5) After calculating the PV Land Surface Emissivity was calculated to analyze the Land Surface Temperature using following formula that has been introduced by Sobrino in 2004.

$$E = 0.004\,PV + 0.986 \qquad (4)$$

(6) Finally Land Surface Temperature (LST) was derived by using following equations (Weng, 2005) to identify the Urban Heat Islands located in Colombo District.

$$BT / 1 + W * (BT / P) * \ln(e) \qquad (5)$$

Where, W is wavelength of emitted radiance (11.5Um) and P was calculated as:

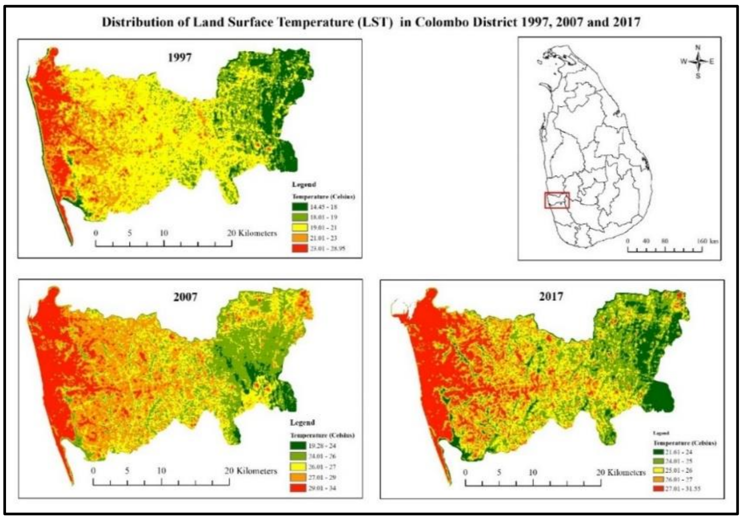
$$P = h*c/s\ (1.438*10^{-2}\ m\ K) \quad (6)$$

Where, h is Planck's constant (6.626*10^-34 Js) and s is Boltzmann Constant (1.38 * 10^-23 J/K) and c is velocity of light (2.998 * 10^8 m/s)

(7) When extraction of building areas the most suitable equation is Normalized Difference Built Index (NDBI). It was calculated by equation 7.

$$NDBI = \frac{(SWIR - NIR)}{(SWIR + NIR)} \quad (7)$$

4. RESULTS AND DISCUSSION



The Land Surface Temperature (LST) of the study area are shown in figure 5. LST values were reclassified into five classes. Therefore, it is clearly identified LST from 1997 to 2017 had been gradually increased but in 2007 data shows elevated temperature in some areas due to cloud cover of the satellite image.

Figure 5. Spatial distribution of Land Surface Temperature in Colombo District

4.1 Deciding the average temperature of the study area

Table 2. Illustration of average temperature of the study area

Temperature (^{0}C)	Area (km^2)	Area of temp. <26 ^{0}C	Area of temp. >26 ^{0}C	Area %
25	243.00	413.00		**60.38**
25.01-26	170.00			
26.01-27	125.00		271.00	39.62
27.01-28	101.00			
>28.01	45.00			
Total area of Colombo District		**684.00**		

Based on results of land surface temperature, LST values of 2017 image were used for further analysis of UHI effect in Colombo District. Initially it was needed to decide surrounding average temperature of the study area to find UHI temperature. The total extent of the Colombo District is 684 km^2. According to the results, the area of 413 km^2 represented the temperature less than 26ºC that represent 60% from total land area of the District while the 40% from the area represent the temperature more than 26ºC. As more than 60% of the study area represented less than 26ºC temperature, average temperature of the study area was decided as 26ºC. According to UHI definition described by USEPA, UHI temperature of 2017 was decided as 28ºC that represent the 2ºC higher than average temperature.

4.2 Identification of the Urban Heat Islands located in the study area

Colombo District is the commercial center and highly urbanized District in Sri Lanka. Thus, there is a high probability of formation of UHIs in this District. Colombo District has 13 LAs. The largest LA is Seethawaka PS and it has area of 240.08 km^2 while Kolonnawa UC has the smallest area and it represented 5.39 km^2. The study area is composed of 592 Grama Niladhari Divisions (GND). Among them most of GNDs have been converted to UHIs. According to the Table 2 illustrated maximum and minimum temperature recorded in each LA type with relevant to their land use /land cover types.

Table 3. Maximum and minimum temperature recorded LU/LC types in each LA type

No	LA Type	No of GNDs	Minimum Temperature (^{0}C)	Mini. Temp. recorded LU/LC	Maximum Temperature (^{0}C)	Maxi. Temp. recorded LU/LC
1	Colombo MC	56	22.98	Park and water bodies	31.02	Port city, harbor
2	Dehiwala – Mt.Lavinia MC	31	22.77	National Zoological garden and water body	30.44	Airport and industrial zone
3	Moratuwa MC	43	21.95	Water body	**31.55**	Industrial zone
4	Sri Jayawardanapura Kotte MC	20	23.35	Water body	29.52	High built up area
5	Kaduwela MC	57	23.17	Water body	30.24	Industrial area
6	Maharagama UC	43	23.36	Paddy area	30.37	High built-up area
7	Kolonnawa UC	14	24.04	Water body	31.01	Oil refinery center
8	Borelesgamuwa UC	29	23.09	Water body	29.52	Solid Waste Dumping site
9	Seethawakapura UC	11	22.80	Forest reserve and tank	31.37	Industrial zone
10	Kesbewa UC	58	22.85	Water body	29.23	High built-up area
11	Homagama PS	82	23.05	Paddy area	31.31	Industrial zone
12	Kotikawatta – Mulleriyawa PS	41	22.96	Paddy area	29.42	High built-up area
13	Seethawakapura PS	107	**21.61**	Rubber land	29.66	High built-up area

According to Table 3 more regions such as high built-up area, industrial zones and areas, airport, harbor and solid waste dumping sites and oil refinery center have shown maximum temperature values. The building density is triggered to produce high temperature values due to urban geometry. The canyons structures cause to scatter the reflected radiance and create enhance the warming. During the day, solar energy is trapped by multiple reflections of the buildings while the infrared heat losses are reduced by absorption. As well as construction of these buildings with materials of low albedo values caused to high temperature values in this area. Industrial areas are caused to release heated energy into the environment due to many industrial activities, hence temperature of surrounding environment has been increased rapidly.Areas with high green cover and water areas represented minimum temperature values in the study area. UHI areas cannot be found in these areas.

Furthermore, figure 6 illustrated maximum and minimum temperature in each type of LA with UHI area. According to that figure, the minimum temperature recorded in the study area was 21.61^{0}C and it was recorded from Seethawakapura PS area. The maximum temperature was recorded from Moratuwa MC and the recorded maximum temperature was 31.55^{0}C. Table 2 illustrate UHI area formed by LA in the study area.

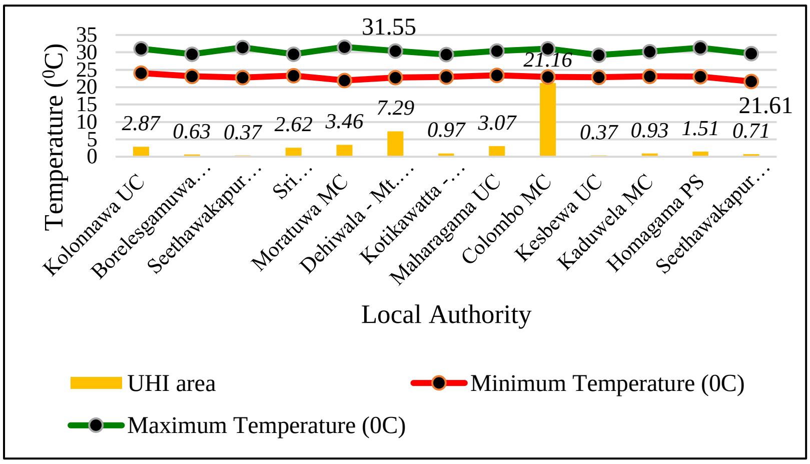


Figure 6. Maximum and minimum temperature of each LA type with UHI area located in Colombo District

Table 4. UHI area by Local Authorities

LA Type	Total LA area (km^2)	UHI Area (km^2)	UHI Area (%)	LA type vise area (km^2)
Colombo MC	43.28	21.16	48.89	**32.00**
Dehiwala - Mt.Lavinia MC	21.13	7.29	34.50	
Moratuwa MC	19.7	3.46	17.56	
Sri Jayawardanapura Kotte MC	16.5	2.62	15.88	
Kaduwela MC	85.73	0.93	1.08	
Maharagama UC	37.08	3.07	8.28	**7.65**
Kolonnawa UC	5.39	2.87	53.25	
Borelesgamuwa UC	11.82	0.63	5.33	
Seethawakapura UC	13.08	0.71	5.43	
Kesbewa UC	50.68	0.37	0.73	
Homagama PS	117.72	1.51	1.28	**3.19**
Kotikawatta - Mulleriyawa PS	22.03	0.97	4.40	
Seethawakapura PS	240.08	0.71	0.30	
Total District	**684.22**	**46.3**	**6.77**	

According to table 4 total UHI area of MCs in Colombo District was 32 km^2 while total UHI area of UC was 7.65 km^2 and total UHI area of PS was 3.19 km^2. According to that it was distinct that MCs are threaten on formation of UHIs than UCs and PSs. With considering of total land area and UHI area formed in Kolonnawa UC represented 53.25% lands of UHIs in the UC area. Therefore, there is a probability to become entire land into UHI area in near future when remedial actions are not taken in future urban planning of this area. On the other hand, lowest UHI area percentage was 0.3% and presented in Seethawakapura PS area. This area can be easily protected from formation of UHIs when taking necessary actions for future urban planning. There are 5 MCs, 5 UCs and 3 PSs in the study area. Among the types of Local Authority Colombo MC, Maharagama UC and Homagama PS presented highest UHI areas. Totally 46.3 km^2 (6.77% from total land area) in Colombo District have been converted into UHI areas.

4.3 Different Land Use/Land Cover (LU/LC) types and their thermal properties

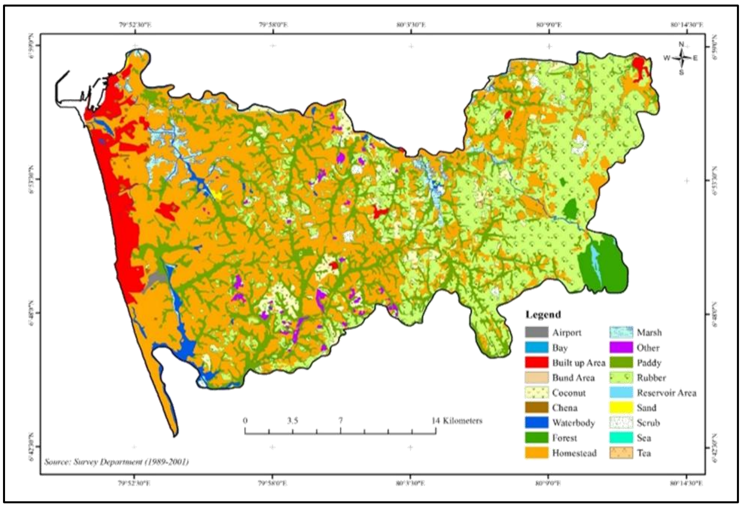
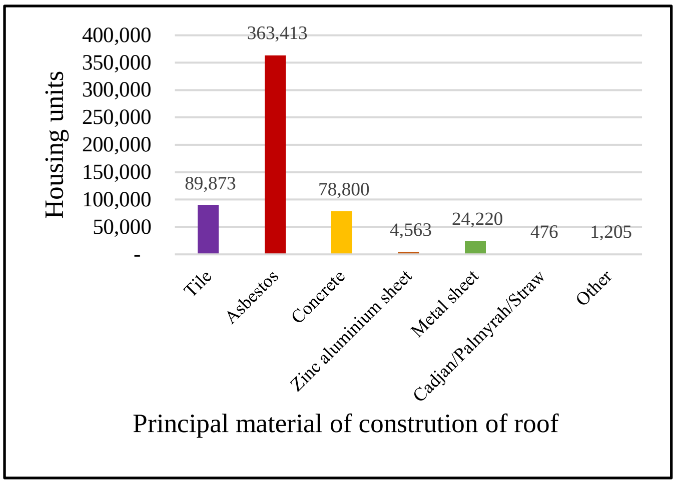


Figure 7. Land use map of Colombo District

The Colombo District is composed of several LU/LC types according to the figure 7. More than 50% of the area in Colombo District is covered with home gardens. When formation of UHIs, structure and location of buildings located in urban areas and physical characteristics of materials has used to build are directly influenced. Particularly depending on their physical characteristics such as emissivity, reflectivity and heat capacity, energy balance etc. temperature of that area will be decided. The intensity of UHIs depends on the amount of radiation energy that reflected, emitted and absorbed.

In an urban environment albedo is the main factor that deciding the urban temperature. The definition of albedo according to Stull (2000, p. 35) is “The ratio of total reflected to total incoming solar radiation”. With the definition, the relationship between the color of different objects and its albedo is clear. The darker objects usually having a lower albedo than light colored objects. When albedo value of surface material is low, the amount of energy stored inside the object is high. Therefore, ultimately it is caused to elevate temperature in surrounding environment. Urban structures are mainly composed of man-made structures such as buildings (commercial, government, industrial, houses etc.) and roads. Typically main roads are covered by tar or asphalt. According to Oke (1987) albedo value of tar ranges from 0.08-0.18. It is a lower albedo value. Therefore, lower albedo values allow to store more energy and finally result the high temperature.



According to the Department of Census, 2012 report totally there are 562,550 housing units located in the Colombo District and the principal material used for construction of roofs are shown graphically in figure 8. According to that, 363,413 roofs of houses are constructed of asbestos. The total no of houses that used concrete, zinc aluminum sheet and metal sheet together as for construction of roofs are 107,583. Therefore, more than 80% of houses have been used for construction of roofs as materials with low albedo values. Those materials have high capacity of storing heat and therefore eventually increase temperature of the area. The total number of houses that have used cadjan/palmyrah and straw for construction of roofs are 476 and it is an ignore amount when compare with other materials.

Figure 8. Housing units by principal material construction of roof in Colombo District

4.4 Analyze the relationship between temperature and different land use type

Normalized Difference Vegetation Index (NDVI) quantifies vegetation by measuring the difference between near-infrared (which vegetation strongly reflects) and red light (which vegetation absorbs). NDVI values are ranged from +1 to -1. To analyze relationship between temperature and different LU/LC types NDVI values were used. According to the results, NDVI map in 2017 illustrates the water bodies in blue color that NDVI values range from -0.11 to 0.05. The NDVI values of 0.05-0.19 represented densely built-up areas with red color. The open areas such as soil or built-up area represented NDVI values of 0.19-0.27 and they show in pink color. The vegetated areas such as shrubs or grasslands show 0.27 to 0.34 NDVI value and maximum NDVI values ranges from 0.34 to 0.51 which values are closer to +1 represented dense vegetation in the area. Dense vegetation represented in dark green color while light green shows sparse vegetation.

Normalized Difference Buildup Index (NDBI) quantifies built- up area by measuring the difference between SWIR and near infrared. NDBI values are ranged from -1 to +1. Value closer to +1 represent buildup areas. It was used to extract building layer to compare with land surface temperature.

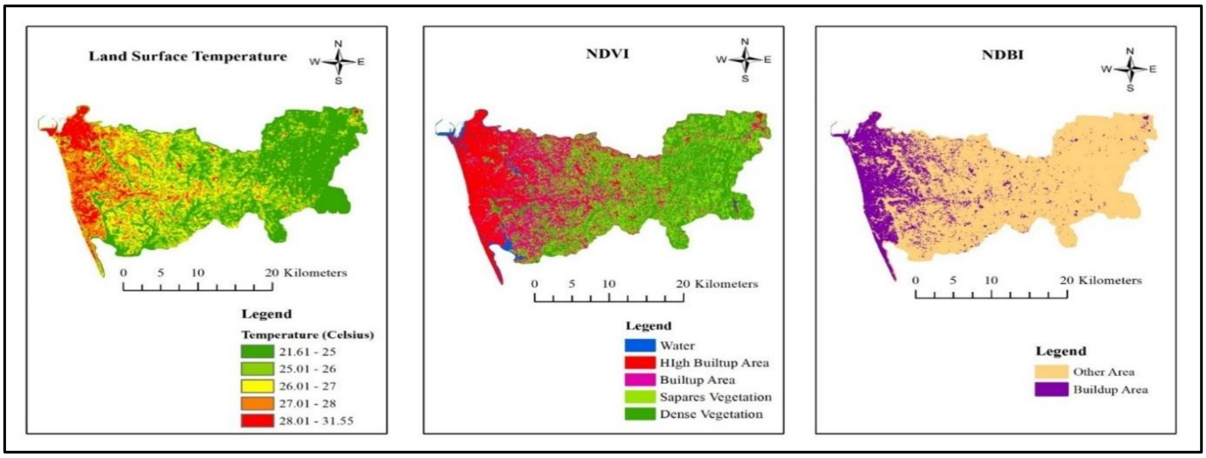


Figure 9. Relationship among land surface temperature, NDVI and NDBI

Figure 9 described the relationship between vegetation, built- up area and the land surface temperature. Both built-up areas and densely built-up areas were directly related with the areas of high surface temperature. According to the temperature values (>28^{0}C) densely built-up areas were identified as Urban Heat Islands. But some non-vegetated and built up areas represent the low temperature condition in coastal areas due to local wind process (sea breeze).

The vegetated areas in NDVI map and other areas in NDBI were directly related with the low temperature areas. Especially when far away from the urban areas of Colombo District, low temperature condition was identified. Water bodies located in the district are also represent low temperature condition. The transpiration from water bodies and evapotranspiration of vegetated areas are the major processes that relate with the distinct spatial pattern of the temperature. This relationship can be clearly verified by observing Google images of some of the areas.

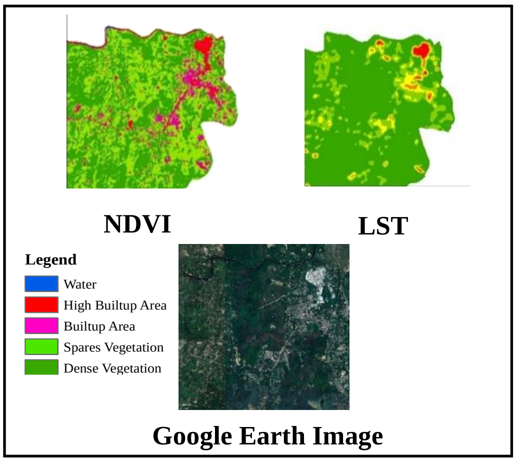


Figure 10. Seethawaka Export Processing Zone

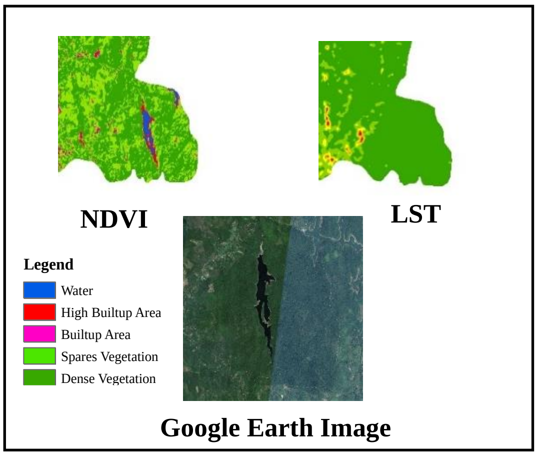


Figure 11. Labugama tank and its surrounding

Seethawaka Export Processing Zone located in Avissawella is one of the main industrial zone and the surface temperature map of zone area represents high temperature and in NDVI map it is represented as densely built-up area as shown in figure 10. Industrial zones have many industrial activities which produce heat energy that cause to increase high temperature. According to the figure 11, Google earth image it was clearly identified dense vegetation surrounded by Labugama tank. In the land surface temperature map, it was verified with low temperature value as <25^{0}C in that area. This is due to evapotranspiration process of trees in the forest.

The relationship between UHIs and different LU/LC types in study area is clearly recognized by figure 12. This graph was developed by selecting 23 random sampling points from different LU/LC types of map in Colombo District. Those sampling points were overlaid with both NDVI and temperature maps and extract the values of those random points. According to those extracted values, built-up area has high temperature values while NDVI values between 0.05-0.15. Forest area has the lowest temperature and paddy, water and marshy areas also represent low temperature. Industrial zone represents highest temperature and roads also represent high temperature values.

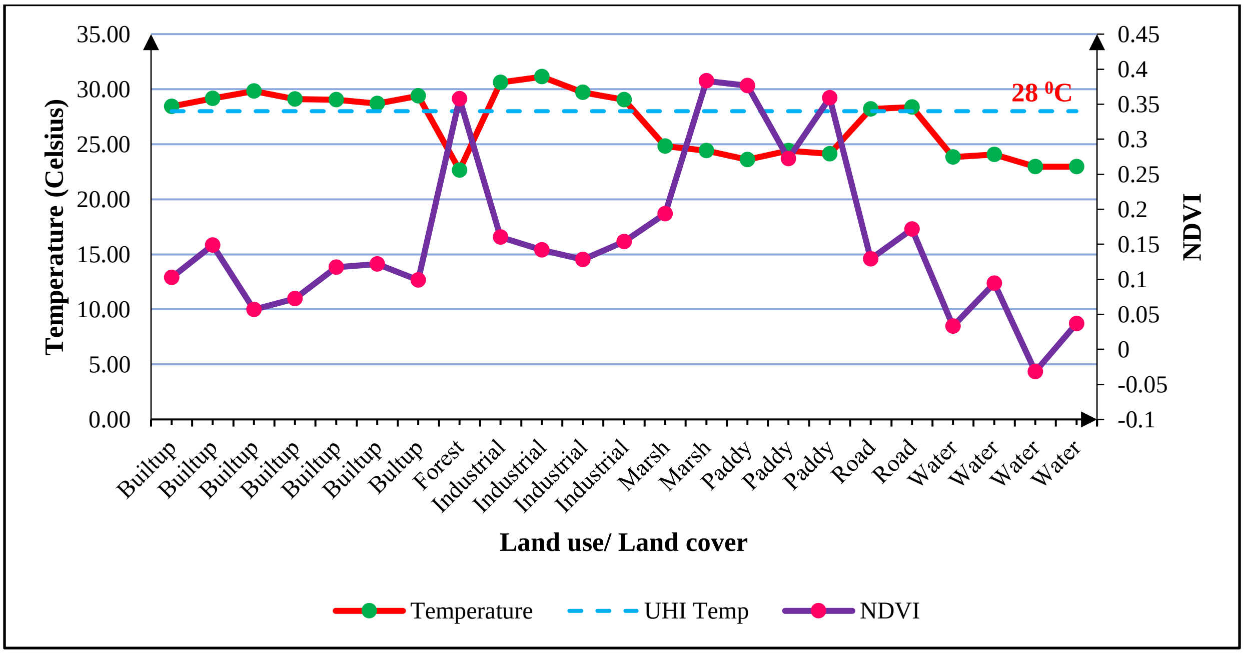


Figure 12. Relationship between temperature and NDVI values on different LU/LC types

5. CONCLUSION

Total UHI area identified in the study area was 46.3 km^2 which represent nearly 7% out of total land area of Colombo District. This study was focused on Local Authority level UHI identification. When comparing LA level, high extent of UHIs were found in MCs and the lower extent of UHIs were identified in PSs. Accordingly, it is clearly identified highly urbanized areas represent high temperature values than rural areas.
According to the results port city, Colombo harbor and more regions of the Colombo MC area were identified as UHI areas due to high building density and main roads and pavements construction with materials of lower albedo values. UHI areas were none in dense vegetation and water areas. The study area is composed of several land use/ land cover types. Thermal properties of urban surface material were highly affected to the elevated temperature conditions of the urban environment. NDVI values in study area in 2017 were ranges from -0.01 to 0.51. Minus NDVI values were belong to water areas with lower temperature and NDVI value closer to 1 represented dense vegetation with lowest temperature. NDVI value closer to zero and between 0 and 1 represented built-up areas with high temperature values. The lands which are densely covered with vegetation represent low temperature values while built-up areas represent high temperature values. UHI areas were mostly found in non-vegetated areas such as industrial zones, build up areas, near main roads and pavements while lower temperature conditions were identified in vegetated areas such as forest, marshes and paddy as well as in water bodies. Therefore, it is clearly identified that there is an inverse relationship between UHIs and non-vegetated areas. Finally, it can be identified there is a direct relationship between UHIs and land use/land cover.

6. RECOMMENDATION

There are two major strategies to mitigate UHI by increasing the albedo of the urban surface and by increasing Evapotranspiration. Increasing albedo values of urban surfaces can be done in several ways such as use high albedo roofing materials for specially roofs in urban areas, use high albedo pavements and maintain green roofs. The increasing evaporation also can be done in three ways such as increase green vegetation, growing of shaded trees and increase amount of water bodies. Other than aforementioned methods there is another method to prevent high temperature conditions in urban areas. It is recommended to use pervious surfaces such as grass pavers, permeable concrete and permeable pavers in pavements in urban areas. The results of this study can be utilized effectively for new development projects and proper urban planning in future. Proper urban planning plays vital role in mitigation of UHIs. When constructing buildings in urban areas especially it is needed to consider geographical location of building. In order to prevent the air circulation inside the city's water bodies in the urban areas should not covered by buildings. The public can be aware regarding effects of UHIs to minimize and encourage maintaining of green environment. Further it is recommended to do studies on how human health impacts that are related with UHI effect.

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