

ICH 2019**International Conference on Humanities****CONVECTIONAL INFLUENCES ON THE WEATHER PATTERN
OF NORTHERN SRI LANKA**

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Abstract

There are three precipitation processes, such as monsoon circulation, frontal process, and the convectional process that influence the rainfall of the Northern region of Sri Lanka. Several natural and anthropogenic factors influence the weather pattern of the study area. Even though, recently, convectional influences on the weather pattern are vital. This paper examines the importance of the convectional process in the weather pattern of the Northern Region of Sri Lanka. The main objective of this paper is, to identify the influence of the convectional process in the weather pattern of Northern Sri Lanka. This study uses meteorological data such as rainfall, temperature, relative humidity, and atmospheric pressure. The data were analysed employing the descriptive statistical method using average, standard deviation, and trend analysis via Microsoft Excel worksheet, and results were mapped using Arc Map 11.2 version. Results show that there are significant influences of the convection process in the weather pattern of the study area. Convection contributes more than 38% of the total rainfall, and this is the leading cause of rainfall during the first inter-monsoon season (FIMS) and the southwest monsoon season (SWMS). The Convectional process is also the primary cause for the variations in the temperature range between day and night during March, April, May, June, July, and August. Convection creates an unstable evaporation rate, which leads to the high rates of relative humidity in the nights during the FIMS. Convectional processes contributing to the unstable atmospheric pressure and resulted in unexpected weather disturbance in the study area.

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1. Introduction

Many factors determine the weather pattern of a place. Natural or human-made activities shape the weather of a particular place. Increasingly, climate change is also changing the factors that influence the weather of a place (Chan et al., 2019). According to Thampaiyapillai (1958), several factors are contributing to the climate of Northern province of Sri Lanka, such as peninsular location, Indian Ocean, the colossal landmass of the Indian subcontinent, elevation, monsoon variations, and the ITCZ. However, the seasonal pattern of weather mainly depends on the natural weather process such as monsoon circulation, the frontal influence of cyclonic process, movement of ITCZ, expansion of jet stream, and the convective process. The convective process is the main factor that contributes to the modification of the weather in some seasons, such as the first inter monsoon season (FIMS) and the second inter monsoon season (SIMS). Convection is the process of lifting air with much density of humidity in the form of gas or liquid. Cold air has a high density than the warm air, and the convective current is produced by the temperature slope. Occurrences of rainfall due to the convective process always depend on the main two factors. Thus are;

1. Substantial heating of earth surface and the lifting of moist air to the lower part of the troposphere of the atmosphere
2. A massive supply of moisture at the high percentage of relative humidity (More than 75%).

The main source for the producing convective current and its movement is the constant solar radiation. Due to this process, convective current is always associated with lightning, thunder, local turbulence wind and the convective rainfall (Lal, 2005).

The Transfer of the heat with moist air is the primary process in the convection, whereby further temperature gradient and moisture variations between the convective induced clouds are the main factors for the thunderstorm associated rainfall in the study area. The convective process is creating many impacts on the weather pattern of Northern Sri Lanka. In this context, this research examines the role of the influence of the convective process in the weather pattern of Northern Sri Lanka.

2. Problem Statement

- Several factors are influencing the weather pattern of Northern Sri Lanka. However, some factors play a crucial role in shaping up the weather pattern of the study area. Many studies have identified monsoon circulation, the frontal influence of cyclonic process, movement of ITCZ, and expansion of jet stream as significant factors affecting the weather pattern (Piratheeparajah, 2015; Rajendram, 2004)
- However, the influence of the convective process is seldom highlighted as a significant influencing factor. This study attempts to prove that the convective process plays a vital influence in the weather pattern of the Northern part of Sri Lanka

3. Research Questions

1. What are the factors contributing to the weather pattern of the Northern Province, Sri Lanka?

2. How is the convectional process contributing to the annual, seasonal, and monthly rainfall pattern in the Northern part of Sri Lanka?
3. How is the convectional process influencing the monthly temperature, maximum-minimum temperature, and spatial variations of temperature?
4. What changes can be identified in the evaporation rate and relative humidity due to convection in the study area?

4. Purpose of the Study

The principal objective of this paper is to study the influence of convectional processing in the weather pattern of Northern Sri Lanka.

5. Research Methods

Various data ranging from primary to secondary were utilized in this study. Data have been used in this study. Primary data was collected using field observation method.

5.1. Data

Various types of secondary data were also collected and used in this study. However, this study mainly depends on meteorological data.

5.1.1. Meteorological Data

Daily, Monthly and annual rainfall, maximum temperature, variation of temperature, minimum temperature, number of rainy days, evaporation rate, wind velocity and wind direction, relative humidity data for thirty-five years for twenty stations such Thirunelvely, Nainathivu, Pointpedro, Mirusuvil, Paranthan, Iranaimadu, Akkarayankulam, Mankulam, vavunikkulam, Ambalpperumalkulam, Pallavarayankaddu, Thannimurippu, Nedunkerny, Muththaiyankaddu, Puliyanakulam, Vavuniya, Pavatkulam, Murunkan, Karukkaithivu and Mannar were collected from Department of Meteorology, Colombo. Due to the limitation of the required data and information, weekly, monthly, and annual temperature data collected were only of ten years' duration for five stations such as Thirunelvely, Vavuniya, Mannar, Iranaimadu, and Vavunikkulam.

5.1.2. Primary data

Primary data of the current research was collected using field observation method. Field observation was helped to observe the thunder and lightning effect, especially to take some photos of death caused by it and to observe the surrounding environment.

5.1.3. Secondary Data

Data related to thunder and lightning were obtained from the report of the Meteorology Department and reports of the District secretariats of each of the five districts. In addition to the Meteorology

Department, reports from local and national newspapers such ‘UTHAYAN,’ ‘VALAMPURI,’ ‘THINAKKURAL,’ ‘THINAKARAN,’ ‘VEERAKESARI,’ ‘DAILY NEWS,’ ‘SUNDAY TIMES’ and ‘SUNDAY OBSERVER’ on rainfall and occurrences of thunder lightning were also used. Reports and publications of the Northern provincial council (Formerly North East Provincial council) and District secretariats of Northern province were also collected and used.

5.2. Method of data analysis

Descriptive statistical analysis has been used in this study to obtain the results. Meteorological data were studied using Mann-Kendall linear analysis for trend, average analysis with the help of Microsoft Excel worksheet. The method of Mann-Kendall trend analysis played a very vital role in the data analysis in this study. Mann-Kendall trend analysis is essential method in statistics that is using widely in climatic study, especially to investigate the temperature, evaporation, wind velocity, and rainfall -related data (Othman et al., 2016). ‘This test contrasts the relative magnitudes of data rather than data values themselves’ (Gilbert, 1987). The significant benefit of this method of testing is the data is not necessary to conform for any specific distribution. In this analysis, every data value in time series is related to all consecutive values. Initially, Mann-Kendall analysis ‘S’ is assumed to be ‘0’, and if a data value in consequent cycle is more significant than a data value in the previous duration, ‘S’ is incremented by ‘01’, and vice-versa. The net result of all that increments and decrements gives the final value of S.

For this study, the Mann-Kendall statistics (S) is given as:

$$S = \sum_{i=1}^{n-1} \sum_{j=i+1}^n \text{Sign}(x_j - x_k)$$

where,

$$\text{Sign}(x_j - x_k) = 1,$$

$$\text{if}(x_j - x_k) = 1,$$

$$\text{if}(x_j - x_k) > 0; \text{if}(x_j - x_k) = 0 \text{ -I } \text{if}(x_j - x_k) < 0.$$

A positive value of S demonstrates a rising trend and a negative value demonstrates a specific declining trend. Nonetheless, this is crucial to perform the statistical analysis for the connotation of the trend. The test procedure using the standard approximation test is described by Kendall (1975). This test accepts that there are no many fixed values within the dataset. The variance (S) is calculated by the following equation

$$\text{Var}(S) = \frac{1}{18} n(n-1)(2n+5) = \sum_{p=1}^g t_p(t_p-1)(2t_p+5)$$

where n is the number of data points g is the number of fixed band and t_p is the number of data points p^{th} in the groups.

$$Z = \begin{cases} \frac{S - 1}{\sqrt{\text{Var}(S)}}; & \text{if } S > 0 \\ 0; & \text{if } S = 0 \\ \frac{S + 1}{\sqrt{\text{Var}(S)}}; & \text{if } S < 0 \end{cases}$$

The trend is explained to be declining if Z is negative, the calculated ‘Z’-statistics is more fabulous than the z-value corresponding to the 5% level of connotation. The tendency is said to be increased if the ‘Z’ is positive, and the calculated Z - statistics is more fabulous than the z-value analogous to the 5% level of connotation. If the calculated Z-statistics is fewer than the z-value analogous to the 5% level of significance, there is no trend (Kumar et al., 2017) Analyzed results were mapped using Arc GIS 11.2 version to investigate the spatial variations of convectonal humidity, evaporation, temperature and rainfall in the Northern Sri Lanka.

6. Findings

The results of the study identified some crucial facts regarding the convectonal influences on weather in the Northern region of Sri Lanka.

6.1. Convectonal influence on Rainfall

The rainfall pattern of Northern Sri Lanka slightly varies from other parts of the country due to its geographical location. The Bay of Bengal plays a crucial role in determining the rainfall pattern of Northern Province of Sri Lanka. The total annual rainfall of the Northern province is 1240 mm (Piratheeparajah, 2015). However, it varies from season to season and place to place. According to the thirty years’ history of the area, 60% of the rainfall is recorded during the northeast monsoon season, especially in November and December, with Mullaitivu district receiving more than 100 mm of rainfall than other districts.

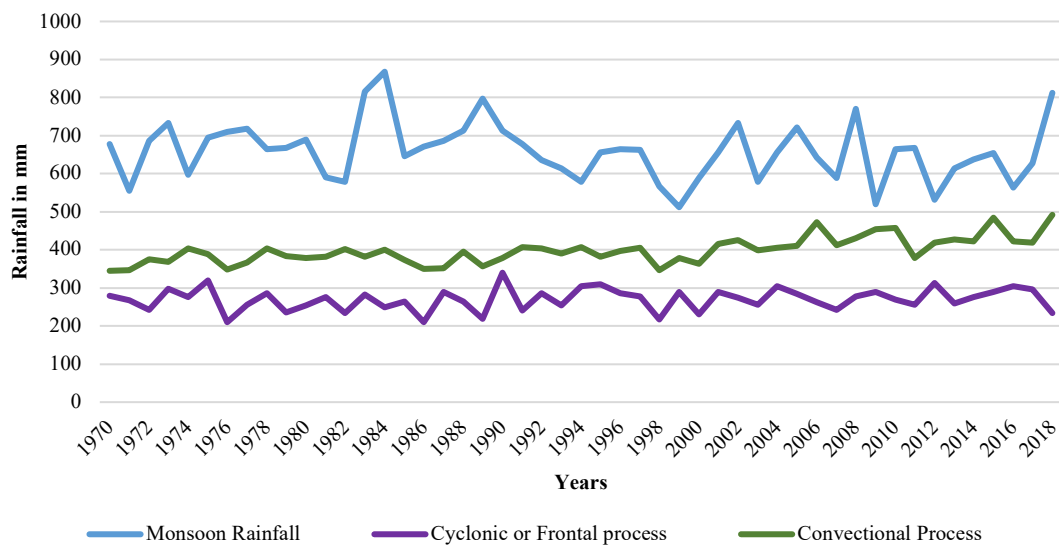


Figure 01. Contribution of Convectional Rainfall in the Annual Average Rainfall of Northern Sri Lanka

The Northern province of Sri Lanka generally receives its total rainfall from various processes such as monsoon process, cyclonic or frontal process (North-East Monsoon rainfall), convective process, and the expansion of Inter-Tropical Convergence Zone (ITCZ). The Monsoon process is the leading contributor to the rainfall of the Northern province of Sri Lanka, and it is the response for 65% of the total rainfall. However, the convective process is playing a critical role in determining the amount of rainfall and the rainy days' amount during the summer months in the study area, especially during the recent past two decades. The convective process is producing unstable and unpredictable weather conditions giving rise to unexpected rainfall.

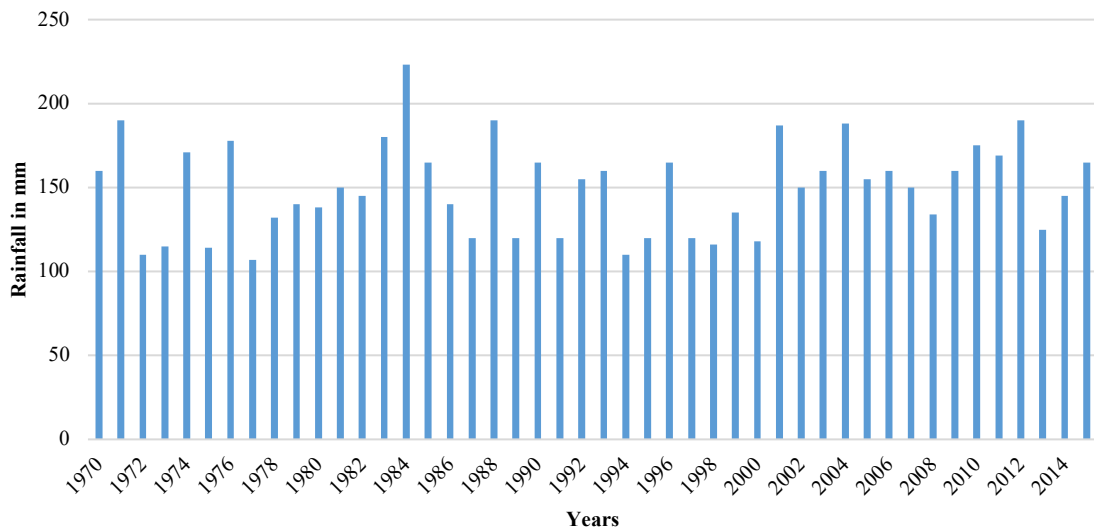


Figure 02. Trends of Convective Rainfall During the Second Inter Monsoon Season in Northern Sri Lanka (1970-2015)

In the Northern province of Sri Lanka, the convective process generally occurs in the evening and early morning during March, April, May, August, and September. During this period, the position of the sun is almost overhead in the study area (At the latitudes near to Sri Lanka). As a result, convective currents have been created during noon and massive uplift of water vapour in to the lower part of the troposphere and cooling by the atmosphere and rainfall occur between 3.30 P.M. and 6.45 P.M. and 4.30 A.M. and 8.00 A.M. This convective process contributes rainfall to the study area during the peak water scarcity season and helps to recharge the surface and groundwater.

Consequently, this rainfall is vital to the northern province. The average rainfall of the convective process is more than 330 mm (it is equal to 38% of total rainfall) in the Northern Province. Compared with the past climatic period 1940-1970, this decade has seen an increasing influence on the pattern of convective rainfall by 40%, with some spatial variations in this percentage also identified. Figure 01, illustrates the steadily increasing pattern of convective rainfall throughout the years at the same time rainfall due to other causes show the fluctuations. From 1970 to 1980 average convective rainfall for a year was 300 mm, but the value has been increased to 330 mm during 1980-1990. This is further increased to 380 mm during the 1990 to 2015 period. However, it varies from year to year, with are some fluctuations being identified.

Compare to other years, some of the years, such as 1976, 1984, 1985, 1989, and 1999 received 40% more rainfall than average convectional rainfall, and 1977, 1988, and 1998 received 40% lower rainfall than the average in the Northern Province (figure 02). However, figure 02 shows that the years of 1971, 1984, 1988, and 2001 has a rainfall of more than 175mm during the SIMS. Generally, 90% of the total rainfall is received during the evenings between 5.30 pm to 8.30 p.m. and early mornings between 4.30 am to 7.00 am.

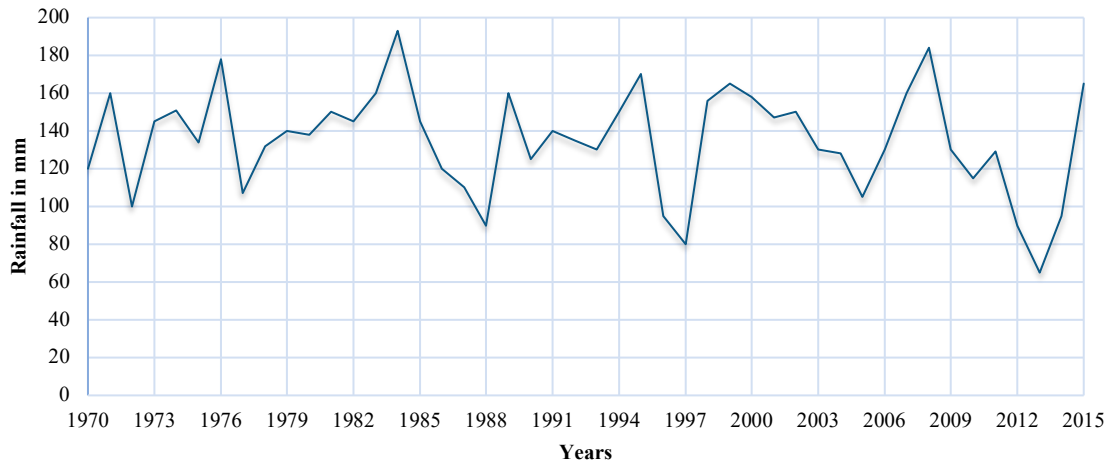


Figure 03. Trends of Convectional Rainfall During the First Inter monsoon season of Northern Sri Lanka

During the FIMS, the study area receiving a certain amount of rainfall due to the convectional process, especially during the April study area receiving more than 75mm average. Figure 03 illustrates the various amount of rainfall experienced in the study area during the FIMS.

Spatially study area receiving the various amount of rainfall. Compare to other convectional months, May receiving a low amount of rainfall. At the same time, all places of the study area receiving the highest amount of rainfall during the October figure 04 explained the trend of the convectional rainfall in October. Compare to the 1970s, convectional rainfall gradually increasing during October. Figure 05, figure 06, figure 07, and figure 08 illustrate the spatial variations of the convectional rainfall during the convectional months.

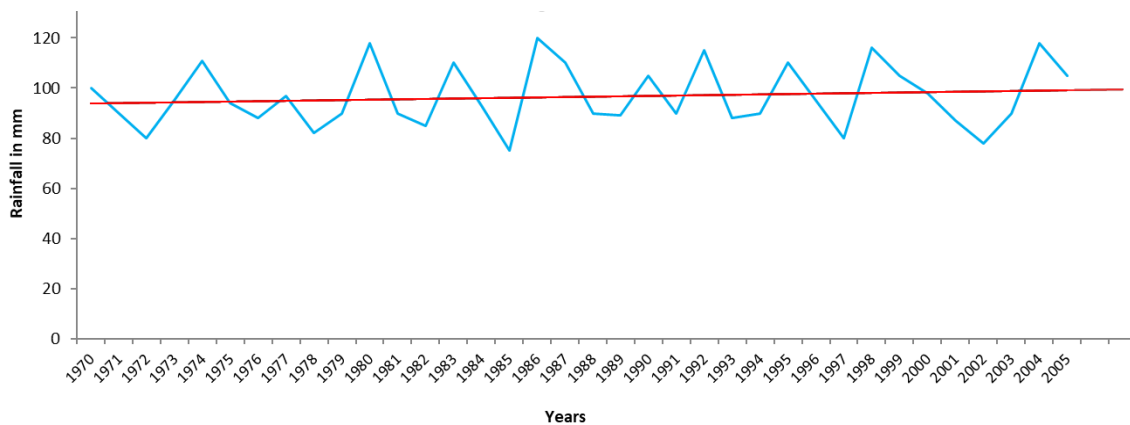


Figure 04. Trends of the Convectional Rainfall During October in Northern Sri Lanka

The month of October generally receives more than 45% of the total convective rainfall, compared to all other months (Figure 05 & 08). March is receiving more than 25% of its (Figure 05). However, total rainfall due to the convective process for October is increasing throughout the year. vitally important because it occurs during the dry period in which people use much of their money and time to get water.

However, an uncertainty situation also prevails during the convective rainfall. Many fluctuations have been identified in this rainfall type. Compared with other periods, the latter part of March and the middle part of April in the First Inter Monsoon Season (Figure 04) is receiving higher amounts of rainfall, which is 50mm more than other months of June, July, August, September, and October. Convective rainfall in the first and second Inter Monsoon Season is significant in the Province because this is the only source of water to mitigate the dry period or drought conditions as well as water scarcity problems. So, this uncertainty will impact in the above-said matters. More than 91% of the people think that this rainfall is

Convective rainfall is the significant rainfall in the province because it is occurring during the two dry seasons of the first inter monsoon season and the later part of the southwest monsoon seasons. These two seasons are identified as drought seasons, with most of the areas of the province facing severe drought vulnerability. Some of the regions, especially Manthai West, Madhu, Poonkari, Island south, Island North, Karainagar, and Delft divisional secretariat divisions, are faced with extreme difficulties in getting drinking water. So, the occurrence of rainfall in these seasons is considered as a “savior” to the people. This convective rainfall is the primary source for the recharge to the groundwater in the Jaffna district as well as the mainland of the Northern Province.

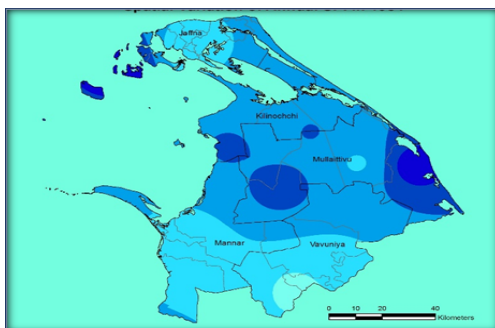


Figure 05. Spatial Variations of Average rainfall in March

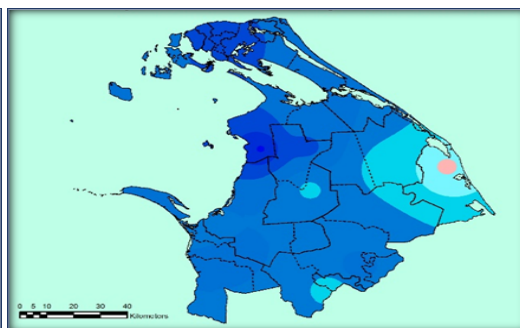


Figure 06. Spatial Variations of Average rainfall in April

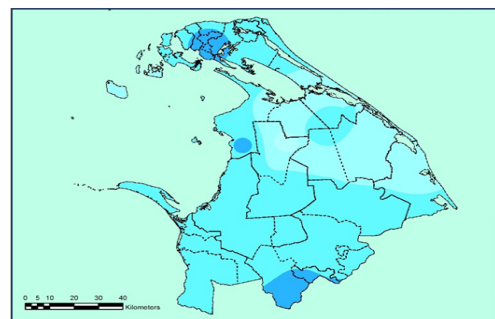


Figure 07. Spatial Variations of Average rainfall in May

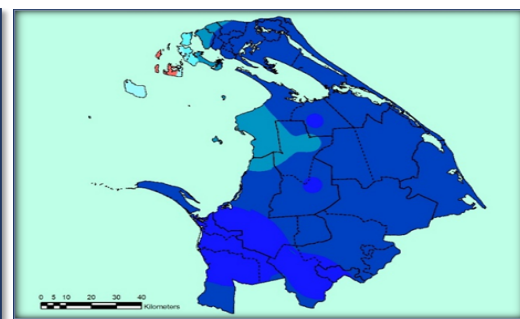


Figure 08. Spatial Variations of Average rainfall in October

6.2. High temperature during the Convictional Period

Analysis results show that the average monthly temperature in the Northern Sri Lanka for the convectional months is higher than during the other months. Also, the hottest month of the study area falls under the convectional period. July identified as the hottest month of the year in the Northern region, but the convectional process is the main reason for the highest temperature in July. However, spatially, all places of the Northern province have the highest monthly rainfall during the convectional periods. Spatially there some variations in the temperature between the places and the However, coastal areas have low temperatures compared to other places due to the changes in the evaporation rate in the coastal parts of the study area.

Generally, we can see the variations in the temperature range between the day and night temperatures in the Northern province of Sri Lanka, which creates severe weather variations between day and night. The relative humidity changes rapidly between day and night and it is indicated in Figure 09. Due to the day-night air temperature variations in the study area impacts the comfort weather system. These temperature variations create wind speed variations in the coastal parts, which disrupt the standard land-sea breeze directions and velocity. Furthermore, these conditions affect fishing activities as well as agricultural activities.

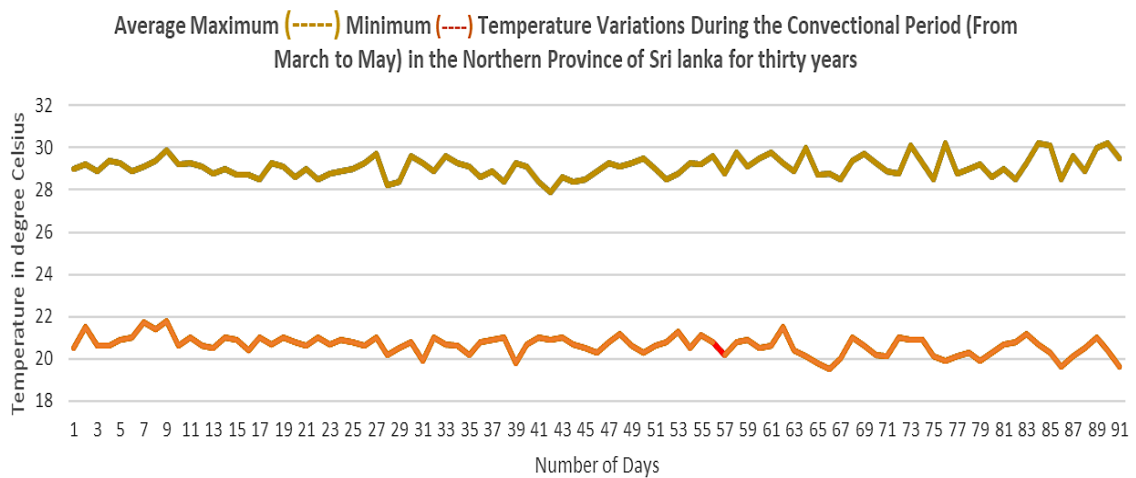


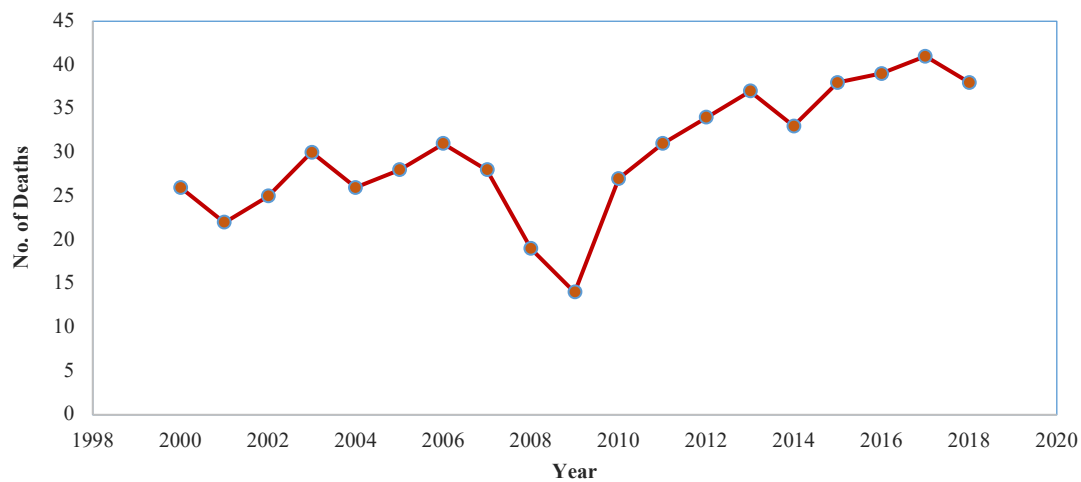
Figure 09. Average Maximum and Minimum Temperature Variations during the Convictional Months of Northern Sri Lanka

6.3. Unstable Relative humidity

Convection creates unstable relative humidity in the Northern province of Sri Lanka during the convection months. Mostly relative humidity is higher than the average. The relative humidity of the research area is averagely 72%, but the values are generally much higher than this during many days of the convection months. The average humidity in the convectional months is 80.15%, but it varies from day to day and place to place. There are vast variations between the day and night time relative humidity. About 83% of the people of the study area expressed that a high percentage of the relative humidity in the night time is the primary reason for the uncomfortable weather situation in the night time in the study area. A vast mass of water evaporation and water vapor are the primary causes of this high rate of relative humidity.

6.4. Severe thunder and lightning events

Data from this study shows that the convective process in the research area is inducing an increasing rate of thunder and lightning events in the study area. Figure 10 indicates the trend of death caused by the thunder lightning event due to the warmed moist air uplifting process. The high numbers of thunder and lightning events recorded during the convective months are due to the tremendous amount of evaporation and the rapid movements of the clouds in the study area. About 90% of the thunder and lightning events are associated with the rainfall, and 73% of the thunder events recorded after 2.00 p.m. The number of lives lost due to thunder and lightning events is recorded in the study area, and the death reported due to such events is increasing in recent years. Lightning occasionally strikes and kills people in Sri Lanka (Amali, 2019). More than 76% of the people expressed their view that at least eight deaths will occur during this convection period, especially during the first inter monsoon season.



Note: *Data not recorded for two district due to severe internal war in 2008 and 2009. Source: Department of Meteorology, 2019

Figure 10. Number of Deaths caused by a thunderstorm in the Northern Province of Sri Lanka

7. Conclusion

This study shows that the convective process has much influence on the weather pattern of the Northern part of Sri Lanka, especially rainfall, and this is contributing to the livelihood and survival of people of the Northern part of Sri Lanka. The percentage of this convective rainfall in annual total rainfall has increased in the area. There is an increasing pattern that has been identified, and not only that, the convective rainfall for October also increasing, and the analysis reveals that increasing. Convective rainfall is the crucial factor which is contributing to recharge the surface and groundwater resources of the study area, two principal sources of water for human society. Compared with the monsoon rainfall and the frontal rainfall, the role played by the convective rainfall in modifying the weather has an enormous contribution to the sustainable development of the study area. Most importantly, the results showed that the convection process generates a significant amount of rainfall during the extended water scarcity months. Convection is shown to contribute more than 30% of the total rainfall in the Northern Province of Sri Lanka.

There are some fluctuations in the temperature and relative humidity for the convectional months; however, there some variations have been identified in the durational range of temperature and humidity. The number of deaths due to thunder and lightning event is increasing in the study area. However, convection can also contribute to the occurrence of severe thunder and lightning, and this causes a certain number of deaths. However, if we adopt the protection and safety methods during the current period, we can reduce the deaths due to severe thunder and lightning events. At the same time, convection is the main reason for the high temperatures in the study area during March, April, May, September, and October. Convection is also shown to contribute to the high evaporation and humidity rates.

Hence, data for the years of 2008 and 2009 are collected only three districts out of five districts due to severe internal war held in the study area. Future climatological research in Sri Lanka should focus on the influence on convection as an important influencing factor on its climate. In conclusion, the Convectional process taking the leading role in determining the weather pattern of the study area. However, it is clear that the convectional process not only affects the weather pattern but also contributes to sustaining the human habitation in the northern province of Sri Lanka.

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