E-ISSN 2656-8039

INTERNATIONAL JOURNAL OF ENVIRONMENT, ENGINEERING & EDUCATION

www.ijeedu.com

Vol. 3, No. 2, 2021

**Research Article**

# Evaluation of Urban Heat Island (UHI) Spatial Change in Freshwater Lakes with Hot Spot Analysis (GI Statistics)

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***Received:*** *April 20, 2021;* ***Accepted:*** *May 24, 2021;* ***Published:*** *August 12, 2021*

**Abstract:** Monitoring spatial changes of surface heat island formation and temperature changes in sub-urban areas is vital in the freshwater lake management of urban areas as frequent phenomena related to climate change have undergone. The purpose of this study was to examine the Spatio-temporal pattern of urban heat island and land surface temperature and vegetation changes by using GI statistics, where hotspot analysis was also performed. The study further examined the effect of heat island and surface temperature on urban freshwater lakes where hot and cold spots identified had undergone a reclassification process. The results revealed that the increasing Land Surface Temperature (LST) due to modification and transformation of vegetated areas into concrete and synthetic built-up extents is one of the challenging problems in the selected suburbs. Both NDVI and LST hot spots and cold spots have changed compared to 2010. The LST showed considerable expansion of the hotspots within ten years rather than cold spots in all three suburbs. The freshwater lakes are in proximity to the city. All three lakes were finally reclassified as hotspot areas for LST, while Kesbewa Lake and Thalangama Lake were identified as NDVI hotspots where the vegetation cover had contracted by 2020. Even though Boralesgamuwa Lake is not recognized as an NDVI hotspot, the encroachment and expansion of the current hotspot area could be identified. The study's findings could be used to design sustainable cities in these suburbs more by prioritizing the conservation of urban ecosystems.

**Keywords:** Hot and Cold Spots, Land Surface Temperature, Normalized Difference Vegetation Index, Remote Sensing, Surface Temperature.

## 1. Introduction

Climate change and increasing temperature are rapidly warming lakes around the world, threatening the freshwater lake ecosystems. National Aeronautics and Space Administration (NASA) and National Science Foundation collaboratively studied 235 lakes on six continents where the largest lakes are found warming an average of 0.34°C each decade. This is greater than the warming rate of either the ocean or atmosphere, which can profoundly affect [1]. Despite the many signs of global warming, global dimming, and changes to the climate, many people will not accept that something very ominous is taking place. However, there is also a broad consensus within the scientific community that climate change is real. The United States Environmental Protection Agency, NASA, Science Academies/Organizations, and Intergovernmental Bodies such as Intergovernmental Panel on Climate Change (IPCC) concur that climate change along with temperature increasing is indeed occurring. The overall energy budget of the planet, the balance between incoming shortwave radiation and outgoing longwave radiation, whether resulting from natural variability or human activity, drive climatic change. Natural factors have caused the climate to change during previous periods of the Earth's history, but human activities are the primary

***This Article Citation:*** *M. D. K. L. Gunathilaka, W. T. S. Harshana, "Evaluation of Urban Heat Island (UHI) Spatial Change in Freshwater Lakes with Hot Spot Analysis (GI Statistics)," Int. J. Environ. Eng. Educ., vol. 3, no. 2, pp. 48-58, 2021.*

cause of the heat changes that are being observed now. The increasing surface temperature has identified as one of the most critical challenges for the survival of living beings with the meeting of demands of the food and other human necessities for the increasing population while sustaining the already stressed environment [2], [3].

Increasing global temperatures are associated with corresponding Earth system changes [4]. Between 1971 and 2010, sea levels rose on average by approximately 2 mm per year. Arctic perennial sea ice extent declined by about 11.5% per decade over this period, and snow cover and glaciers have diminished in both hemispheres. According to the IPCC, the sea level will rise between 26 and 98 cm by 2100. As a result, the average global temperature will rise to 4 (four) Celsius degrees, and global sea levels will rise by upto1- 4 ft by the end of the century. Scientists have high confidence that global temperatures will continue to rise for decades to come, primarily due to greenhouse gases produced by human activities [5]. Climate change and its severe impacts have come upon us in a relatively short time and are accelerating with an alarming period [6]. Thus, it is perhaps the most severe problem that the civilized world has had to face.

The most demanding challenge of climate changes and its intensified impact directly targeted small island nations and developing countries. Coastal developing countries; Bangladesh, Thailand, India, Maldives, Micronesia and Melanesia, Pacific island nations, Sri Lanka, coastal countries at the zone of Sahel are among them. Provide a better and safe life with a shrinking environment is one of the most significant challenges in these countries. Climate change in Sri Lanka manifests through a slow but steadily rising temperature and erratic and unpredictable rainfall seasons. Although total annual rainfall (past ten years compared to the 30-year average) remains steady, climate-induced changes are already observed. The impacts of climate change on weather patterns in Sri Lanka can be identified with temperature and rainfall variability. There are some significant temperature phenomena observed; 1) Average air temperature has increased by 0.64 Celsius over the past 40 years and 0.97 Celsius over the last 72 years, revealing a trend of 0.14 Celsius per decade, 2) An assessment of a more recent time band has shown a 0.45 Celsius increase over 22 years, suggesting a rate of 0.2 Celsius per decade, 3) Ambient mean minimum and mean maximum temperatures have increased, and 4) The number of warm days and warm nights have increased, while the number of cold days and cold nights has decreased. According to the National Adaptation Strategy (2011-2016), while the increased frequency of dry periods caused by consecutive dry and droughts are expected, the general warming trend is expected to increase the frequency of sweltering days. Being an island nation subjected to the tropical climate system, Sri Lanka has experienced several challenges in several key trust areas of Sri Lanka's development framework, such as agricultural, transport, health, power, environment, settlement, and vulnerable populations. Among the trust areas, the 'environment' is crucial concerning biodiversity. The ecosystem diversity, species diversity, and genetic diversity of Sri Lanka have led to the country's designation as one of the biodiversity hotspots in the world. Along with the rapid urbanization and intensified land use and land cover conversion, the degradation and loss of ecosystem diversity have become a frequent and debatable topic in Sri Lanka. Heat island formation inline to urbanization has been identified in many urban areas [7].

When an urbanized area is warmer than the outlying areas, those areas can be referred to as heat island areas where the temperature is within a specific geographical range, and it is defined as a heat island. Such areas are identified by comparing the temperature difference between the area with the highest temperature and the surrounding area. Often the most prevalent of these areas are the semi-urbanized or suburban areas. Two main types of heat islands are identified as follows; Surface heat islands and Atmospheric heat islands.

The main factor influencing the formation of surface heat islands is the thermal currents emitted by the surface. These surface heat islands thrive on days when the sun is high. The main reason for atmospheric heat island is the heat in the air, where physical factors often have a more significant impact than human factors in which the topography and climatic features are the basis.

Human and physical factors are the two key factors underlying the formation of thermal islands [8]. The leading factor is the human factor due to the interference and minimization of the natural landscape, increased dry surface texture, and manufacturing and industrial activities. Disruption of the natural landscape can be identified as a significant factor contributing to deforestation in natural land cover and the intensity of sunlight falling directly on the Earth's surface due to the loss of land cover. Therefore, the ground absorbs heat during the daytime and releases the absorbed heat during the night. This causes heat to be released into the atmosphere.

Furthermore, decreasing land cover reduces the absorption of gases such as atmospheric $CO_2$ and the release of gases such as $O_2$ into the atmosphere. This is due to the release of greenhouse gases into the atmosphere, which increases the temperature of the islands, causing the formation of tropical heat islands. The second factor is as decisive as the first, human desire to create more dry surfaces. That is, the main reason is the design of buildings for commercial purposes. For example, concrete slabs for roofing, carpeting pavements absorb most of the sun's heat during the daytime. However, the emission occurs at night, and the heat mass accumulates in the atmosphere as the atmosphere humidity increases during the night.

Furthermore, the extent of the building also plays a significant role in the formation of these islands. That is the spaciousness of the building and the construction of one building very close to the other, which blocks the natural flow of air. In this case, the atmospheric heat generated within that range is stored in the air stream, preventing it from circulating. This causes an increase in local temperature and resulting heat islands.

Among the physical factors, weather conditions and topography are paramount. Weather factors such as wind, rain, drought, and atmospheric humidity are essential in forming heat islands. The effect of dry winds on tropical islands is enormous. This is a naturally occurring process. Moreover, the absence of prolonged rainfall and drought conditions is also fundamental to heat islands' formation. When the heat is released during the night, the geothermal heat stays in the atmosphere as the atmospheric humidity rises. This creates tropical islands by increasing the local temperature. Mountains and plains are predominant topographical features due to the heterogeneity of the terrain. Colombo Urban Zone and Kandy Urban Zone are good examples of this. Although the Colombo area is more urbanized than the Kandy area, the current situation is that the Kandy urban area is a warmer region due to the proximity of the ocean to Colombo and a plain anomaly around the city of Colombo [9]. With the high level of industrialization and building density associated with the Colombo metropolitan area, with minimal forest density, the heat currents generated in that area do not stay in the area and move out of the main urban area through the plains under the influence of ocean winds. Hence, suburban areas such as Kesbewa, Maharagama, Battaramulla, Kaduwela, Athurugiriya, and Homagama areas have been detected as victims of increasing temperature. These areas are predominated in a process called suburbanization.

What can be identified as a suburban zone are the sub-residential zones at the edges of the urban areas. There are several main reasons for the emergence of suburbs. Among them are lower locational rent, rural-urban migration, environmental conditions, socio-political factors, social status in such areas, and living status with infrastructural facilities of the community in such suburbs. Urban filtration has finally resulted in creating these suburbs at the edges of urban zones. The sub-urban population is growing fast due to the migration of the population to suburban areas due to the harshness of the urban environment [10], [11]. The maximum impact in an urban ecosystem is degradation. Accordingly, the relationship between suburban zones and heat island formation can be explained as follows.

It is clear from the above that human factors strongly influence the formation of heat islands and that human factors in suburban areas are more intense than physical factors or environmental factors in the formation of heat islands. The process is influenced by the gradual development of human activities in suburban areas over time. The main reason is the gradual movement of industrial units and settlements into suburban areas. Another cause of suburbanization that affects urban heat island formation is heavy and prolonged hour traffic in suburbs. Greenhouse gases and primary emissions from factories and vehicles can store this solar heat in the atmosphere, increasing the air temperature and activating the thermal island phenomenon. Recent technologies have detected the heat island phenomena in urban areas [12]–[15]. This study focused on the spatial distribution of the suburban heat island effect and the impact of increasing temperature on freshwater lakes in those areas. To quest, the aim of the study remotely sensed data was used, and GI statistics identify and classify the impact rate based on the degree of the temperature severity. Hence, this study emphasized how important GI statistics in urban planning since the urban ecosystem must receive sustainable persistence.

## 2. Research Methods

### 2.1. Study Areas

The Colombo district consists of 13 Divisional Secretariat Divisions (DSD) is situated in the western province of Sri Lanka. Of which three DSDs' having identified with the sub-urbanization process selected for the study. Kaduwela DSD, Kesbewa and Maharagama DSD are among them. One freshwater lake in each DSD has purposefully chosen. The DSDs' are situated in the lowland region, typically having a hot and humid climate. The study area experiences two main monsoon and two inter-monsoon periods where much rainfall received from the southwest monsoon from May to the end of September and from the end of November to mid-February Northeast monsoon brings relatively more minor rainfall hence, considered as a dry period of the study area [15].

### 2.2. Remotely Sensed Data

Landsat images acquired during the dry season on Jan. 26 in 2010 (Landsat 5TM) and Feb. 03 in 2020 (Landsat 8OLI) were downloaded from earth explorer and used in this study. The three study areas are located on path 141 and row 55, which is the same path and row for the Colombo district. Two satellite images were projected using WGS84/UTM 44N projection in which the spatial resolution is 30*30 meters. Pre-processing of satellite images was undergone using ERDAS Imagine software v.14. The pre-processed images were subjected to extract the LST, NDVI, and RVI for the study area for 2010 and 2020.

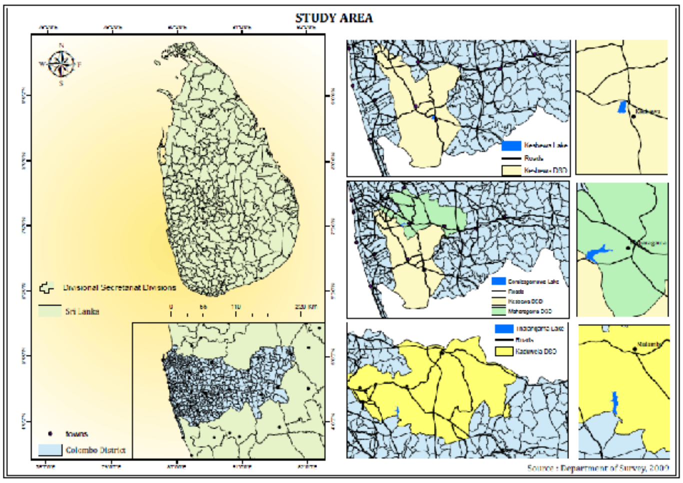


**Figure 1.** Location of Study Area

2.3. Normalized Difference Vegetation Index Calculation

The NDVI calculation is among the most detailed spectral indices used to study urban climate and urban land use and land cover, derived from remote sensing data by using reflectance in Red and Near-infrared bands of the electromagnetic spectrum. The NDVI value ranges from -1 to +1. Higher the positive NDVI value indicates vegetation cover lower the positive value indicate built-up while negative value stands for water and bare area [16], [17]. The NDVI is calculated using the following formula:

$$NDVI = \frac{NIR - R}{NIR + R} \quad (1)$$

NIR is band 4, and 8 for Landsat 5 TM and 8 OLI, and Red is band 3 and 4 for Landsat 5TM and Landsat 8OLI.

2.4. Land Surface Temperature (LST) Retrieval

Land Surface Temperature (LST) retrieval has undergone several steps. First, thermal infrared digital numbers converted to top of atmosphere radiance spectral radiance. Second, spectral radiance data converted to top of atmosphere brightness temperature using constant thermal values. Third, land surface emissivity calculated using NDVI. Finally, land surface temperature calculated using the top of atmosphere temperature, the wavelength, and emitted brightness using the following formula:

$$LST = \left(\frac{BT}{1}\right) + W * \left(\frac{BT}{144380}\right) * ln(E) \quad (2)$$

BT= top of atmosphere brightness temperature in Celsius; W= wavelength of emitted radiance, E= land surface emissivity.

2.5. Hot and Cold Spot Analysis

The hotspot analysis tool 'Getis-Ord Gi*' tool in Arc GIS was used for spatial analysis. The techniques identified hot and cold spots of LST and NDVI for the three study areas using their respective mean values. The Gi* statistics for each feature class indicated the z-score. Higher the positive z score is hots spot where the lower negative z score is cold hots spot. The z values represent the clustering significance for a specified distance based on the confidence level [18]. The study followed the same methodology to classify hot and cold spots classification done. In this study, hot and cold spots were classified into seven categories based on their Gi Bin values: very hot spot (99% significant), hot spot (95% significant), warm spot (90% significant), not statistically significant, cold spot (90% significant), cold spot (95% significant) and very cold spot (99% significant) [7]. The Getis-Ord local statistic is as follows:

$$G_i^* = \frac{\sum_{j=1}^{n} w_{i,j}x_j - \bar{X}\sum_{j=1}^{n} w_{i,j}}{S\sqrt{\frac{\left[n\sum_{j=1}^{n} w_{i,j}^2 - \left(\sum_{j=1}^{n} w_{i,j}\right)^2\right]}{n-1}}} \quad (3)$$

$$S = \sqrt{\frac{\sum_{j=1}^{n} x_j^2}{n} - (\bar{X})^2} \quad (4)$$

$$\bar{X} = \frac{\sum_{j=1}^{n} x_j}{n} \quad (5)$$

$X_j$ is the attribute value for feature j, wi, j is the spatial weight between features i and j, n is equal to the total number of features.

The $G_i$* statistic is a Z-score, so no further calculations are required. The $G_i$* statistic returned for each feature in the dataset is a Z score. For statistically significant positive Z scores, the larger the Z score is, the more intense the clustering of high values (hot spot). For statistically significant negative Z scores, the smaller the Z score is, the more intense the clustering of low values (cold spot).

2.6. Spatial-temporal Analysis of Hot and Cold Spots

The seven categories of hot and cold spots identified previously were reclassified into three categories: Hotspot, cold spot, and not significant for each year, and compare the spatial distribution changes of each area. The fluctuation of hot spot spatial coverage was used to determine the effect of LST and vegetation degradation on selected freshwater lakes.

## 3. Result and Discussions

### 3.1. Land Surface Temperature (LST) Hot and Cold Spots

Figures 2-4 show the Land Surface Temperature (LST) hot and cold spots of Kesbewa-Maharagam, Kaduwela, and Kesbewa DSDs' for 2010 and 2020. LST has increased over the Kesbewa-Maharagama area within the ten years, where the hotspot is significantly expanded by 2020. Cold spots were marginalized only to the northwestern part of the Kesbewa-Maharagama DSD within ten years. Kaduwela DSD also the same. The cold spots identified in the eastern sphere of the DSD have transformed into a hotspot by 2020, while most of the cold spots were restricted towards the western boundary of Kaduwela DSD. Most of the very hot spots with a 99% confidence level accumulated in western parts of Kaduwela DSD. When considering Kesbewa DSD alone, cool spots with a 90% confidence level were gathered in the central-south parts of the DSD, which were shifted to the northwestern corner and the southwestern corner of the DSD and restricted only to a narrow line. Hence the number of cold spot clusters in Kesbewa DSD has reduced by 2020. Typically, all three study areas were experienced high-temperature values, while a slight increase shown in Kaduwela DSD in 2020. The minimum temperature values fluctuated between 15 and 19 over the decade (Table1).

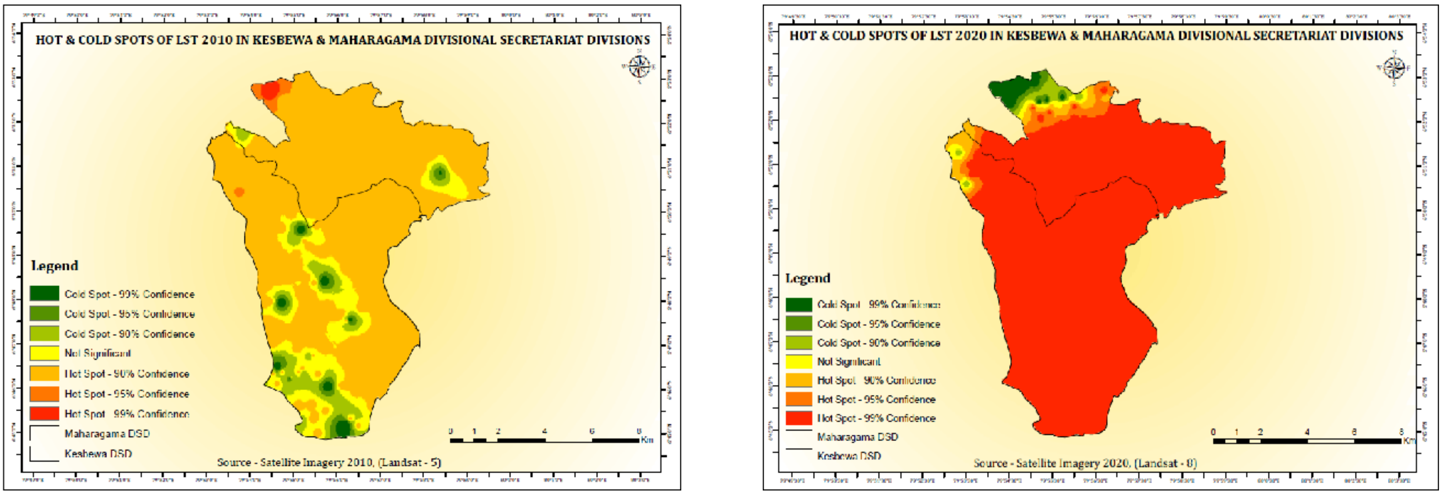


**Figure 2.** Hot and Cold Spot of LST in Kesbewa-Maharagma DSD (2010 and 2020)

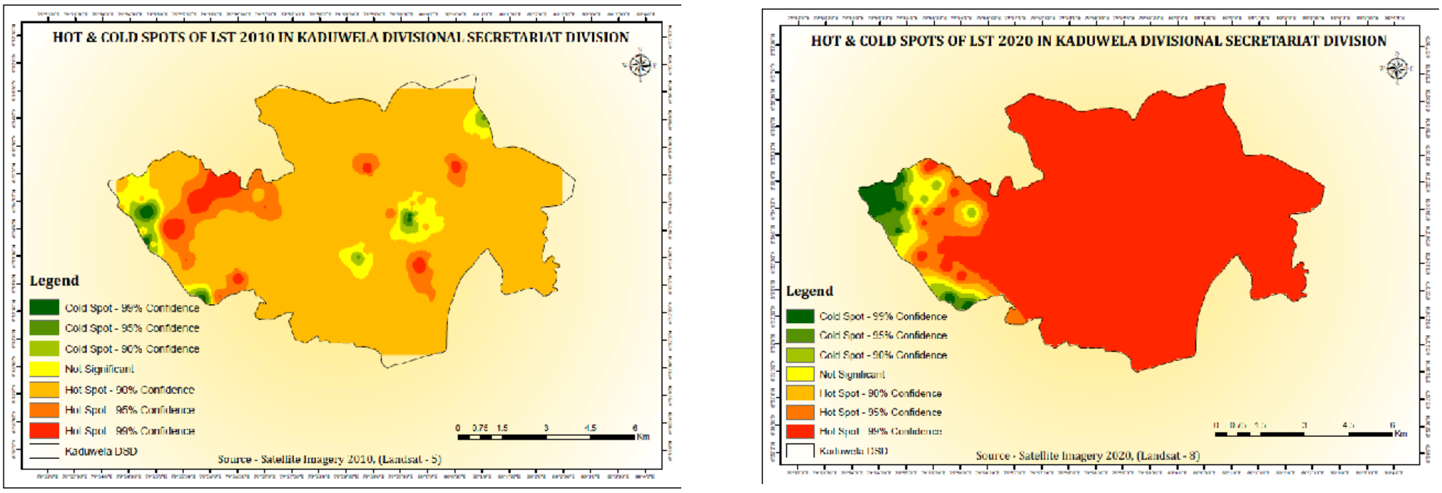


**Figure 3.** Hot and Cold Spot of LST in Kaduwela DSD (2010 and 2020)

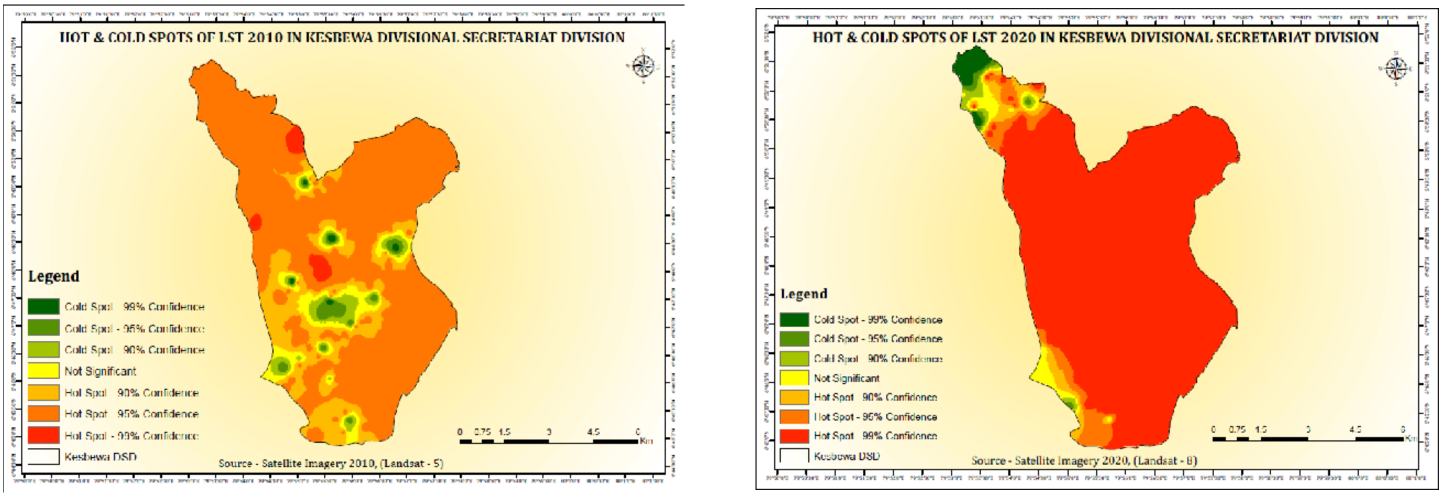


**Figure 4.** Hot and Cold Spot of LST in Kesbewa DSD (2010 and 2020)

**Table 1.** Land Surface Temperature (LST) of the DSDs'

| Years | Kesbewa-Maharagam | | Kaduwela | | Kesbewa | |
|---|---|---|---|---|---|---|
| | Max °C | Min °C | Max °C | Min °C | Max °C | Min °C |
| 2010 | 30.78 | 17.48 | 31.65 | 19.28 | 30.78 | 17.48 |
| 2020 | 30.75 | 15.43 | 32.96 | 17.06 | 30.56 | 19.29 |

### 3.2. Normalized Difference Vegetation Index (NDVI) Hot and Cold Spots

Figure 5-7 illustrates the NDVI hotspot and cold spot clustering for 2010 and 2020 in all three study areas. The NDVI value for all three areas ranged from -0.5 to +0.5 in 2020, while slight changes were identified in 2010. The results demonstrated the declined extent of vegetation cover in all three areas compared to 2010—the cold spots identified in the Kesbewa-Maharagama area for 2010 centralized in the area. The cold spot clusters were at 95% and 99% confidence levels. At the same time, the confidence level at a 90% hotspot cluster was identified at the proximity of the northwestern boundary.

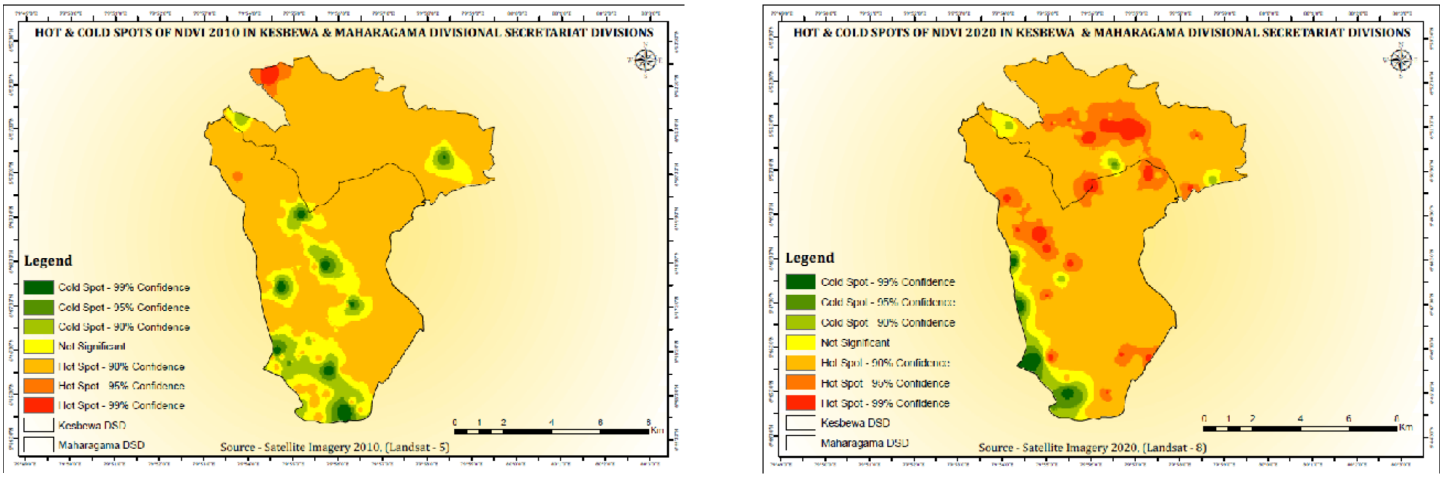


**Figure 5.** Hot and Cold Spot of NDVI in Kesbewa-Maharagma DSD (2010 and 2020)

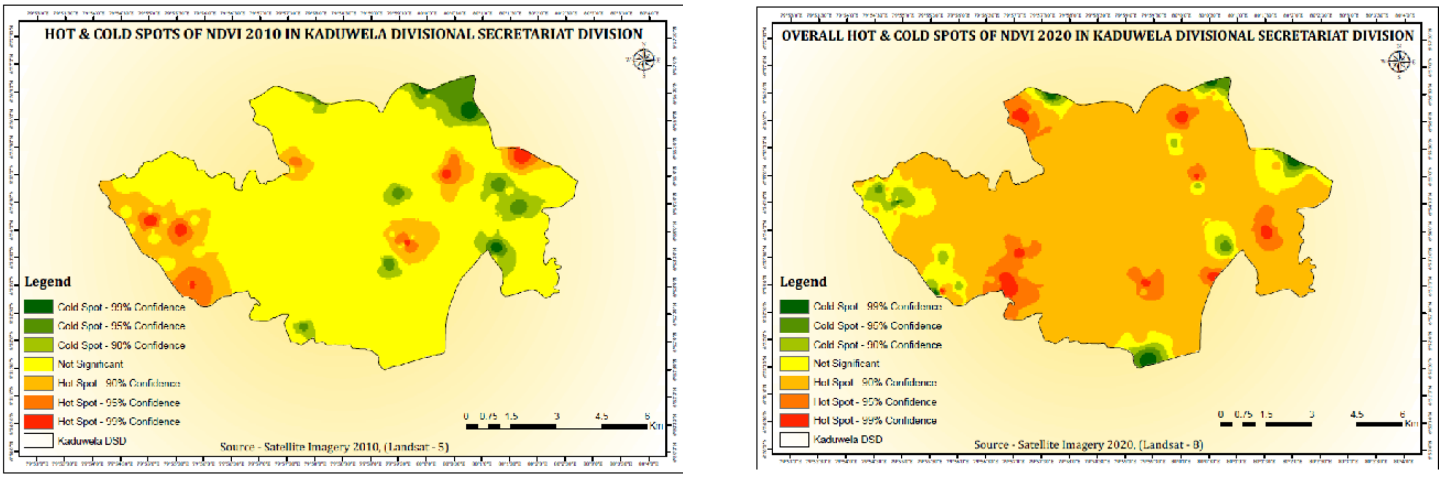


**Figure 6.** Hot and Cold Spot of NDVI in Kaduwela DSD (2010 and 2020)

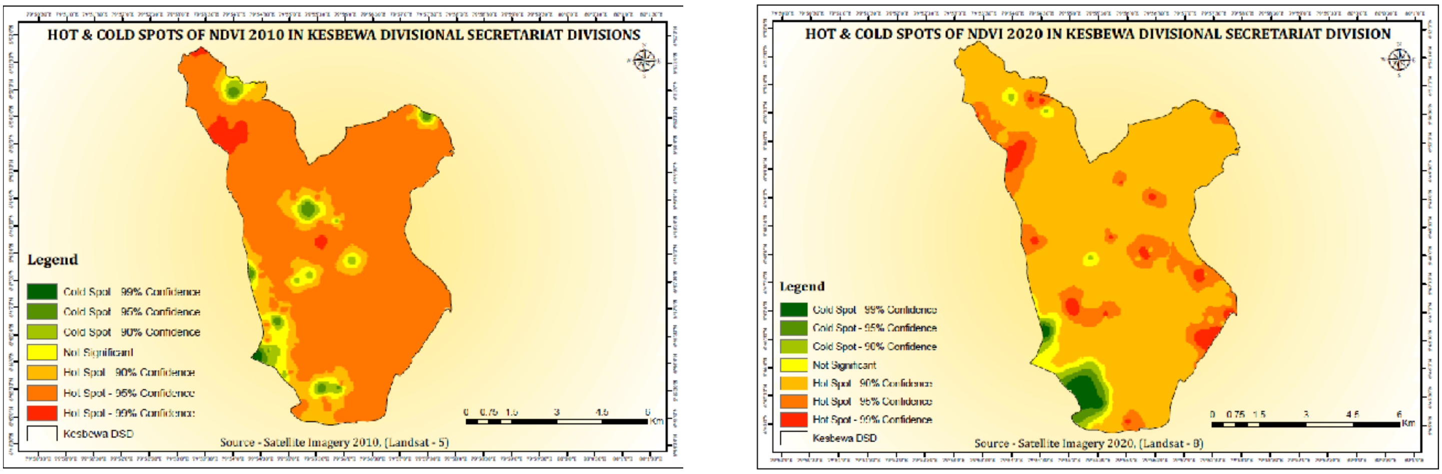


**Figure 7.** Hot and Cold Spot of NDVI in Kesbewa DSD (2010 and 2020)

By 2020 hotspots with a 99% confidence level emerged in the Kesbewa-Maharagama area while the number of hotspots clusters with a 95% confidence level increased. Mostly the cold spots were restricted to the western border where the part of Bolgoda lake and Bolgoda river distributed. Having cold spots with a 95% confidence level eastern periphery of Kaduwela DSD was significant. Hots spot with a 95% confidence level was in the western sphere of Kaduwela DSD. Few clusters of cold and hot spots were accumulated in the central part of the DSD. The larger clusters fragmented by 2020 into several clusters, and the hotspots shifted towards the east. Overall, Kaduwela DSD was categorized under a hot spot with a 90% confidence level, thus being classified as a warm spot. When considering Kesbewa DSD alone, several cool spots with a 90% confidence level were identified for 2010. Few of the cool spots were confined around Bologoda lake. Overall, the DSD is classified as a hotspot with a 95% confidence level. Within ten years, cold spots were highly restricted to the Bologoda lake area while the very hot (99% confidence) and hot spots (95% confidence) clusters increased in number.

### 3.3. The Pattern of Change and The Effects of Hot and Cold Spots

Figures 8-13 illustrate the changing pattern of hot and cold spots of Land Surface Temperature (LST) and NDVI, which were assessed by reclassifying the classified images. Accordingly, three categories were identified as a hot spot, a cold spot, and not significant. The LST hotspots were not significant in 2010 in Kesbewa-Maharagama and Kesbewa alone, while Kaduwela DSD demonstrated four large patches of LST hotspots for the same year. The westernmost hotspot has spread over the Thalangama freshwater lake ecosystem indicating the risk of being a high-temperature zone. Kesbewa lake in Kesbewa DSD was in a cold spot, an eco-friendly sign of the lakes' ecosystem health. Contrastingly, within ten years, the extent of LST hotspots expanded broadly. All three lake ecosystems became under the risk of the high-temperature zone by 2020. Cold spots were narrowed towards the western and northwestern border of the DSDs.

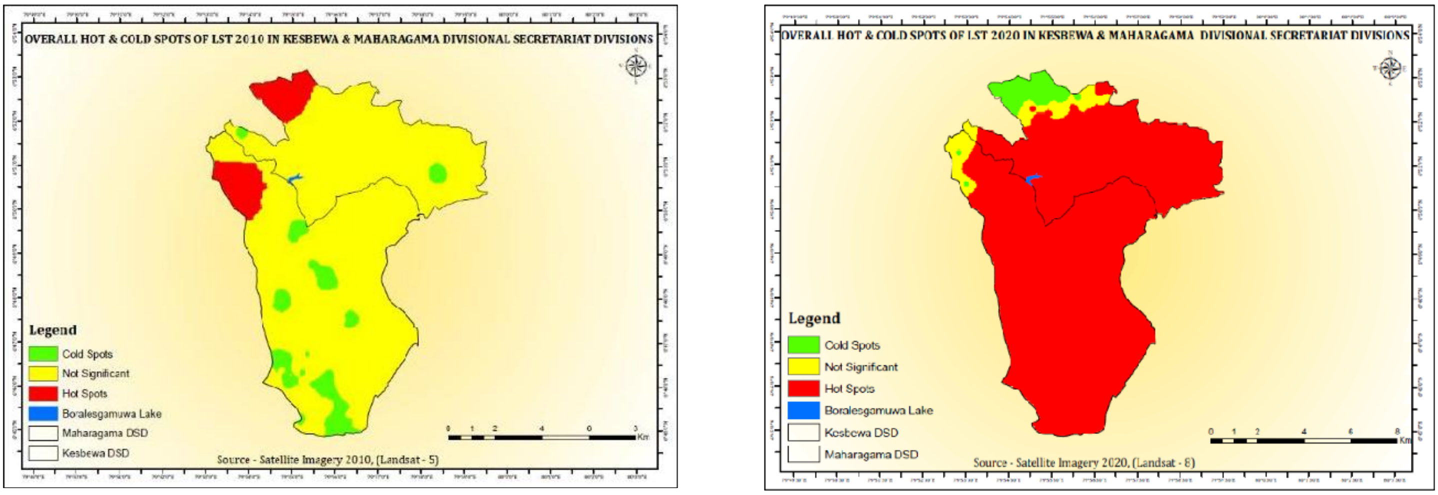


**Figure 8.** Changes in LST Hot and Cold Spot in Kesbewa-Maharagma DSD (2010 and 2020)

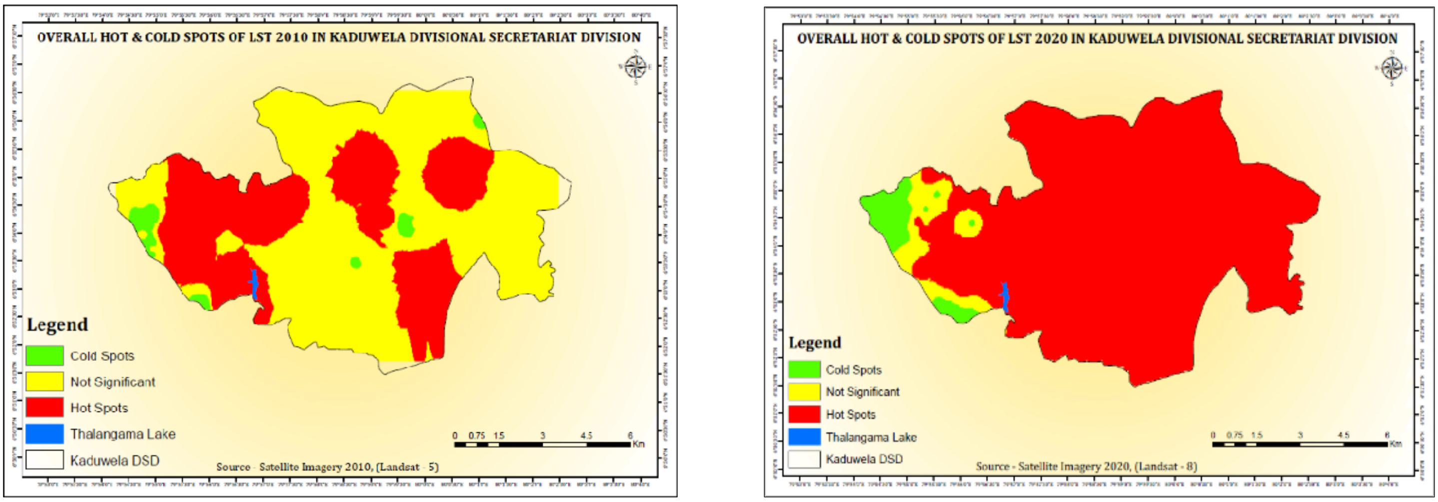


**Figure 9.** Changes in LST Hot and Cold Spot in Kaduwela DSD (2010 and 2020)

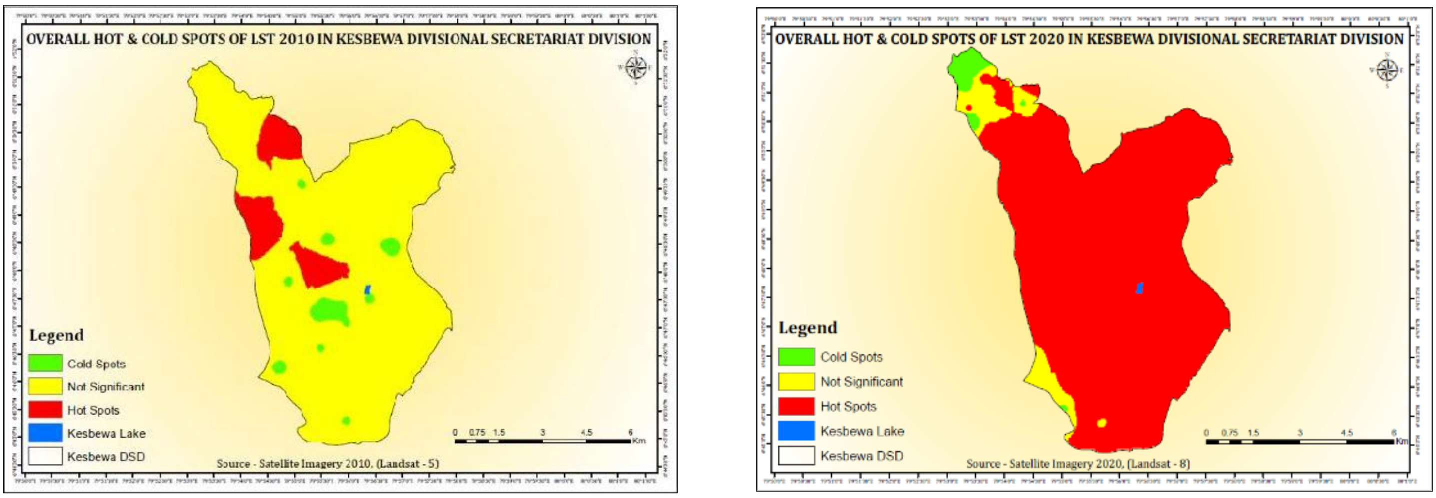


**Figure 10.** Changes in LST Hot and Cold Spot in Kesbewa DSD (2010 and 2020)

The reclassified NDVI hot and cold spots were also the same where Kaduwela DSD showed much significant NDVI hot spot patches over the area; however, the lake ecosystems were not at-risk levels in 2010. This has changed by 2020, but not as Land Surface Temperature (LST) hot and cold spots; the NDVI hot and cold spots were limited to several large patches over the whole DSD in each area. Surprisingly only Boralesgamuwa lake was not identified as an NDVI hot spot but will be at risk due to the encroachment and the expansion of the NDVI hot spot. Thalangama lake and Kesbewa lakes were identified as NDVI hotspots where the loss of vegetation and increasing land surface temperature was significant by 2020. Also, it is remarkable that all three study areas have no many NDVI cold spots indicating dense vegetation cover. NDVI cold spots were restricted only to few small patches in all three DSDs'.

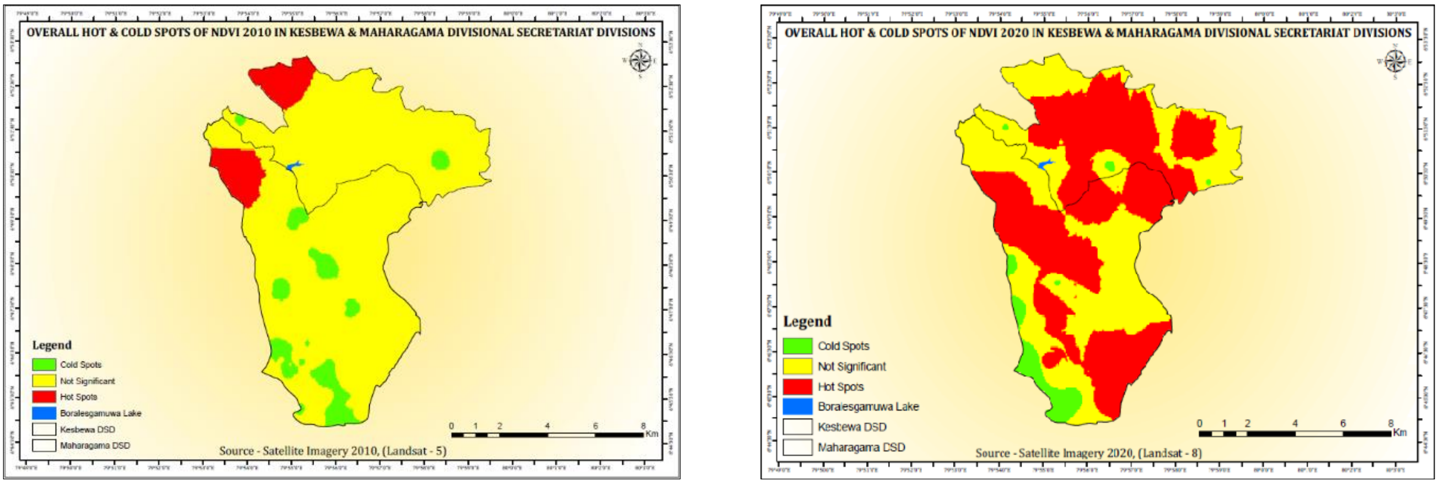


**Figure 11.** Changes in NDVI Hot and Cold Spot in Kesbewa-Maharagma DSD (2010 and 2020)

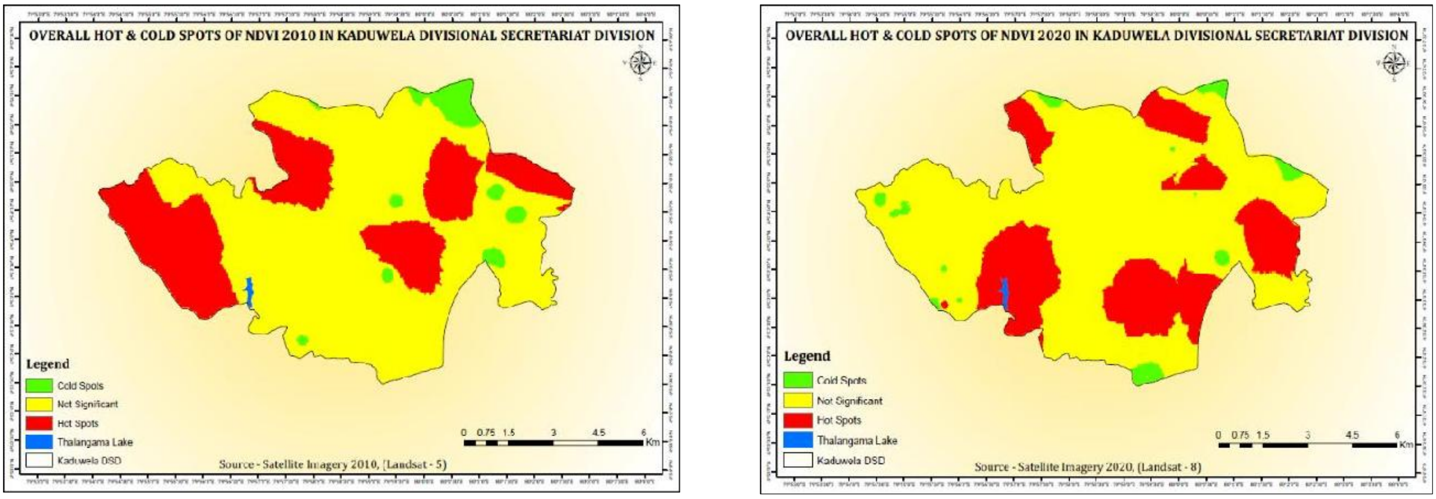


**Figure 12.** Changes in NDVI Hot and Cold Spot in Kaduwela DSD (2010 and 2020)

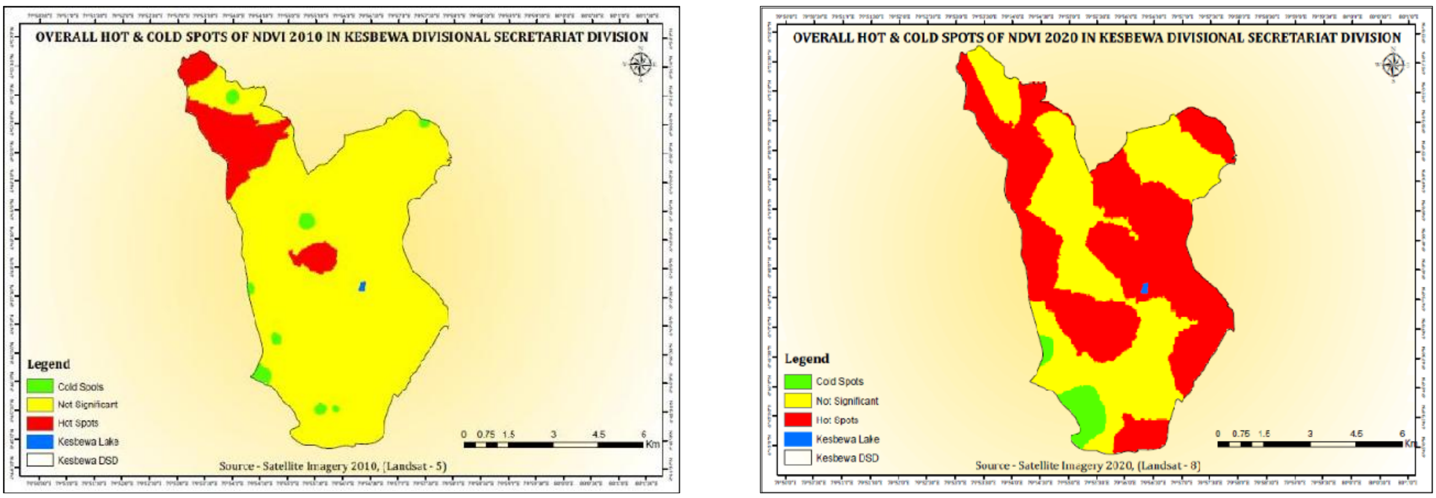


**Figure 13.** Changes in NDVI Hot and Cold Spot in Kesbewa DSD (2010 and 2020)

Increasing LST due to modification and transformation of vegetated areas into concrete and synthetic built-up extents is challenging in urban areas. United Nations in 1977 documented an estimation of the urban population, indicating that over 60% of the world population projected to be lived in urban areas by 2030 [19]. The emergence of large urban agglomerations in developing countries identified in the late 90s' [20]. The size and the number of urban agglomerations were increased since then, so does the relative importance of the urban environment in various aspects. Land modification and transformation in urban and suburban areas have positively impacted the urban thermal environment. Hence, one of the most critical indicators in an urban environment is the urban thermal environment. Vegetation is also a crucial component of the urban ecosystem that influences cities' physical environment via selective absorption and reflection of incident radiation and latent heat and sensible heat exchange [14]. Vegetation in urban areas has a strong influence on energy demand and the formation of urban heat islands. The urban heat island effect indicates the higher air and land surface temperature in urban areas [13]. In this respect, the land surface temperature is a prominent indicator in determining the ecological health of the modern urban environment [12].

Remote sensing offers the latest and most synoptic capabilities to collect many samples over a large area almost instantaneously. Therefore, remotely sensed data could be valuable for studying urban vegetation and thermal variations within an urban ecosystem. In this study, hot spot, and cold spot maps for Land Surface Temperature (LST) and NDVI were created using Getis-Ord Gi* for 2010 and 2020. The resultant z-score and p values indicate were features with high or low values cluster spatially considering the neighboring features.

According to the results, Thalangama lake, Boralesgamuwa lake, and Kesbewa lake are located at the Land Surface Temperature (LST) hotspot. Only Boralesgamuwa lake is not significant as an NDVI hotspot. The number and the extent of hotspot clusters have increased within ten years while cold spots decreased. All three lake ecosystems are in the proximity of the central suburb city; hence the impact of urban expansion can be identified concerning the vegetation decline and temperature increasing. In line with the results and the literature, it is evident that freshwater biota is highly vulnerable to climate change. The influence of vegetation on freshwater bodies is significant via particulate and dissolved organic matter and nutrients via mineralized accumulated litterfall [21]. Along with the temperature increasing, changes occur in phenology, species and size distribution, food-web dynamics, nutrient dynamics, and ecosystem metabolism. Phytoplankton productivity is also affected due to vegetation loss as it increases solar radiation and water temperature [22].

Even though Boralesgamuwa lake was not identified as a hotspot, there is an imminent threat towards the lake area, whereas the adjacent hotspot may expand. Thalangama lake in Kaduwela DSD is an environmentally protected ecosystem. However, the lake is located at the center of a hotspot. Further, it is surrounded by the pressure of Battaramulla suburb as well. Battaramulla is also one of the rapidly expanding suburbs in the Colombo district.

The results indicate that the trend of the hot spot in the suburbs is a critical environmental issue integrated with unplanned urbanization. Therefore, this study aware of where to restore urban vegetation cover to reduce the land surface temperature and to conserve urban freshwater ecosystems. Besides, the results provide essential information for effective urban planning. However, not significant areas have converted to hot spots rather than cold spots, which is a critical risk in the urban environment. Hence, the study stressed the absolute importance of identifying Land Surface Temperature (LST) and NDVI hot and cold spots in urban segments of a developing country.

## 4. Conclusion

The study results show the spatial pattern of LST and NDVI hot and cold spots in Kaduwela, Kesbewa-Maharagama, and Kesbewa DSDs, identified as prominent suburbs of Colombo district. The results show that the not significant and cold spots were particularly vulnerable to hot spots shortly, especially LST hot spots where the maximum temperature already reached 32 Celsius degrees. Though the degree of vulnerability of becoming hotspots is not significant in NDVI, it was also illustrated the signs of becoming hotspots. The study recommends further comprehensive hotspot analysis using more satellite images multiple times to extract more information for more substantial trend analysis. The study concludes spatial and temporal variations of the urban heat island formation and its effect on freshwater lake ecosystems in suburban areas in the Colombo district. The findings are helpful for urban planners to lift sustainable urban city planning.

## Acknowledgments

Thanks for supporting the University of Colombo and the Urban Development Authority (UDA) of Sri Lanka until this research can be completed.

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