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Spatial and Temporal Variations of Rainfall in the Northern Province of Sri Lanka

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Abstract

Survival of every species in a place is controlled by weather factors. Rainfall is the important weather parameter that influences all sectors of the economy of the study area viz the Northern Province of Sri Lanka. Rainfall pattern of the study area varies from other regions of Sri Lanka. In this respect this study focuses on the trend and distribution of the rainfall in the study area. The main objective of this paper is to discuss the spatial and temporal pattern of the rainfall in the northern province of Sri Lanka. Primary data were collected using direct observation, which helped to identify the spatial variations of the rainfall of the study area. Secondary data were collected mainly from two sources i.e Department of Meteorology and the Statistical Handbook of the Northern Provincial Council. Data related to rainfall from department of meteorology were collected for forty-four years from 1972 for the analysis. Data have been analyzed using excel worksheet and they were mapped using the ARC GIS software 9.1 version to identify the temporal and spatial pattern of the rainfall in the study area. Annual average rainfall of the study area varies from year to year. Seasonally Second Inter Monsoon Season and the North East Monsoon Season receive 85% of rainfall and South West Monsoon Season receives 17% of rainfall. The Months, November, December and January receive 90% of the total rainfall. Spatially eastern part of the study area receives the highest amount of rainfall and the western area receives the lowest amount of rainfall. Number of rainy days decrease year by year and the depression in the Bay of Bengal is the main reason for the 92% of the total rainfall of the study area.

Key Words: Rainfall, Northern Region of Sri Lanka, Spatial Pattern, Temporal Variations and Seasons

1. Introduction

Sri Lanka, located in the Indian Ocean, is one of the tropical countries. Due to its location, the climate of the country is much related to the tropical climatic pattern. Sri Lanka's climatic conditions are closer to the tropical climate features. The climate of Sri Lanka is slightly different from the tropical climatic pattern, because of its geographical location and the topographic features of the entire country. The Northern Region of Sri Lanka comes within the dry zone of the country; though some parts of the Northern Region such as Manthai West, Musali and Mannar areas have semi arid climatic features .In any case, the Northern region predominantly has climatic features pertaining to the dry zone.

2. Study Area

The study area for this research is the Northern Region of Sri Lanka. It is located in the northern most part of Sri Lanka. The northern boundary of the Northern Region is the Palk Strait, while in the east it is bounded by the Bay of Bengal. The Southern and Western boundaries are the North Central province and the Arabic sea respectively.

Administratively the Northern region has been divided into 05 Administrative Districts, 34 Divisional Secretariats Divisions, and 921 Grama Niladhari Divisions. For the purpose of Local Governance the region has been divided into One Municipal Council, 5 Urban Councils and 29 Pradeshiya Sabhas. Total area of the Northern Province is 8,848.58 sq. km

Table 1. Area of the Northern Region

District	Total Area		Land Area		Inland Water	
	Sq.Km	Percent	Sq.Km	Percent	Sq.Km	Percent
Northern	**8847.98**	***100.00***	**8596.61**	***100.00***	***251.30***	***100.00***
Mullaitivu	2616.90	29.58	2516.90	29.28	100.00	39.79
Vavuniya	1966.90	22.23	1966.90	22.88	0.00	0.00
Mannar	2002.07	22.63	1991.00	23.16	11.00	4.38
Kilinochchi	1237.11	13.98	1192.81	13.88	44.30	17.63
Jaffna	1025.00	11.58	929.00	10.81	96.00	38.20

Source: Planning Branch, NPC, 2014

There are many types of soils identified in the study area. The table 1.2 indicates the types of soils found in the Northern province of Sri Lanka.

Table 2. Types and extent of soils in the Northern Region

Nature of Soil	Total Extend in He.
Sandy Regasoals	54044.4
Alluvial	81776.2
Grumosol	11075.3
Alkaline	187331
Redish Brown	68537.6
Latosol	28680.2
Calcic Red Yellow Lattesol	78818.4
Red Yellow Lattesol	4092.9
Coral Limestone	5432
Rock Knob Plain	1500
Earths and low humid clay soils	111362
Solidized Solozatz & Solonchak	32322
Eroded land	30779
Erosional Remnants	1966
Others	3471

Source: Planning Branch, NPC, 2012

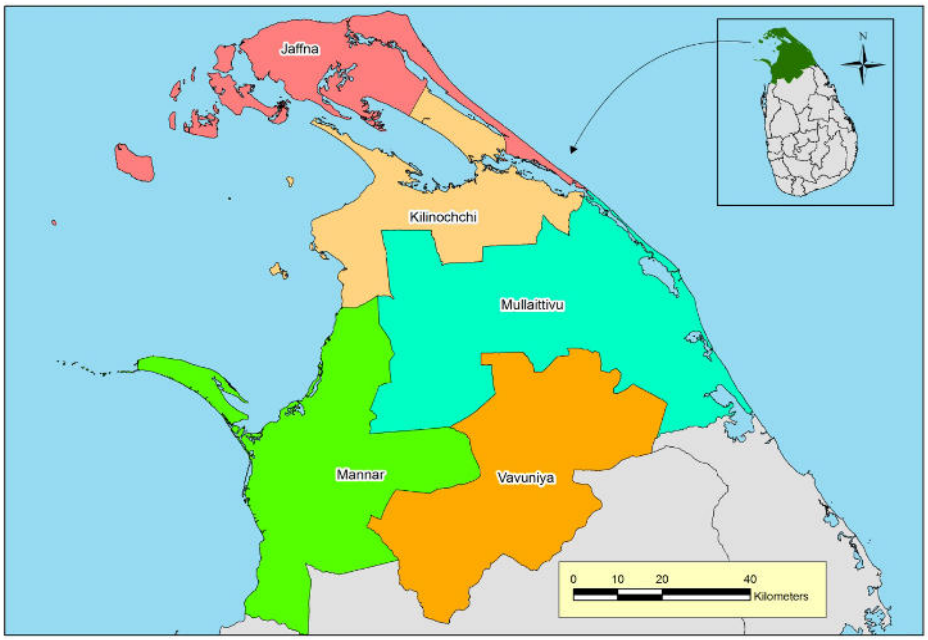


Figure 1. Map of the Northern Region

The main stay of economy is predominantly Agriculture and Fisheries. As per the last complete census of 2011 the population of the Northern Province was 1109404 and about 36% of internal and external migration has taken place thereafter and the demographic pattern has changed. The total population of Northern Province is 1058762 for the year 2012 (National Statistical Department-2012)

Table 3. Population details of Northern Region of Sri Lanka

Districts	Total	Male	Female
Jaffna	583,378	275,533	307,845
Mannar	99,051	49,967	49,084
Vavuniya	171,511	84,780	86,731
Mullaitivu	91,947	46,180	45,767
Kilinochchi	112,875	55,658	57,217

Source: National Statistical Department, Colombo, Sri Lanka, 2012

3. Objectives

The main objective of this study is to identify the spatial and temporal patterns of rainfall in the Northern region of Sri Lanka.

4. Data and Methods of Data Analysis

According to the objective of this study various types of data ranging from primary to secondary have been used immensely in this research. Even though secondary data were helped in this study in much extent. Primary data were collected using direct observation method. Secondary data also helped to this study.

Rainfall data were obtained from the Meteorological Department. Annual Average rainfall data, Monthly rainfall data, Seasonal Rainfall data, Rainy days data have been collected for following stations from 1972 to 2014. Missing data were collected from very nearest station. If any nearest station located after 05 km, average data considered analyzing the data.

Basic secondary data related to rainfall of the Northern Province of Sri Lanka required for the study were collected from the Meteorological Department of Sri Lanka in Colombo. During the years of 2008 and 2009, there are no data for some stations of Mullaitivu, Kilinochchi and Vavuniya, due to the severe war.

Rainfall data collected for the following stations for forty-two years. Akkarayankulam, Iranaimadu, Nagapaduvan (Kariyalai), Pavatkulam, Eratperiyakulam, Vavuniya (Agriculture Department), Vavuniya, Chavakachcheri, Jaffna, Kondavil, Kudaththanai, Mirusuvil, Nainathivu, Punguduthivu, Thirunelveli, Thondaimanaru, Thandikkulam, Kanukkerny, Mullaithivu, Madu, Nedunkerny, Mannar, Murungan, Karukkaikulam, Ampalapperumalkulam, Oddusuddan, Muththaiyankaddu, Point Pedro, vavunikkulam, Poonkari and Paranthan. Statistical Handbook of the Northern Provincial Council (North and East Provincial Council till 2008) also used as one of the secondary data source to this study.

Descriptive analysis method has been used to analyze data and interpret the results in to this study. Standard Deviation has been used to identify the annual deviations of the rainfall in every station of the study area. The collected data process and analyzed in the excel work sheet and geo spatial maps prepared by using Arc GIS software (9.2 version).

5. Results and Discussion

5.1. Spatial and Temporal Patterns of Annual Rainfall

Annual rainfall of the Northern Province is 1244 mm. But it varies from place to place, year to year, and season to season (Table 1.4 Table 1.5 and Figure 1.2 and 1.3). Even though 75 percent of the total rainfall (700 mm) is received during the North East Monsoon Season (NEMS) due to the North East Monsoon Wind various depressions formed in the Bay of Bengal also cause rainfall. This period of this monsoon is from December to February. Also 60% of the rainfall (550 mm) of the Northern Province is recorded between, November 15 to December 30. According to the last 10-year history of Northern Province, 70 % of the total rainfall has been received due to depressions in the Bay of Bengal. Also, the maximum rainfall that amounts to more than 300 mm is recorded within a period of one or two weeks. Heavy rainfall within a short period is the major reason for the flood hazard in the Northern Region. It also has its impact on the ground water level of the Northern Province. Domestic and other users of water depend mainly on the ground water in all districts of the Northern Province. The level of ground water depends on the amount of infiltration due to the rainfall, as the rainfall received within a short period has its impact on the recharge of ground water. (Much of the water runs into the sea as surface run off.)

Table 4. Annual Average Rainfalls in the Districts of the Northern Province (1972-2012)

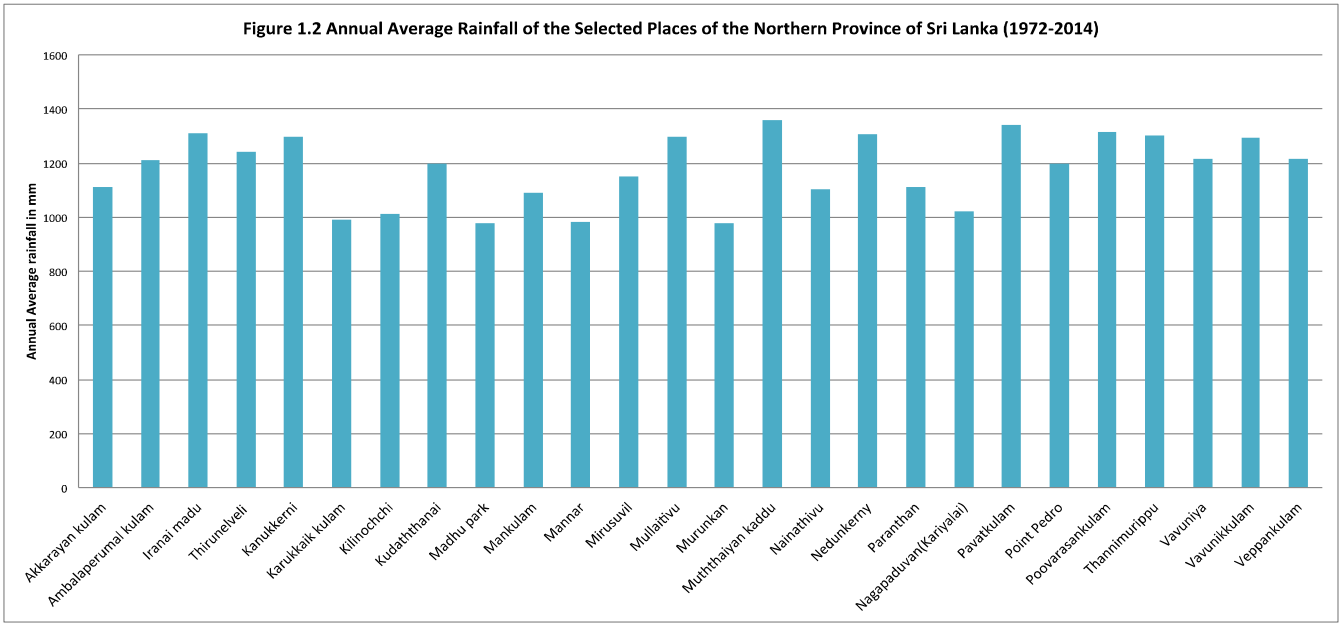
District	Annual Rainfall in mm
Jaffna	1240
Kilinochchi	1210
Mullaitivu	1340
Mannar	1140
Vavuniya	1290

Source: Department of Meteorology, 2014

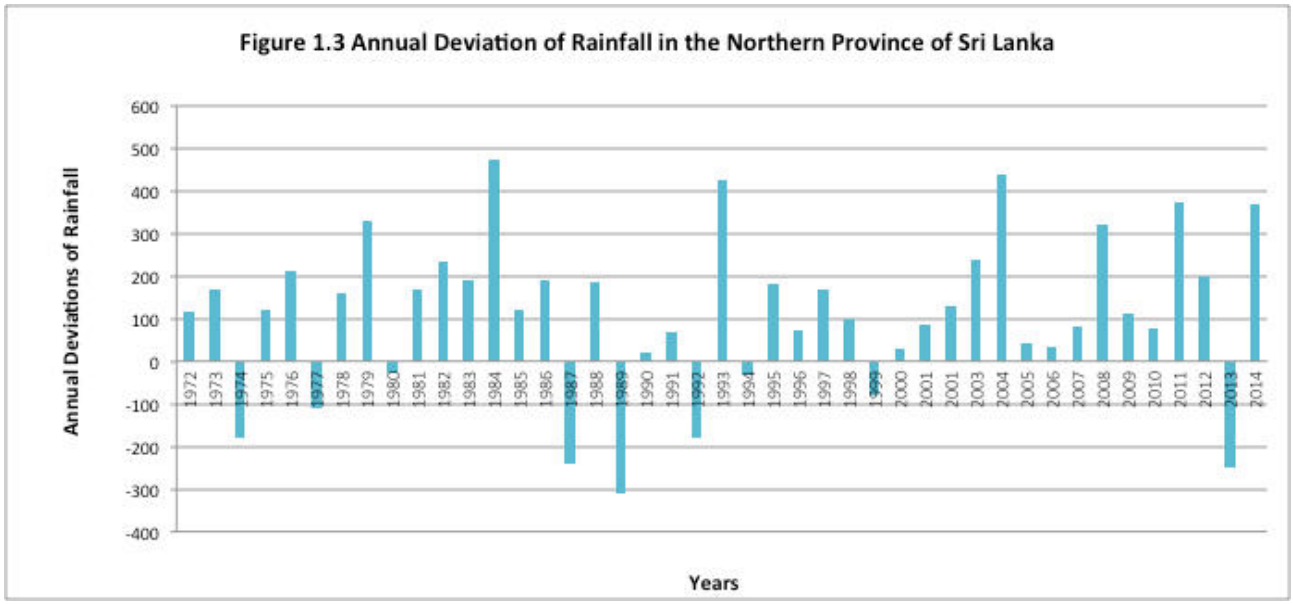
Table 5. Seasonal Average Rainfalls in the Northern Region (1972-2012)

Seasons	Average Rainfall (mm)
First Inter Monsoon	160
South west Monsoon	120
Second Inter Monsoon	280
North East Monsoon	650

Source: Department of Meteorology, 2014



Source: Data Analysis



Source: Data Analysis

Movement of the Inter Tropical Convergence Zone (ITCZ) causes rainfall during the months of March, April and middle part of the May. During certain years, Northern Region receives more than 100 mm rainfall in the month of March and April due to the movement of ITCZ. i.e. 343 mm rainfall recorded during the 2008 March in Thirunelvely station.

Convectional processes cause rainfall during the months of April, May, July and September in this region. The rainfall occurs normally in the afternoon or evening time. Northern Province receives only about 15 % of the total rainfall due to such convectional process.

Frontal process in the Bay of Bengal is another factor that brings in rainfall, to the Northern Province of Sri Lanka. Nearly 10% of the rainfall is recorded from the frontal process.

1.5.2. Spatial Patterns of Rainfall in the Northern Region of Sri Lanka.

There are some spatial variations in the annual and seasonal rainfall in the Northern Region of Sri Lanka (Figure 1.4) Annual rainfall of the Northern Province is generally 1230 mm. But, Kyts, Delft, Manthai West and Madu areas of the region, the average annual rainfall is below 980 mm. Such areas include, Mundampiddi, Iluppaikkadavai, Kalliyadi, Aththimoddai, Vidaththalthivu, Periyamadhu, Balampiddi, Andankulam, Madhu, Iranai iluppaikulam, Periyapandivirichchan, Pandivirichchan, Ulukulam, Adampan, Uyilankulam, Mathoddam, Nanaddan, Vankalai, Erukkalampiddi, Thottaveli, Pesalai, Arippu, Silavatthurai, Kondaichchi, Maruthondikkuda, Marichchukkaddi, Kayts, delft Pallavarayankaddu, Nagapaduvan, Kiranchi, Veravil and Valaippadu. Following areas such as Pavatkualm, Vavuniya, Kanukerni, Thirunelveli, Iraniamadu, Vavunikkulam, Muththayankaddu, Oddsuddan, Nedunkerny and Iretperiyakulam and other areas have recorded their annual rainfall even above 1250 mm.

During the First Inter Monsoon Season (FIMS) all areas of the Northern Province receive a lesser amount of rainfall. However, compared to other areas, the rainfall in the coastal areas of the Mullaitivu district and Jaffna District and some parts of the Vavuniya district is a little higher during the FIMS. The average rainfall here is above 160 mm. On the other hand, the entire Kilinochchi District, and the Western part of the Manner district received below 160 mm of rainfall during this season. During this season, the position of the Sun is directly overhead to the province. Consequently, the above areas experience a high temperature throughout day and night. This high temperature creates the land water heat differences and leads to high rainfall in these areas. The influence of the ITCZ causes rainfall during this season in all areas of the Northern Province.

Average rainfall in the Second Inter Monsoon Season (SIMS) is 280 mm. But, during the SIMS Seasons, the central parts of the province receive more rainfall due to convectional process and the changes in stability of air in the lower atmospheric layer of the province. Due to this, some of the areas such as, Uyilankulam, Panikkankulam, Manniyankulam, Vavunikkulam, receive a more rainfall (More than 280 mm). Cyclonic process in the Bay of Bengal had been one of the major reasons for the heavy amount of rainfall in these areas,

during certain years. This seasonal rainfall is very favorable for the agricultural activities in the study area especially for paddy cultivation.

During the South West Monsoon Season (SWMS) the study area receives a very low amount of rainfall because of the dry air blowing in the Northern Province, and its location opposite to the direction of the South West Monsoon Seasonal wind, though some parts located in the western coastal areas, receive a little higher amount of rainfall compared to other areas. The rainfall here is more than 100 mm. These areas include the western parts of Mannar, Vavuniya, Mullaitivu and Kilinochchi. During the South West Monsoon season most of the central land areas of Northern Province are affected by the very low amount of rainfall, generally below 90 mm. During this season some areas including the secretarial divisions of Manthai West, Vavuniya North, Thunukkai, Musali, Vavuniya, Delft, Island North and Island South tend to have a rather dry weather due to it.

During the North East Monsoon Season, all areas of the Northern Province, receive comparatively more rainfall than in other seasons. Average rainfall of the Northern Province during the NEMS is 650 mm. But Madukkanda, Iratperiyakulam, Mamaduwa, Nelukkulam, Ilamaruthankulam, Arumugaththanputhukkulam, Maruthodai, Nainamdu, Nedunkerni, Thanduvan, Puliyankulam, Kanagarayankulm, Karippaddamurippu, Iranaimadu, Akkarayankulam, Vaddakkachchi, Karaveddi, Puloli, Vavuniya, Thandikkulam, Pavatkulam, Kanukkerni, Thannimurippu and Udaiyarkattu areas receive more rainfall during the NEMS amounting to more than 700 mm. Wet wind blowing from the Bay of Bengal and the depression in the Bay of Bengal are the major causes for such high rainfall during these seasons in the Province. During this season the study area becomes vulnerable to natural disasters like floods in particular.

The average number of rainy days in Northern Province is 59. But here too variations occur from stations to station as follows: Jaffna 54, Mullaitivu 61, Vavuniya 63, Mannar 51, and Kilinochchi 59. Due to the impact of global climatic changes, the number of rainy days has decreased in this province recently (Manawadu, 2009).

Annual average rainfall of the Northern Region is 1250 mm. But it is vary to district-to-district as well as place-to-place. Following tables shown the variations of the annual rainfall in the districts and the selected places of the Northern Region of Sri Lanka (Figure 1.4)

Table 7. Seasonal Average Rainfalls in the Northern Region (1972-2012)

Seasons	Average Rainfall (mm)
First Inter Monsoon	160
South west Monsoon	120
Second Inter Monsoon	280
North East Monsoon	650

Source: Department of Meteorology, 2014

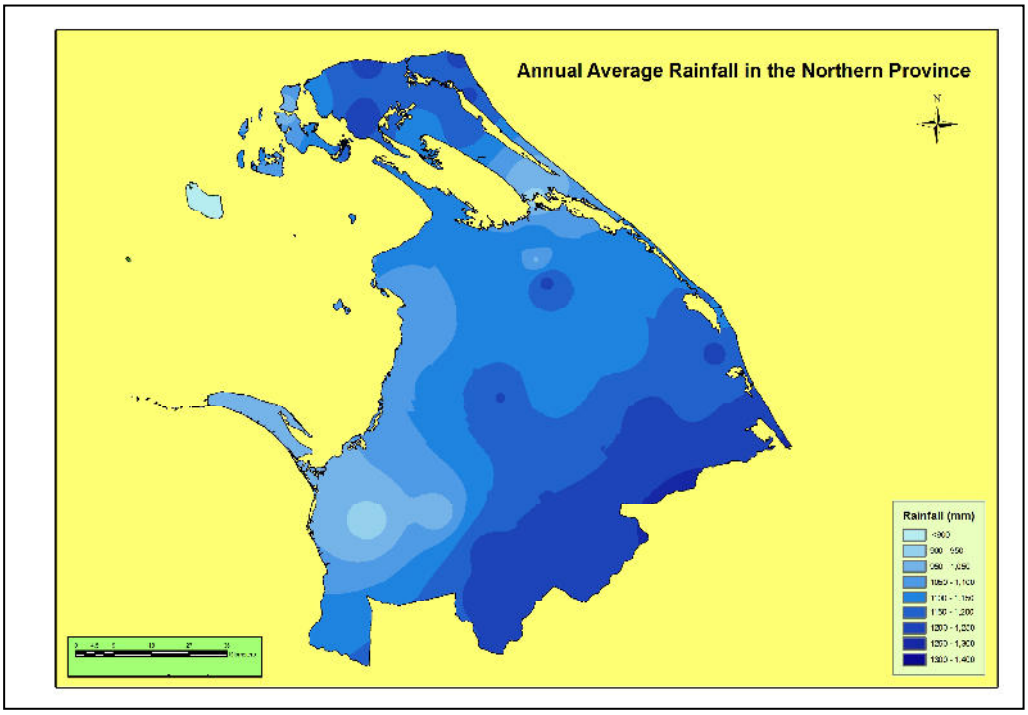


Figure 4. Average Annual Rainfall of the Northern Region of Sri Lanka (1972-2014)

1.5.2. Seasonal Pattern of the Rainfall in the Northern Region of Sri Lanka

Seasonal rainfall varies across the seasons. North East Monsoon wind, Convectional process and the movement of the ITCZ, bring in most of the rainfall to the Province. During the FIMS period, the province recorded an average annual rainfall of 160 mm. Sometimes such recording may take place even within a week during the month of March. Sometimes unexpected rainfall occurs during the FIMS due to the movement of the ITCZ. Local residents call this season a "miniature winter" (Figure 1.5).

During the SIMS, Northern Region receives certain amount of rainfall due to the frontal processes in the Bay of Bengal. It amounts of the average is to 290 mm. During these periods frontal types of rainfall frequently occur. During the latter part of October and early part of the November, Northern Region receives more than 70% of the total rainfall for this season (Figure 1.6).

During the SWMS, the amount of rainfall received is comparatively less than during other seasons, because Northern Region is located opposite to the direction of the moisture laden South West Monsoon wind. The average rainfall recorded during this period is 120 mm (Figure 1.7).

It is during the NEMS that the Northern Region receives most of its rainfall, averaging 650 mm. This is due to the cool airflow from the Bay of Bengal caused by the North East Monsoon wind. Especially in the latter part of the November and early part of the December, the province receives more than 350 mm of rainfall. Mostly February with a rainfall of 65 mm is the month of the lowest amount of rainfall compared to other months (Figure 1.8)

In the Northern Region, November and December are the wettest months of the year, receiving more than 600 mm while; July is the hottest month with less than 20 mm, based on the amount of rainfall received.

The annual averages of the rainfall of the Northern Region, and the number of rainy days have decreased in recent years, due to global climatic changes (Manawadu, 2008). Further studies regarding this rainfall change will help to find the future changes in the pattern of annual rainfall in the Northern Region.

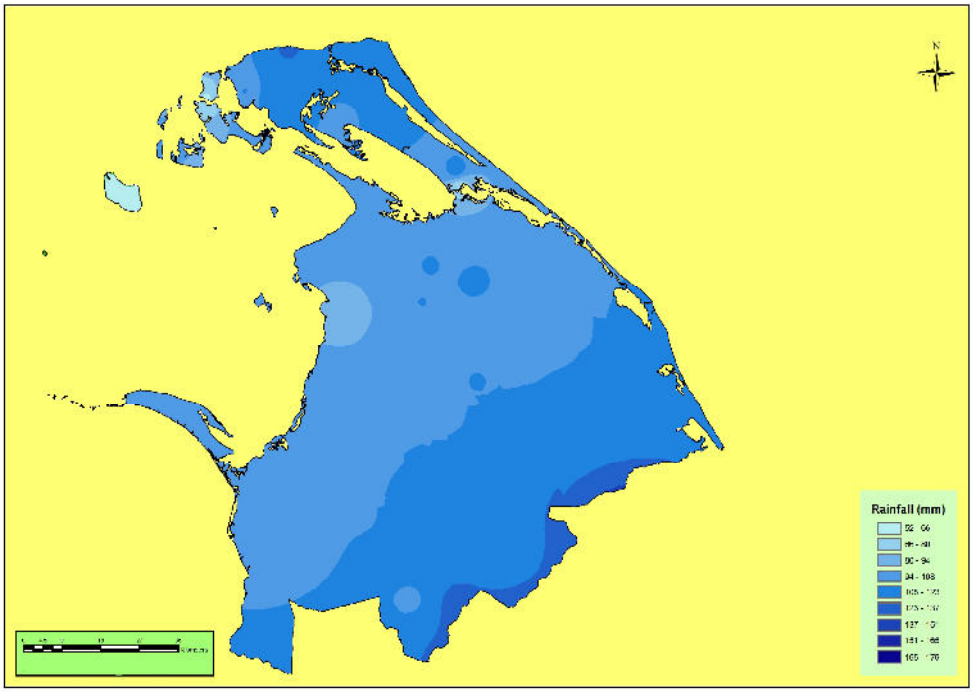


Figure 5. Average Rainfalls During the First Inter Monsoon Season (March to April) in the Northern Region of Sri Lanka (1972-2014)

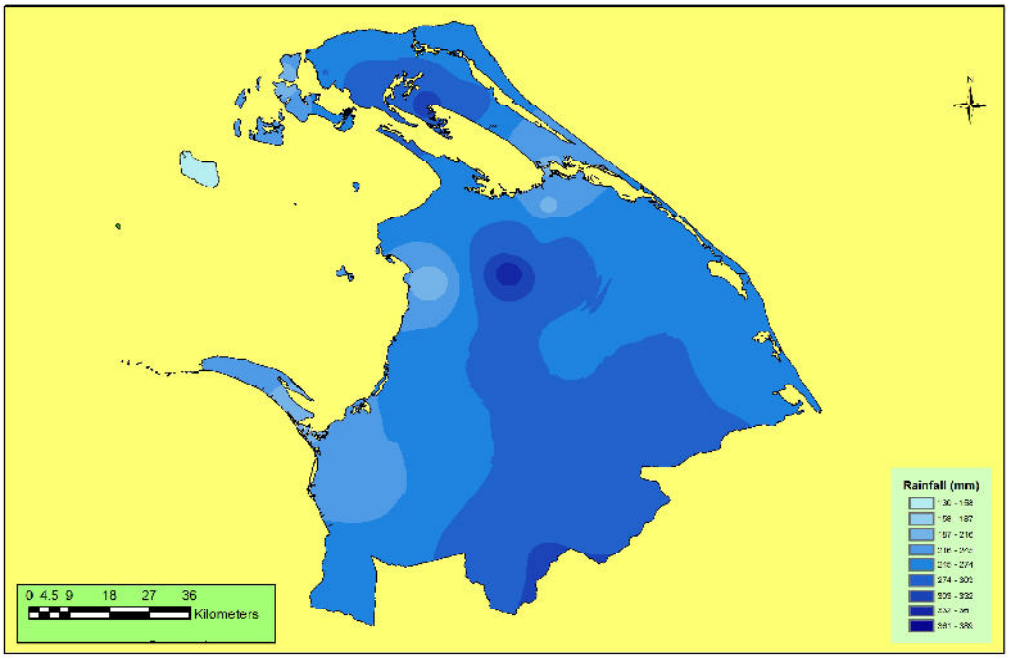


Figure 6. Average Rainfalls during the Second Inter Monsoon Season (October to November) in the Northern Region of Sri Lanka (1972-2014)

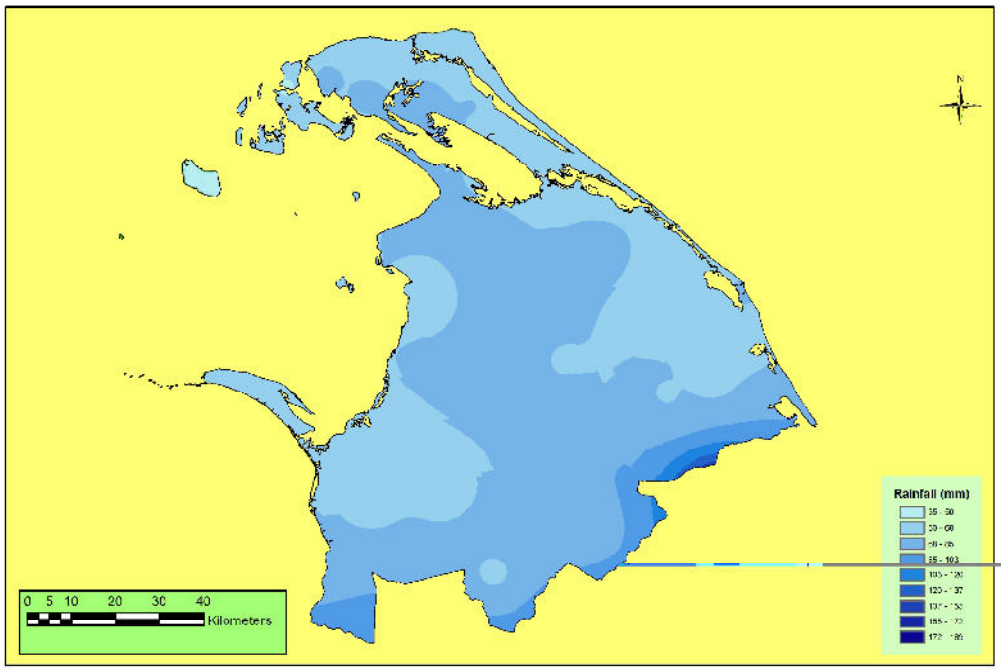


Figure 7. Average Rainfall during the South West Monsoon season (May to September) in the Northern Region of Sri Lanka (1972-2014)

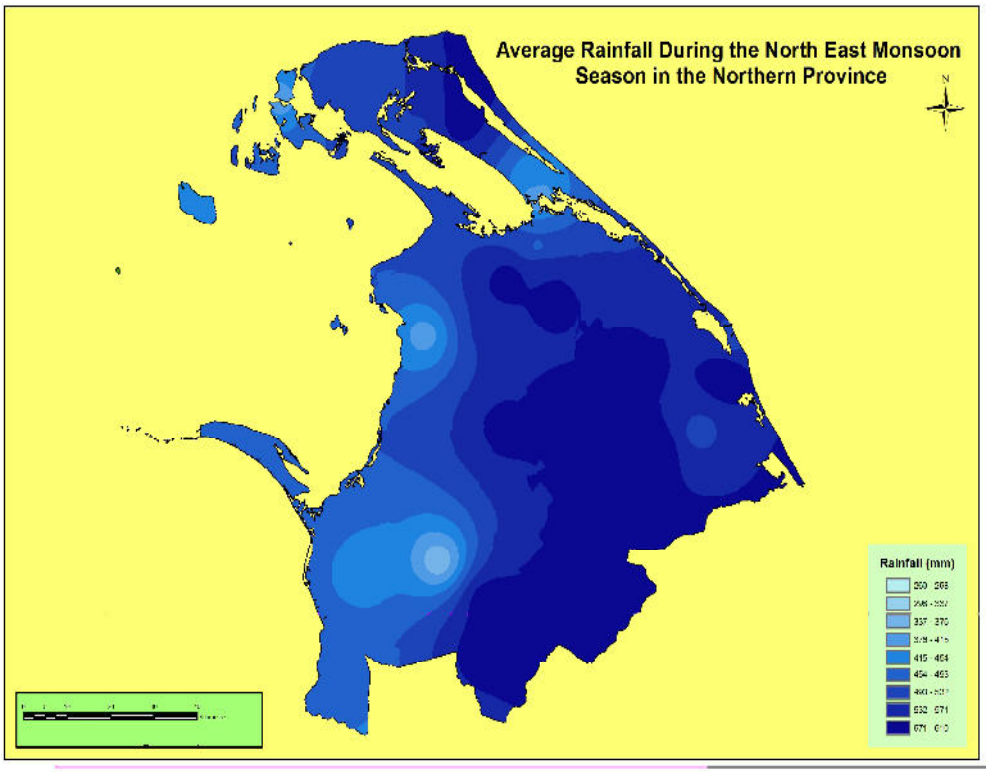


Figure 8. Average Rainfall during the North East Monsoon season (November to December) in the Northern Region of Sri Lanka (1972-2014)

According to the climatic history of the Northern Region, November, December, January, April, and October are rainy months. History also reveals that the highest hourly rainfall was recorded in Chavakachcheri in 1984; daily rainfall recorded in Nedunkerny on 15 December 1897 was 805.7 mm. (This is also the highest rainfall as far as the whole Island is concerned) The highest monthly and annual rainfall was recorded in Mullaitivu in

February 1984. In 1984 all parts of Northern Region received one week's heavy showers, amounting to more than 750 mm. rainfall in each district as a result of the, Cyclone that formed in the Bay of Bengal.

1.6 Recommendations

Obtaining accurate climatic data is the main problem for the researches related to climate in the Northern Region of Sri Lanka. Before 1985 there were many meteorological, and rainfall measuring stations which observed and measured the weather parameters in the Northern Region of Sri Lanka, but due to the thirty years of the civil conflict many of them do not function today. In the Northern region only 13 rainfall stations have continuous rainfall data from 1972 to 2012. For the climate studies at least thirty years of continuous weather data is needed. These stations (13) are not enough for conducting intense studies in the Northern Region of Sri Lanka. So, the Department of Meteorology should establish new rainfall/ meteorological stations or re establish the old stations. There should be one within ten Km of the study area. Also, at least 02 Agro- meteorological stations should also be established in every district. There isn't any system to observe the Ocean surface atmospheric conditions.

1. Northern Region of Sri Lanka consists of oceans as their sides. In the developed countries a number of weather observation stations are located on the surface of the oceans. So at least 03 Ocean Weather Observation Center (OWOC) should be established in the Northern, Eastern and Western ocean surface of the Northern Region.

2. A separate Regional Meteorological Department should be established in the central part of the Northern Region of Sri Lanka. According to Balasundarampillai (1980) Mankulam is the central part of the Northern Region. Hence Regional Meteorological Department (RMD) should be established in Mankulam. This department may coordinate with the other meteorological stations, rainfall stations and the Agro-meteorological stations and provide separate forecast to the Northern Region and it has to link with the other regions and national MET departments and stations.

3. There are no early warning systems to predict the flood and the drought hazards in the study area. According to this research, there are some findings. As per these findings in drought or flood seasons (flood in NEMS and SIMS drought in SWMS) the vulnerable areas have to be forecast to the people to reduce the impact on agriculture due to hazards. Rainfall analysis may help predict the drought and analysis of the depression in the Bay of Bengal and help predict the flood in the Northern region of Sri Lanka. In addition the systems that are followed in the developed countries to predict the drought and flood to the Northern region of Sri Lanka have to be adopted.

4. Drought and flood hazards occur in the Northern Region of Sri Lanka and cause many types of damages. Northern Region of Sri Lanka has suffered several times due to war and natural hazards several times. It's high time the Northern Region got developed. In this context, this study should help to predict the drought and flood hazards and create awareness of the risk to be caused by flood and drought, to plan the future activities related to such hazards and mitigate them in the Northern Region of Sri Lanka. All the departments, Non Government Organizations (NGOs), Community Based Organizations (CBOs) and people in the Northern Region of Sri Lanka should contribute collectively to implement drought and flood mitigation activities. A sense of cooperation, unity dedication and national spirit are essential virtues required in this noble commitment to fight against disasters.

1.7 Conclusion

Climate studies are the very important mater to the future planning and development activities of a place. During the last four decades there are no any studies regarding the climate of the northern region of Sri Lanka due to the international war. Average temperature and the rainfall of the study areas are varying in every year and month. Seasonally During the SWMS study area receiving much amount of the temperature and during the NEMS, study area receiving much amount of the rainfall. Spatially, Manthai west area is receiving much amount of temperature than other areas, eastern part of the study receiving the much amount of rainfall in the study area. Geographical factors of the every place determine the spatial variations of the temperature and the

rainfall of the study area. Seasonal variations of the rainfall and temperature determine by the temporal weather characteristics and the global climate change in the study area.

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