Spatial and Temporal Changes of Air Temperature in Sri Lanka

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1. Introduction

Climate change is one of the major environmental issues in both developed and developing world at present. Impacts of climate changes can be seen in all geographical regions even in coldest region of the world. High rate of urbanization, Industrialization, usage of heat trapping gases (Green House Gases) are some of the influencing factors in altering the climatic parameters in the world. Alteration of climatic parameters is reflected by depletion of Ozone layer, sea level changes, rainfall variation and global warming. Global warming resulting from the Green House Effect is the key process for the climate change.

Global warming is the outcome of the different process which increases the air temperature in the earth's surface. Scientists have pointed out that earth's surface temperature rose by an estimated 1.3^0 C in the last hundred years. In fact, eleven out of the last twelve years rank among the warmest since temperatures was first recorded to increase in the late century.

Even small increases in average global temperatures can have devastating effects on people, wildlife, and environment. Rising temperatures in the Arctic area have already reduced average ice cover, disrupting the feeding habits of polar bears and the way of life of Inuit communities.

2. Objectives

The main objective of this study is to find some concrete evidence of changing pattern of air temperature in Sri Lanka. The dichotomy between the wet zone and dry zone and rainfall seasons were considered as some of the explanatory

variables in this analysis. In addition to the main objective, following specific objectives were formulated.

1. Identifying the temporal changes of air temperature in Sri Lanka
2. Examination of the spatial changes of air temperature in Sri Lanka

3. Literature Review

As shown below, the Intergovernmental Panel on Climate Change (IPCC - Fourth Assessment Report (AR4), published on 2 February 2007 indicated that the global warming as one of the important threats facing by human in present world.

'Climate change is one of the greatest environmental, social and economic threats facing the planet. The warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global mean sea level. The Earth's average surface temperature has risen by 0.76° C since 1850. Most of the warming that has occurred over the last 50 years is very likely to have been caused by human activities'.

Temperature is a measure of the average heat or thermal energy of the particles in a substance. Since it is an average measurement, it does not depend on the number of particles in an object. In that sense it does not depend on the size of it. For example, the temperature of a small cup of boiling water is the same as the temperature of a large pot of boiling water, even if the large pot is much bigger than the cup and has millions and millions more water molecules (NASA).

Global spatial temperature patterns are changing from month to month and year to year. But the considerable temperature pattern can be seen according to seasons for both northern and southern hemisphere. This temperature patterns born with earth's oscillation and sun's effects. NASA has interpreted the global temperature patterns as images demonstrate the types of maps that can be made from Atmospheric Infrared Sounder (AIRS).

Moist Tropical Climates are known for their high temperatures and rain year round and for their large amount of year round rain while dry climates are characterized by little rain and a huge daily temperature range. In Humid Middle Latitude Climates, land/water differences play a large part. These climates have warm, dry summers and cool, wet winters. Continental Climates can be found in the interior regions of large land masses where total precipitation is not very high and seasonal temperatures vary widely. Cold Climates are part of areas where permanent ice and tundra are always present in which only about four months of the year have above freezing temperatures.

Different studies have given slightly different statistics of average air temperature in Sri Lanka as follows;
Sri Lanka is a tropical island situated in the Indian Ocean. The average annual temperature of the island is about 32^0 C (about 90^0 F) in the low lands and about 21^0 C (about 70^0 F) in the higher-mountainous regions. The air temperature within the island varies slightly through out the year, except for few mountainous areas.

There are no marked seasons in Sri Lanka. The weather in plains and the coastal areas are hot and humid with an average mean temperature of 27° C. Relative Humidity varies from 70% during the day to 90% at night. The cooling sea breeze moderates the temperature. The hills are cool and pleasant with an average mean temperature of around 20° C.

4. Research Methodology

4.1 Data collection and checking

Basically this study depends on the secondary data collected from the different government organizations. The main data sources were Meteorological Department of Sri Lanka and the NASA. The daily average air temperature data for the last 40 years from 1961 to 2001 collected from the Department of Meteorology and daily surface temperature data (during the period 1881-1981) were collected from NASA. In addition to the ancillary, locational data for meteorological stations were collected from the Department of Meteorology of Sri Lanka.

4.2 Analysis

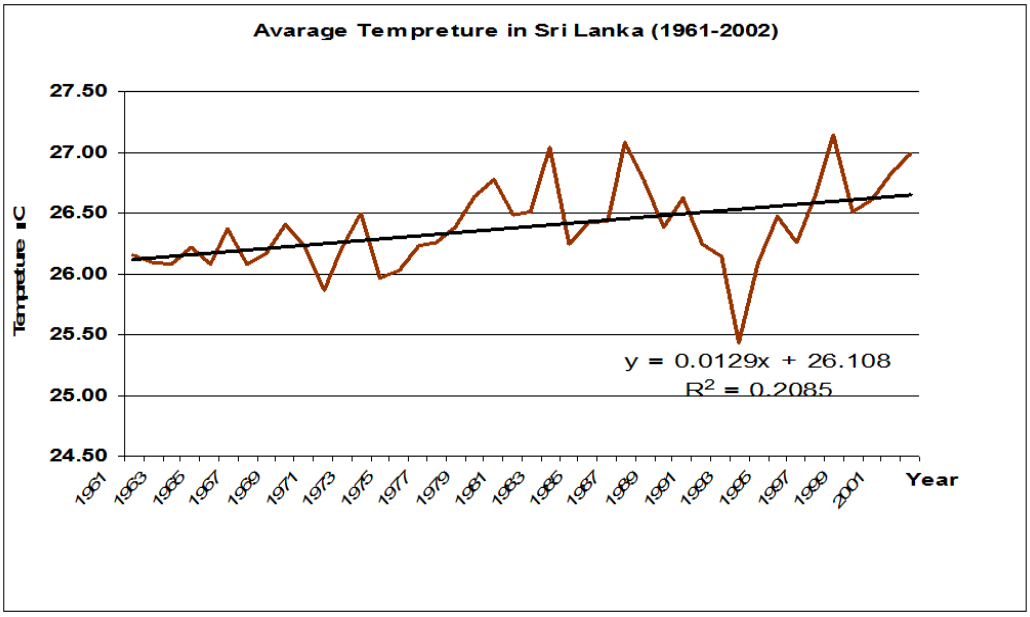
The statistical analysis as well as spatial analysis was adopted to accomplish the set objectives. Under the statistical analysis, liner simple regression and time series analysis were applied to examine the statistical changes and periodical changes of air temperature in meteorological observatories. In order to examine the spatial pattern of air temperature in the country, using point data (23 Metrological observatories) grid surfaces were generated in 5 year intervals from 1961 to 2001. Grid analysis was adopted to examine the expansion of high temperature area and shrinking pattern of low temperature area in the country.

5. Results and Discussion

5. 1. Increasing trend of air temperature

The increasing trend of air temperature is one of the prominent climatic patterns in Sri Lanka (Figure 1). Though there are a few outliers in recent past, trend line is well fitted for the data strip. The correlation coefficient also provides necessary evidence for appropriates of the curve fitted (Figure 1). Based on the regression line, the average air temperature of Sri Lanka in 1961 was 26.20^{0}C and in 2001 the average air temperature is 26.60^{0}C.

Figure 1



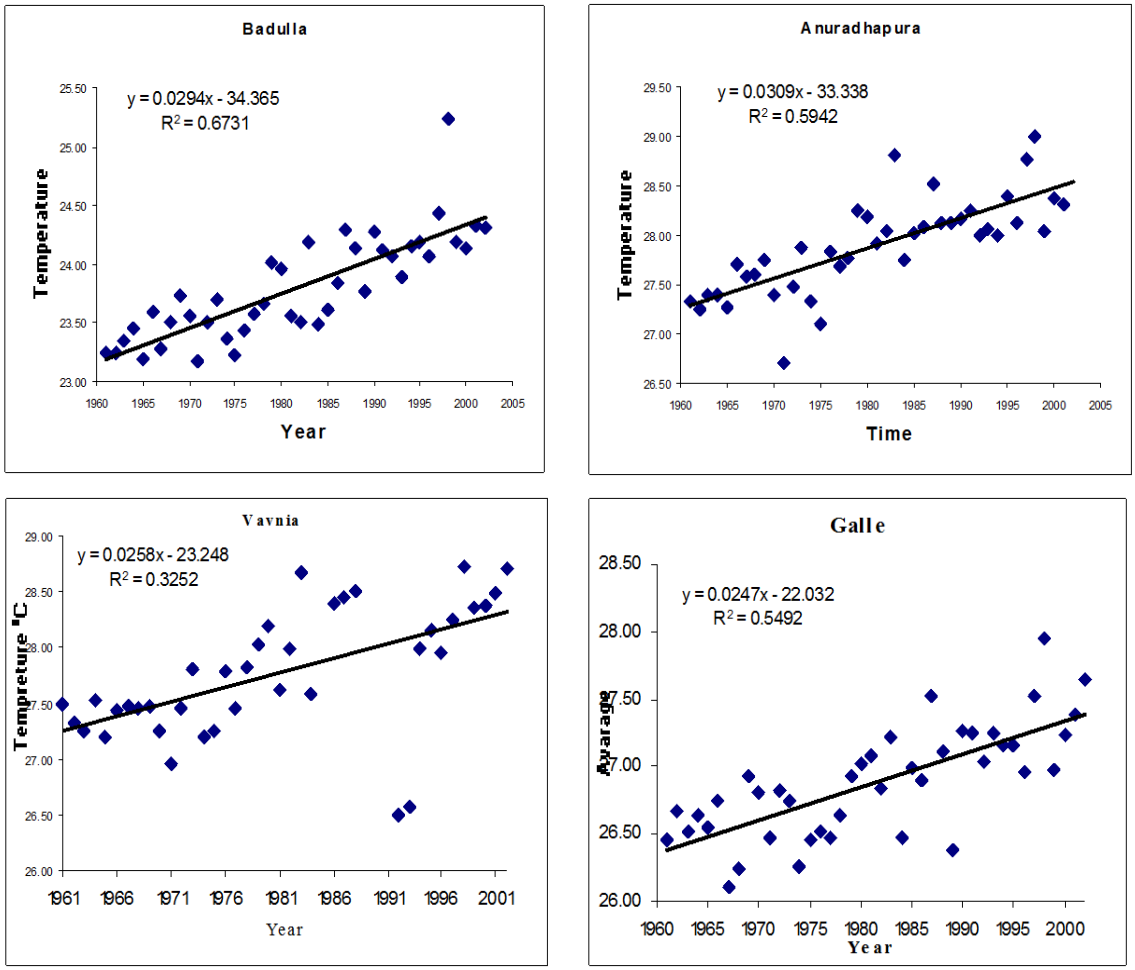
Therefore the average increase of air temperature is 0.4^0C during the study period. However some meteorological observatories show very rapid increase in air temperature (Table 1).

Table 1: Regression Parameters

Station	Intercept (a)	Slope (b)	r
Anuradhapura	- 33.33	0.030	0.7708
Badulla	- 34.36	0.029	0.8204
Vavniya	- 23.24	0.025	0.5703
Galle	- 22.03	0.024	0.7411
Kurunegala	- 11.64	0.019	0.7118
Hambantota	- 9.398	0.018	0.6977
Katunayake	- 7.717	0.017	0.6547
Puttalam	- 7.216	0.017	0.6024
Kandy	- 9.041	0.017	0.3389
Trincomalee	0.1773	0.014	0.4951
Mahailluppalama	2.8358	0.012	0.4151
Batticaloa	6.5464	0.010	0.4856
Nuwara Eliya	- 5.091	0.010	0.4288
Ratnapura	16.566	0.005	0.2307

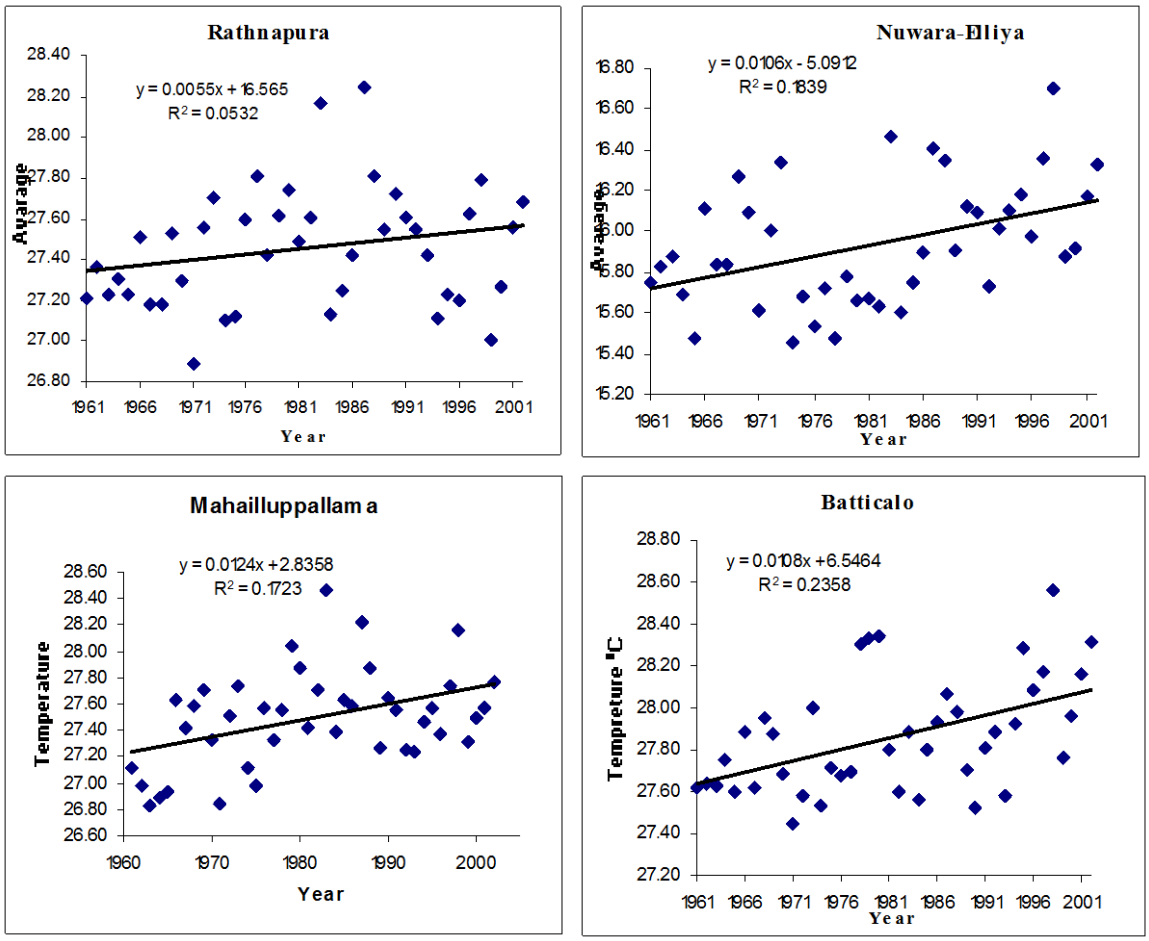
According to the regression parameters given in Table 1, Anuradhapura is the area which shows highest increase in air temperature during the study period followed by Badulla, Vavniya and Galle (Figure 2).

Figure 2



In the other hand Ratnapura Metrological observatory slows least slope value in the regression analysis followed by Nuwara Eliya, Batticaloa and Mahailluppalama (Figure 3). Its difficult to find out any spatial arrangements by examining these extremes. Observatories from both climatic regions (Wet zone and Dry zone) can be seen in both categories.

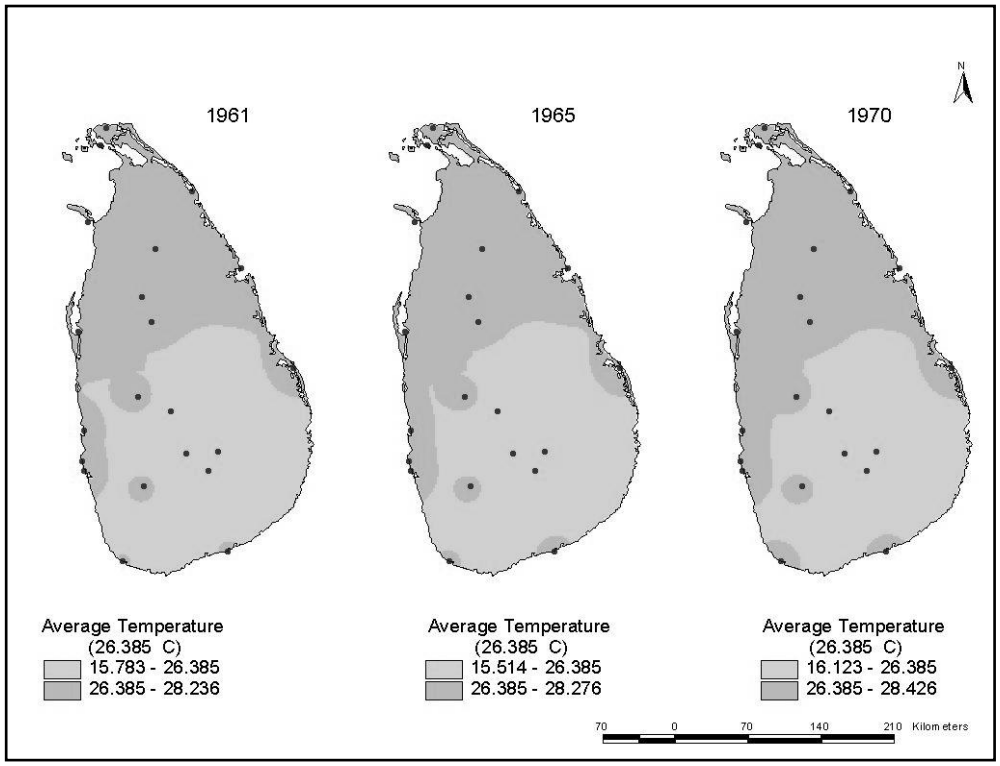
Figure 3: Meteorological observatories show very low increasing trends of temperature

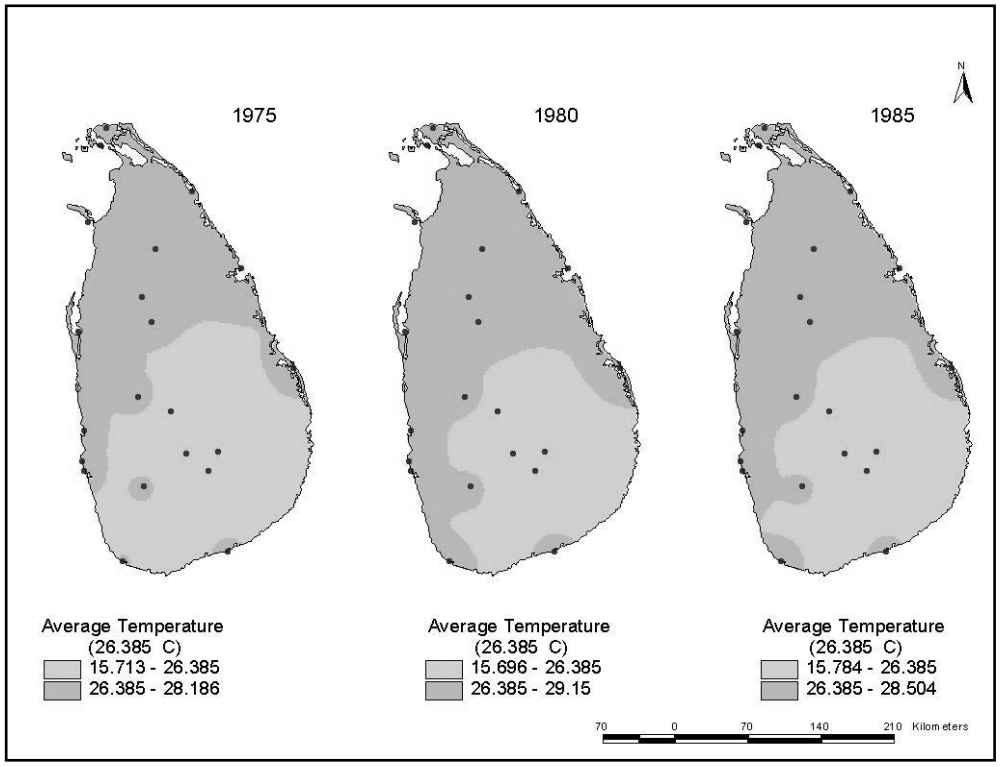


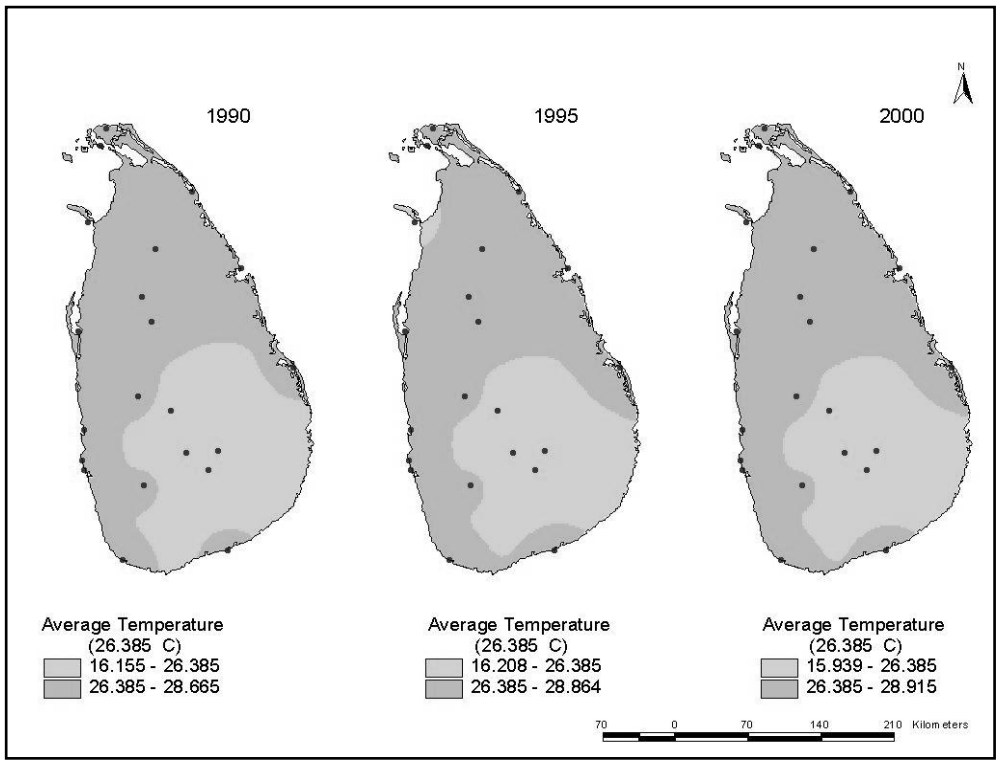
5. 2. Spatial pattern of air temperature

In general, relatively high temperature areas can be expected in the Dry zone and decreasing trend can be seen towards to the Wet zone of the country. However, this section attempts to examine the spatial changes of air temperature in Sri Lanka. For this analysis, Nine (09) years have been selected from the study period with 5 year regular intervals from 1961 to 2001. The selected years are: 1961, 1965, 1970, 1975, 1980, 1985, 1990, 1995 and 2000. Therefore, nine interpolated grid surfaces were generated as shown in Figure 4, 5 and 6. In each map, two prominent regions can be seen. The darker parts in the shows the area which has higher temperature than average (26.38^0C) and the lighter area depict the area which has lower temperature than average. Figure 4, 5 and 6 show very clear spatial dichotomous with the darker area or high temperature have expanded wiliest low temperature areas have shrunken.

Figure 4, 5 and 6: Spatial pattern of air temperature in Sri Lanka from 1961 to 2000







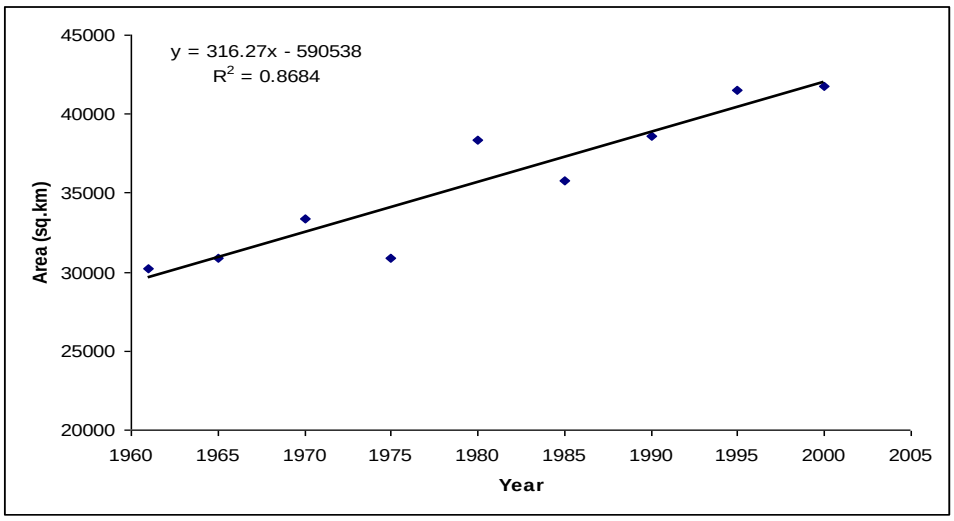
In order to examine this increasing trend of spatial pattern of high temperature extracted area statistics are given in Table 2.

Table 2: Area falling within the high temperature from 1961 - 2000

Year	Area Km2
1961	30236.4396
1965	30861.6913
1970	33347.9866
1975	30880.0811
1980	38379.4243
1985	35768.0787
1990	38629.5250
1995	41494.6492
2000	41774.1735

Area statistics show that the area with high temperature has expanded by 11,537.73 sq.km during the study period.

Figure 7: Increasing trend of high temperature area



The most important feature is observation points in the scatter plot are not showing high deviations. (Deviations between observations and regression line). This can be interpreted as a very significant linear increment of the area wise high temperature. In addition to the low residuals, correlation coefficient also indicates a very significant relationship.

5. 3. **Identification of most critical area**

The most critical areas were identified by using the interpolated grid surfaces generated. In general, the most critical area is similar to the Intermediate zone. Actually this critical area is comprised of parts from 15 Administrative Districts including all districts in the Wet zone and 101 DS Divisions (Table 3 and Figure 6).

Figure: 5 Critical Area

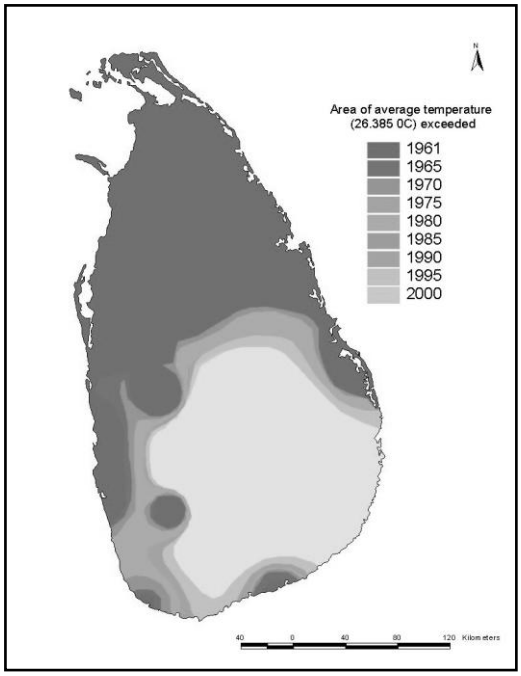
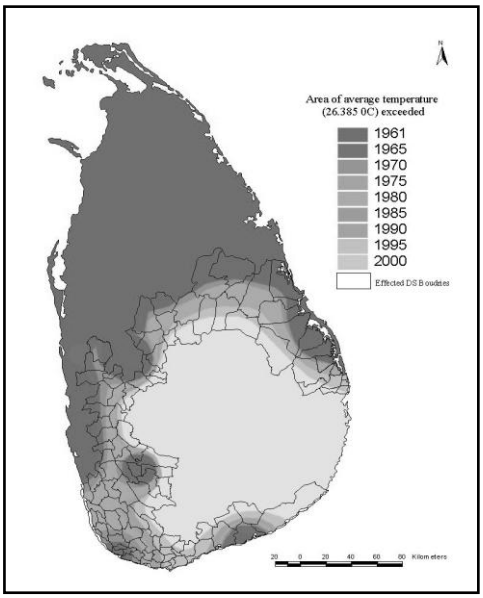


Table 3: Divisional Secretarial divisions belong to the most critical areas

District	No. DS	Name of the DS division
Ampara	9	Eragama, Mahaoya, Uhana, Ampara, Navithanveli, Samanthurai, Karativu, Ninthavur , Addalachchenai
Anuradhapura	1	Palagala
Batticaloa	7	Koralai Pattu North, Koralai Pattu West (Oddamavadi), Koralai Pattu (Valachchenai), Eravur Pattu, Manmunai West, Manmunai South-West, Porativu Pattu
Colombo	2	Hanwella, Padukka
Galle	18	Welivitiya-Divithura,Ambalangoda,Hikkaduwa,Galle Four Gravets, Bope oddala, Akmeemana, Yakkalamulla, Benthota, Balapitiya, Karandeniya, Elpitiya, Niyagama, Thawalama, Neluwa, Nagoda, Baddegama, Hikkaduwa, Imaduwa, Habaraduwa
Gampaha	3	Mirigama, Attanagalla, Dompe
Hambantota	8	Lunugamvehera, Thissamaharama, Hambantota, Ambalantota, Angunakolapelessa, Beliatta, Tangalle
Kalutara	9	Agalawatta, Walallavita, Ingiriya, Bulathsinhala, Madurawala, Beruwala,Dodangoda , Mathugama, Palindanuwara
Kandy	2	Thumpane, Hatharaliyadda
Kegalle	5	Dehiovita, Rambukkana, Galigamuwa, Warakapola, Ruwanwella
Kurunegala	10	Ganewatta, Polpithigama, Ibbagamuwa, Panduwasnuwara, Mawathagama, Rideegama, Kuliyapitiya West, Pannala, Narammala, Alawwa
Matale	4	Galewela, Dambulla, Naula, Pallepola
Matara	14	Welipitiya, Pitabeddara, Mulatiyana, Athuraliya, Akuressa, Akuressa, Malimbada, Kamburupitiya, Hakmana, Kirinda Puhulwella, Thihagoda, Weligama, Matara Four Gravets,Devinuwara, Dickwella
Polonnaruwa	7	Medirigiriya, Hingurakgoda, Lankapura, Welikanda, Dimbulagala, Thamankaduwa, Elahera
Ratnapura	10	Elapatha, Kahawatta, Eheliyagoda, Kuruvita, Kiriella, Ratnapura, Pelmadulla, Ayagama, Kalawana

Figure: 6: Critical Area by DS Divisions



6. CONCLUSION

According to this study, there is a very significant spatial and aspatial changes of air temperature have taken place in Sri Lanka within last 40 years. Hundred and one Divisional Secretarial divisions are highly influenced, which come under 15 Administrative Districts. All these districts are in the Wet zone of the country.

Since this study was carried out by using secondary data available in different government organizations, this model should be verified by using the ground observed data.

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