VEGETATION COVER DEPLETION AND INCREASE OF HEAT ISLAND EFFECT OF TRINCOMALEE DISTRICT OF SRI LANKA

G.M.W.L Gunawardena,

Department of Town and Country Planning, Faculty of Architecture, University of Moratuwa, Katubedda, Moratuwa, Sri Lanka

w.lakpriya@gmail.com

KEYWORDS: Urban heat islands, land cover, built-up area, thermal images

ABSTRACT

Urbanization is an unavoidable phenomenon in modern world. With the rapid urbanization, hordes of requirements emerged for people. To satisfy these requirements, the natural land cover has been converting to different types of land uses. It changes the physical chemical and biological properties of the earth surface. Urbanization is the main cause to increase the imperviousness of the earth surface. It causes lots of bad outcomes to the environment, such as flash flooding, increase of temperature and pollution. This research mainly focused on the increase of temperature with the depletion of natural vegetation cover to satisfy the human needs. For this study, Trincomalee district of Sri Lanka was selected due to two reasons; it was the recently highly populated district after civil war of Sri Lanka and naturally the area gain a high concentration of solar energy with its topographical characteristics. Natural vegetation cover maps were prepared with the help of NDVI values for four years from 1991 to 2017 and the heat maps were prepared for the same years to identify the relationship between vegetation cover depletion and the increase of heat. The results clearly displayed that there is a very relationship between them. With the time the heat has increased significantly due to land clearing for urbanization process. Therefore it is a timely requirement to find the alternatives to satisfy the human needs without scarifying the natural vegetation cover. This is very crucial for this district due to its inborn characteristics causing high temperature throughout the year. If this vegetation cover depletion happens for next few years, there is a possibility of converting the district into a semi dessert.

1. INTRODUCTION

Low green coverage is one of the main causes of increasing the heat island effects. With the urban development, green coverage tends to decrease gradually. It is a theory of the environment (Almutairi, 2015). Urban heat islands and global warming are burning issues in the world. Scientists first discovered the heat island effect in the 1800s when they observed cities growing warmer than surrounding rural areas, particularly in summer (BOI, 2016). Concrete, asphalt and other impervious materials of urban surfaces absorb more solar radiation during day time. At night, the absorbed heat is emitted to the urban air, increasing temperature over a city that can be as much as 1 to 3°C higher than temperatures in surrounding rural areas.

Being impervious urban surfaces show faster runoff from land, reducing the natural cooling effects of water on the landscape. Lack of trees in urban areas causes less evapotranspiration, less shade, and less infiltration of water to soil. Thus the cooling effect of urban landscape becomes lower with lack of enough vegetation cover (Nakata-Osaki et.al., 2015).

Urban development is an unavoidable phenomenon in present world. However, they can use strategies to reduce the environmental impacts. Being a tropical country, Sri Lanka receives high amount of solar radiations causing higher temperature in the country. The condition aggravates with the urbanization.

There were lots of international studies on UHI and Global Warming (Peterson et.al., 1999, Huang, 2015, Sailor, 2011). However there are very few researches undertaken in Sri Lanka about these burning issues (Senanayaka, 2013, . Therefore this research is attempted to find out the relationship between forest cover depletion and the increase of heat in Eastern Province of Sri Lanka. Eastern Province naturally gets a higher degree of sun's radiation. According to the agro ecological categorization, Eastern Province categorized as Dry and Semi-arid zones. Thus naturally this area faces a high temperature issues. It has aggravated with the human encroachment of the natural vegetation. Therefore, this research attempts to show the clear relationship between natural vegetation depletion and the Heat island effect.

2. OBJECTIVES

- To identify the relationship between UHI and natural vegetation depletion

- To quantify the increase of UHI through time series analysis

3. STUDY AREA

Eastern Province of Sri Lanka was selected for the study. Eastern province included 3 districts; Trincomalee, Baticaloa and Ampara . Out of these three districts, the main concern of this study is on the Trincomalee district. It has an area of 2,727 square kilometres. Trincomalee District is divided into 11 Divisional Secretary's Division (DS Divisions), and these DS Divisions are further sub-divided into 230 Grama Niladhari Divisions (GN Divisions). The population of the study area was 378,182 in 2012 (Census of Population and Housing, 2011). According to the statistics of Forest Department of Sri lanka, Trincomalee had total of 126746.0 ha of all types of natural vegetation caver in 1999 (Forest Department, 2012). Apart from that most of the settlement areas consists with vegetation. Figure 1. Displays the study area.

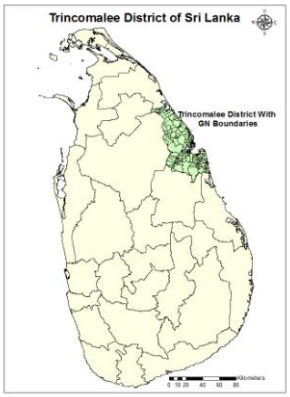

Figure 1. Trincomalee District of Sri Lanka

4. METHODOLOGY

4.1 Data

Landsat TM images from 1980 to 2017 covering the study area were selected for both vegetation analysis and heat island identification.
The land use and land cover maps of 1983 and 2010 were used for the Landsat image classification verification
Secondary information from forest Department of Sri Lanka and the other data sources were used for statistical verifications

4.2 Method

The main objective of this research is to find out the relationship between vegetation cover depletion and the increase of heat island effect. To achieve this objective NDVI images were prepared for1991, 1999, 2008 and 2017 years. Through this series of NDVI images, the depletion of vegetation cover of the study area was observed and measured. Using thermal bands of Landsat TM and ETM images, the heat maps were prepared for same years as NDVI calculated. Preparation of maps carried out with the help of Erdas Imagine and Arc GIS software. Using these images, the increase of heat islands were identified and measured.

Heat maps were obtained by applying the following equations.

Top of atmosphere Radiance:

$$L_l = M_l Q_{cal} + A_l$$

Where:

L_l = Top of Atmosphere (TOA) radiance in (Watts/m^2*srad*um))

M_l = 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)

This formula is relevant to all data bands.

At-Satellite Temperature of Landsat 4-5 thermal and Landsat 8 TIRS Bands:

$$T = K_2 / ln (K_1/L_l + 1)$$

Where:

T = at-satellite brightness temperature in degrees Kelvin

K_2 = Band-specific thermal conversion constant from the metadata (K2_CONSTANT_BAND_x where x is band number 10 or 11)

K_1 = Band-specific thermal conversion constant from the metadata (K1_CONSTANT_BAND_x where x is band number 10 or 11)

L_l = product of the Radiance formula

(HEXAGONAN Geospatial, 2016).

5. RESULTS AND DISCUSSION

First the NDVI maps were prepared to identify and to measure the natural vegetation cover of the district. NDVI values of the area were divided into three categories based on the value. Those are vegetation, water and other land uses (mainly considered settlements). For each year the vegetation maps were prepared with these three classes. The created vegetation maps were displayed below.

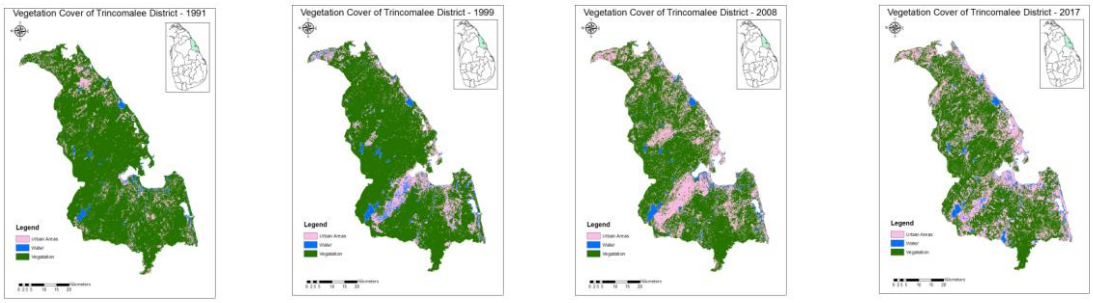

Figure 2. Vegetation cover depletion from 1991 to 2017.

Classified maps for 4 years clearly showed how the vegetation cover of the area depleted and how other land uses (mainly considered settlements) increased in the district during considered 26 years period. In 1991 the size vegetation cover (mainly forested areas) was around 175 km^2. In 1996 it was around 124 km^2, for 2008 and 2017 the cover was 107 km^2 and 99 km^2 respectively. The calculations clearly prove the depletion of vegetation cover with the increase of other land uses. Drastic changes have occurred within and around Trincomalee bay, Kantale, Padavi Sri Pura, Gomarankadawala and verugal DS divisions.

Next the heat maps were prepared for same years to identify whether there is a relationship between vegetation cover depletion and the increase of heat. The prepared heat maps are displayed in figure 3.

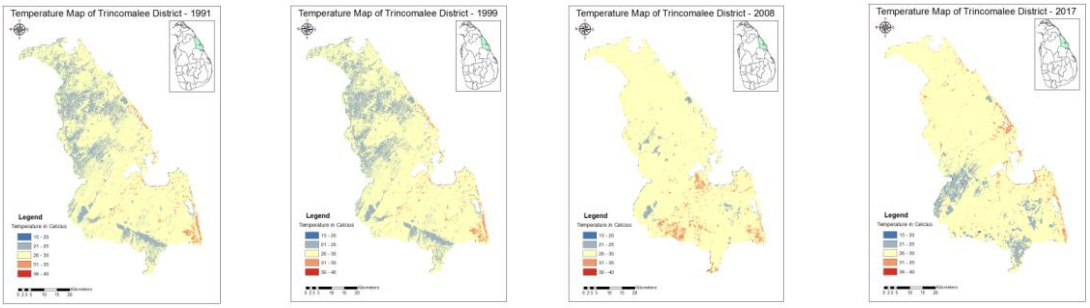

Figure 3. prepared heat maps for 1991, 1999, 2008 and 2017 years.

Temperature of Trincomalee varies between 24-35 C^0. The classified maps were prepared with 5 temperature classes; 15-20, 21-25, 26-30, 31-35 and above 35 C^0. According to the classified maps high temperature could be observed along the coastal belt for all considered 4 years. In addition right corner of southern Trincomalle (Verugal area) displayed a patch of high temperature all the time. It was the common heat pattern of the area. This heat pattern was changed in 2008 drastically showing heat patches around Trincomalee bay and around left side of the southern Trincomalee (Kantale area). The same new patches could be observed in year 2017 with less magnitude than 2008. However these results imply that the heat of the area has drastically increased and new heat patches occurred around Trincomalee bay and around Kantale area.

Vegetation maps displayed above described the spatial pattern of vegetation depletion. It clearly displayed same Kantale and Trincomalee bay areas with higher vegetation cover depletion. Thus it clearly shows the relationship between vegetation cover depletion and the increase of heat of the area.

There are lots of variables which affect the increase of heat of the earth surface, however, depletion of vegetation is one of the main variables and this research clearly displayed this relationship.

The emerging heat patches around Trincomalee bay and around kantale area may remain constant or increase with time if the land cover continues to change in future as well.

Therefore it is urgent to think about the gravity of the situation and take quick decisions or set rules and guidelines to minimize the depletion of vegetation cover of the study area and to guide the people to take maximum utilization from the available land without harming to the environment.

6. CONCLUSIONS

The research was carried out with the objective of finding out the relationship between vegetation cover depletion and the increase of heat in Trincomalee district.

The classified maps with the help of NDVI values clearly displayed that there is a significant change in the area. The vegetation cover has converted into other land uses during considered 26 years period. The changes were significant around Trincomalee bay, Kantale, Padavi Sri Pura, Gomarankadawala and Verugal DS divisions.

The heat maps prepared for the same time duration showed there are emerging high heat patches in the district especially around Trincomalee bay and Kantale area.

Thus there is a clear relationship between vegetation cover depletion and the increase of heat of the area having emerging high heat patches within low vegetative areas of the District such as Kantale and Trincomalee bay.

Therefore it is essential to think about this matter seriously and take actions to stop this pathetic condition quickly to avoid the bad outcomes to the people and the environment of the Trincomalee district and the whole Sri Lanka.

Recently the Meteorological Department of Sri Lanka has announced there is a threat of converting several parts of the Sri Lanka into semi desserts. Trincomalee is one of them having high risk of becoming a semi dessert. Thus if these land use changes continue, it is inevitable to stop this pathetic transition of land into a semi dessert in future.

7. RECOMMENDATIONS

There should be a proper mechanism to aware the people in the area about this situation. Thus the mass media and the respective governors need to arrange awareness programs to explain the general public about these bad outcomes of their activities

The rules and regulations of Sri Lanka must revisit and strengthen to avoid all loop holes to stop illegal land cover destructions throughout Sri Lanka.

REFERENCES

"A2 : Population by ethnic group according to districts, 2012". Census of Population & Housing, 2011. Department of Census & Statistics, Sri Lanka.

Almutairi, M. K. 2015. Derivation of Urban Heat Island for Landsat-8 TIRS Riyadh City (KSA). From http://www.scirp.org/journal/gep.

BOI, S. L., 2016. Zones/Park. Retrieved from Board of Investment: from http://www.investsrilanka.com/setting_up_in/bo

Forest Department of Sri Lanka, 2012. From http://www.forestdept.gov.lk/web/index.php?option=com_content&view=article&id=112&Itemid=131&lang=en

HEXAGONAN Geospatial, 2016. From http://www.hexagongeospatial.com/

Huang, Q.; Lu, Y. (2015). "The Effect of Urban Heat Island on Climate Warming in the Yangtze River Delta Urban Agglomeration in China". International Journal of Environmental Research and Public Health. 12 (8): 8773–8789.

Nakata-Osaki C. M., De Souza L. C. L., and Rodrigues D. S., 2015. A GIS extension model to calculate urban heat island intensity based on urban geometry. Proceedings of 14th International Conference on Computers in Urban Planning and Urban Management, July 7-10, 2015, Cambridge, MA USA

Peterson, T.C.; Gallo, K.P.; Lawrimore, J.; Owen, T.W.; Huang, A.; McKittrick, D.A. (1999). "Global rural temperature trends". Geophysical Research Letters. 26 (3): 329–332.

Sailor, D. J. (2011). "A review of methods for estimating anthropogenic heat and moisture emissions in the urban environment". International Journal of Climatology. 31 (2): 189–199.

Senanayake I.P., Welivitiya W.D.D.P., Nadeeka P.M., 2013. Remote sensing based analysis of urban heat islands with vegetation cover in Colombo city, Sri Lanka using Landsat-7 ETM+ data. Urban Climate Volume 5, October 2013, Pages 19-35