# Spatial Variations of the Flood and Drought in the Northern Region of Sri Lanka

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**Abstract**
There are no any systematic orders in the occurrences of drought and flood hazards in Sri Lanka. Some areas have higher number of disaster occurrences and some other areas have lower numbers. In this situation this study focused the spatial variations of the drought and flood hazards in the Northern Region of Sri Lanka. Main objective of this study is to identify the spatial patterns of drought and flood hazards in the study area. Monthly, Seasonal and annual climatic data for the stations Akkarayankulam, Ambalapperumalkulam, Iranaimadu, Kanukkerny, Karukkaikulam, Murunkan, Muththaiyankaddu, Nainathivu, Pallavarayankaddu, Pavatkulam, Thirunelveli, Vavunikkulam, and Vavuniya, were collected for the period from 1972 to 2012. Primary data for this study were collected using interviews and discussions and direct observations. Also varius sources of secondary data were used to carry out this study. Standardized Precipitation Index (SPI) has been used to identify the drought and flood hazards in every station for the period from 1972 to 2012. Krigging method of Arc GIS 9.2 version was used to identify the spatial variations of the drought and flood hazards. During the South West Monsoon Season (SWMS) 03 severe drought in Vavunikkulam station and 09 in Akkarayankulam, 08 in Murungan, and 08 in Pavatkulam were identified. During the First Inter Monsoon Season (FIMS), extreme floods were experienced in several areas. Three in Iranaimadu, 03 in Thirunelveli, 03 in Pallavarayankaddu and 03 in Nainathivu station were identified in the Northern region using SPI method. During the Second Inter Monsoon Season (SIMS), 02 extreme floods in Thirunelveli, 02 in Vavuniya, and 03 in Murungan, and 02 in Akkarayankulam station and 07 severe droughts in Nainathivu and 05 in Vavuniya were also identified. During the North East Monsoon Season(NEMS), 03 extreme floods in Akkarayankulam, 03 in Ambalapperumalkulam and 03 severe floods, 03 extreme floods in Pallavaraykaddu, 03 severe floods in Muththaiyankaddu, 04 severe floods in Vavunikkulam station and 03 severe floods in Vavuniya were identified in the Northern region of Sri Lanka.
Spatially some areas have been affected many times by flood and drought in the Northern Region of Sri Lanka. Comparatively, Eastern Parts of the study have more flood hazards and more number of droughts has occurred in the Western part of the study. Also 70% of the people expressed above thing. Also frequencies of the flood occurrences gradually decrease in the direction from the east to the west and similarly drought occurrences gradually decrease from the west to the east.
**Key Words:** Drought, Flood, Seasons, Spatial Variations and Northern Region

## 1.1 Introduction

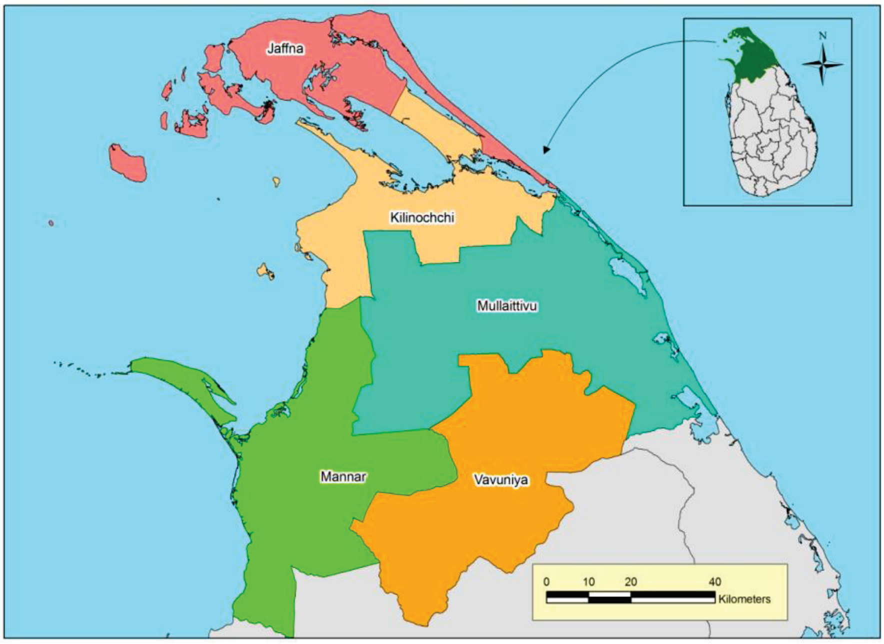
During the 100 last years, there has been an increase in the reports of natural disasters. In addition to the global warming discussion which has sparked a stream of literature analyzing what the effects may be, the reality is that we are experiencing an increasing number of natural disasters, and this is also an area still to develop (Eduardo Rodrigues-Oreggia et al, 2008). The occurrences of natural disasters have increased in frequency across the globe over the past 50 years. Estimates of the economic and financial losses from natural disasters have also risen.(Nicole Laframboise and BoileauLoko, 2012). Reports of the National Disaster Management Center also indicate this situation in Sri Lanka.

There are many development activities are initiating in the Northern Region of Sri Lanka after the thirty years of internal war by varius sources. But, those all activities are facing threats due to the natural hazards especially to the drought and flood hazards. Due to this, many people have concerned on the studies about the natural disasters to promote the sustainable development of the Northern Region of Sri Lanka. In this juncture this study analyzes the spatial variations of the drought and flood hazards in the Northern Region of Sri Lanka during the last forty two years from 1972 to 2013.

## 1.2 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 5 Administrative Districts, 34 DS Divisions, 921 GN Divisions. For the purpose of Local Governance the region has been divided into one Municipal Council, 5 Urban Councils and 29 Pradeshiya Sabhas. The Northern Province has a total area of 8,848.58 sq km




### 1.3 Objective

The main objective of this study is to identify the spatial patterns of drought and flood hazards in the Northern Region of Sri Lanka from 1972 to 2013.

### 1.4 Methodology

Various types of data ranging from primary to secondary have been used immensely in this research.

Primary data were collected using two methods such as interviews and discussions and direct observations. According to the objectives, the primary data were to help identify the economic impacts of the climatic hazards in the Northern Region of Sri Lanka.

#### 1.4.1. Primary Data

Primary data to a great extent helped this study particularly to identify the trends and patterns of climatic hazards such as droughts and floods, and to study the impacts of climatic hazards especially on the economy of this region. Primary data collection method helps especially to study the drought and flood occurrences and their impacts during the year 2012, in the Northern Region of Sri Lanka.

#### 1.4.1.1.Interviews and Discussions:

Interviews and discussions regarding such matters as the identification of flood level, flood impacts, flood patterns, flood prone areas, drought impacts, drought prone areas, and also as to which sectors of economy had faced much threat from climatic hazards and the extent of impacts such climatic hazards had on the economy of the study area, were held with the people who are living and working in the Northern Region. 100 samples from each district (totally 500 in the Northern Region) were collected during the interviews and discussions were held on the basis of stratified sampling method. In the 100 samples 50 from agricultural sector, 20 from fisheries sector, 10 from small scale industries, 10 from commercial activities, and another 10 from other sectors in each district in the Northern Region (Table 1.4). During the selection of samples for the interviews, much priority was given to the most vulnerable areas of every district based on the data regarding the drought and flood hazard impacts during the year 2012.

Unstructured questions were asked from that interviewee, based on the objectives of this study. In addition, to the identification of the economic impacts due to climatic hazards, some interviews were also held with the Government and Non Government officers who are responsible for the economic activities of each district. A maximum of ten officers were selected for such interviews from each district. Altogether 50 samples were selected from these categories. All these interviews helped to elicit the qualitative information regarding the climatic hazards and their impacts on the economy of the Northern Province of Sri Lanka.

### 1.4.1.2.Direct Observations

Direct observation was also one of the methods used in collecting primary data. This method helped to observe the climatic hazards occurrences and the economic impacts due to climatic hazards especially during the years 2011 and 2012. To identify the drought impact in the study area direct observations made during the months of May to September 2012 were of help. To study the flood events and their impacts, direct observations were made during the North East monsoon period of the year 2012. During those periods direct observations were made to find out the economic impacts caused by climatic hazards in the study area. Direct observations helped to take photos and collect information. During the direct observations, interviews and discussions were also held. Direct observations helped to observe the floods and droughts and the impacts of these climatic hazards on agriculture. In fact direct observations did help to identify the real situations that prevailed during the climatic hazards in the years of 2011 and 2012 in the Northern Province of Sri Lanka.

### 1.4.2. Secondary Data

Secondary data also helped to identify the climatic hazards and their impacts on the economy of the Northern Province.

Sources from the Departments mentioned in the following paragraph were used to obtain the necessary secondary data. Such secondary data can be classified into two types, based on the objectives of this study, those related to the climatic hazards, and those related to the economic impacts of climatic hazards.
Secondary data related to climatic hazards in the Northern Province of Sri Lanka, were obtained from the meteorological data kept at the Meteorological Department. Basic secondary data required for the study were collected from the Meteorological Department of Sri Lanka in Colombo. Data was collected for thirteen stations including Akkarayankulam, Ambalapperumal Kulam, Iranaimadhu, Thirunelveli, Kanukkerni, Karukkaikkulam, Murunkan, MuththaiyanKaddu, Nainathivu, Pavatkulam, Kariyalai Nagapaduvan, Thandikkulam, Vavuniya, and Vavunikkulam from 1972 to 2012 . Data related to Temperature (Monthly Average, Monthly Maximum, and Monthly minimum), Rainfall (Monthly Total, and Annual Total), Relative Humidity, Atmospheric Pressure, and Wind velocity, Wind Direction, and Evaporation were obtained from the Meteorological Department.
Statistical Abstracts of the National Statistical and Information Department.
Statistical Abstracts of this department for the period from 1970 to 2010 also served as secondary data. Information and statistics from the statistical abstracts related to the weather and climate of the five districts, in addition to agriculture, Fisheries, Industries and service sectors within the study area for thirty years were collected as secondary data.
Reports, Press Statements, Annual Symposium Proceedings and other Publications of the Disaster Management Centre. This is an important source of secondary data to identify the natural disaster profile of the country and the impacts of the natural hazards and the mitigation measures adopted by the Ministry of Disaster management

### 1.4.3.Data Analyzing Method

The second objective is to study the drought and flood hazard occurrences in the study area. To achieve this second objective, thirteen stations were selected (Refer figure 1.2 and table 1.1) on the basis of the availability of complete data and spatial distributions of meteorological/rainfall stations in the Northern Province.

Monthly rainfall data were collected for each station from 1972 to 2012 to study the climatic hazards in the study area.
Based on the second objective, to study the occurrence of the drought and flood hazards, rainfall data of selected thirteen stations were analyzed using the Standardized Precipitation Index (SPI)

Over the years, many drought indices were developed and used by meteorologists and climatologists around the world. Those ranged from simple indices such as percentage of normal precipitation and precipitation percentiles to more complicated indices such as Palmer Drought Severity Index. However, scientists in the United States realized that an index needed to be simple, easy to calculate and statistically relevant and meaningful. Moreover, the understanding that a deficit of precipitation has different impacts on ground water reservoir storage, soil moisture, and snowpack and stream flow led American scientists McKee, Doesken and Kleist to develop the Standardized Precipitation Index (SPI) in 1993.

The SPI (Mckee and others, 1993) is a powerful, flexible index that is simple to calculate. In fact, precipitation is the only required input parameter. In addition, it is just as effective in analyzing wet periods/cycles as it is in analyzing dry periods/cycles.

Ideally, one need at least 20-30 years of monthly values, with 50-60 years (or more) being optimal and preferred (Gutman, 1994, WMO,2012) The strength of this method, precipitation, is the only input parameters. The SPI can be computed for different time scales, provide early warning of drought and flood and help assess drought and flood severity. It is less complex than the Palmer Drought Severity Index and many other indices.

The SPI can be calculated for any location which is based on the long term precipitation record for a desired period such as 1 month, 3 month, 6 month, 9 month, 12 month, 24 month, 48 month and 72 month. This long-term record is fitted to a probability distribution, which is then transformed into a normal distribution so that the mean SPI for the location and desired period remain zero (Edwards and Mckee, 1997).

According to Edwards and Mckee (1997), a gamma probability density function to a given frequency distribution of precipitation totals for the station of interest is fitted as

$$g(x) = \frac{1}{\beta^{\alpha}\Gamma(\alpha)} x^{\alpha-1} e^{\frac{-x}{\beta}} \text{ for } x > 0$$

Where $\alpha$ is a shape parameter $(\alpha > 0), \beta$ is a scale parameter $(\beta > 0), x$ is the precipitation amount $(x > 0)$ and

$$\Gamma(\alpha) = \int_{0}^{\infty} y^{\alpha-1} e^{-y} dy$$

Where $\Gamma(\alpha)$ is the gamma function

Then the shape parameter $\alpha$ and the scale parameter $\beta$ are estimated for each time scale of interest (either weeks or months) and for each week or month of the year, depending on whether the weekly or monthly SPI is calculated:

$$\hat{\alpha} = \frac{1}{4A}\left(1 + \sqrt{1 + \frac{4A}{3}}\right)$$

$$\hat{\beta} = \frac{\bar{x}}{\hat{\alpha}}$$

Where $A = \ln(\bar{x}) - \left[\sum \ln(x)\right] / n, n$ is number of precipitation observations, and $\bar{x}$ is mean precipitation over the time scale of interest

The cumulative probability of each observed precipitation event for the given time scale for the station of interest is then computed using the estimated shape and scale parameters. An equiprobability transformation is made from the cumulative probability to the standard normal random variable Z with mean zero and variance of one, where the SPI takes on the value of Z.

Positive SPI values indicate greater than median precipitation and negative values indicate less than median precipitation. Because the SPI normalized, wetter and drier climates can be represented in the same way; thus, wet periods can also be monitored using the SPI. Mckee and others (1993) used the classification systems shown in the SPI value table below to define drought and flood intensities resulting from the SPI.

**Table 1.1 SPI Values**

| SPI Values | Category |
|---|---|
| Over 2.0 | Extreme Flood |
| 1.5 to 1.99 | Severe Flood |
| 1.0 to 1.49 | Flood |
| -0.99 to 0.99 | Neutral |
| -1.0 to -1.49 | Drought |
| -1.50 to -1.99 | Severe Drought |
| Below -2 | Extreme Drought |

Source: WMO,2012

For SPI analysis in this study, monthly rainfall data of the selected thirteen stations such Akkarayankulam, Ambalappermalkulam, Iranaimadu, Muththiayankaddu, Murungan, Kanukkerny, Thirunelvely, Nainathivu, Pallavarayankaddu, Karukkaikulam, Vavunikulam,Pavatkulam and Vavuniya have been computed using the SPI method. To obtain the annual SPI 12 months rainfall data, the First Inter Monsoon Seasonal(FIMS) SPI, 02 months rainfall data (March and April), the Second Inter Monsoon Seasonal SPI, 02 months rainfall data (October and November the North East Monsoon Seasonal SPI and 03 months rainfall data (December, January and February) and to obtain the South West Monsoon Seasonal SPI, 05 months rainfall data (May, June, July, August and September) have been analyzed using the Standardized Precipitation Index (SPI). The data of the missing months of some stations have been added from very nearest stations of the study area. The SPI results have been mapped using the Kriging method of the ARC GIS, 9.2 versions.

Spatially there are variations in the occurrence of droughts and floods of the study area. Some areas have a greater amount of drought and flood while other areas have a lesser amount of drought and flood. Nevertheless they undergo variations annually and seasonally. There are some variations in the annual drought and flood situations in every station.

**1.5. Results**

**1.5.1. Spatial Variations of Flood and Drought Years**

There many spatial variations have been found in drought years and flood years according to the annual (12 months) SPI analysis of the rainfall data of the thirteen stations. In this way, some of the stations have much number of flood and drought and some of the stations have small numbers of drought and flood hazards.

**1.5.1.1 Akkarayankulam**

In the Akkarayankulam station, four floods and five droughts years were recorded within the 42 years from 1972 to 2012. Extreme floods have occurred in 1984 and 2001. Severe floods occurred in 1993, while a normal flood occurred in 1998. An extreme drought situation prevailed in 2009. Severe droughts occurred in 1980 and 1974 while normal droughts occurred in 2007 and 2011.

**1.5.1.2.Ambalapperumal Kulam**

Five floods occurred in Ambalappperumal station. Extreme floods occurred in 1979 and 1984 but others were normal floods. Such normal floods occurred in 1981, 1985 and 1986. Severe drought conditions prevailed in 1992 while normal droughts occurred in 1989,1991,1993,1994, 1995, 2008 and 2009.

**1.5.1.3.Iranaimadu**

In Iranaimadu, three floods and four droughts occurred. Floods occurred in 1975, 1984 (Extreme flood) and 2010 while droughts occurred in 1974(Severe drought) 1987, 2008 and 2009(Extreme drought).

**1.5.1.4. Kanukkerny**

Eight floods and three droughts occurred in the station of Kanukkerny. In this station, extreme floods occurred in 1984. Severe floods occurred in 1993 and 2011 while normal floods occurred in 1973 and 1981, Extreme drought occurred in 2009 and normal droughts occurred in 1980 and 1998.

**1.5.1.5. Karukkaikulam**

In the Karukkaikulam station, there was one extreme flood (1979), one severe flood (1984) and one normal flood identified in 2008. Two severe droughts occurred in 1992 and in 2010 and a normal drought occurred during 1974, 1991 and 1999.

**1.5.1.6. Murunkan**

Four flood years, and four drought years have been identified in Murunkan Station. Extreme flood year was identified in 1993. Severe flood years were identified in 1984 and 2008. Extreme drought years were identified in 1990 and 1991 and normal drought years identified in 1974 and 2009.

**1.5.1.7. Muththaiyankaddu**

In the Muththiayankaddu station severe floods were identified in 1973 and 1984 while normal floods were identified in 1993, 2004, 2011 and 2012. Extreme drought occurred in 2009, while severe droughts were identified in 1991 and 1992 and normal droughts in 1974 and 1989

**1.5.1.8.Nainathivu**

Five flood years and eight drought years have been identified in the Nainathivu station. There was one extreme flood year (1984) and four normal flood years (1996, 1998, 2003 and 2010) identified in this station. In this station there were no extreme or severe droughts. All were normal droughts identified during the years of 1975, 1978, 1981, 1982, 1985, 1987, 1988 and 2002.

**1.5.1.9.Pallavarayankaddu**

The Pallavarayankaddu station identified two extreme flood years in 1984 and 2001. Severe flood occurred in 2004, while normal flood occurred in 1998. Extreme drought was identified in 2008, severe drought occurred in 1995 and normal droughts were identified in 1994 and 2005.

**1.5.1.10 Pavatkulam**

In the Pavatkulam station, extreme flood years were identified in 1972 and 2010. Severe floods were identified in 2012 while normal floods were identified in 1973,1981,1984,2008 and 2011. Extreme drought year was identified for the Pavatkulam station in 1990 and a severe drought was identified in 2005 while normal droughts were identified in 1988, 1995, 1997, 2003 and 2006.

**1.5.1.11. Thirunelvely**

Seven floods were identified in the Thirunelvely stations from 1972 to 2012. Among these seven floods, three were severe floods (1984, 1993, and 2001) and others were normal floods identified in the years of 1975,1985, 2003 and 2008. Seven severe droughts were also identified in this station within forty two years. These droughts occurred in 1982, 1987, 1989, 1992, 1996, 1997 and 2005.

**1.5.1.12. Vavunikkulam**

In the Vavunikkulam station, two extreme floods have been identified in 1984 and 1993 while normal floods were identified in 1979 and 2011. In this station, one extreme drought was identified in 2009. One severe drought was identified in 1974 while one drought was identified in 2010.

**1.5.1.13. Vavuniya**

Six flood years were identified in Vavuniya station. Severe floods occurred in 1999, 1984, 2000 and 2007 while normal flood years were identified in 1972, 1980, 2008 and 2011. Droughts were identified in 1974, 1986 and 1988.

Out of the annual flood and drought years of the Northern Region the higher number of flood years were identified in Kanukkerny station (08). Maximum numbers of two extreme flood years were identified within Vavunikkulam, Pallavarayankaddu, Akkarayankulam and Ampalapperumalkulam. Maximum numbers of severe floods were identified in Vavuniya, of which the number is four and the maximum numbers of normal floods have been identified in Vavuniya, Thirunelvely and Muththaiyankattu.

The maximum numbers of drought years have been identified in Murungan and Nainathivu and eight drought years have been identified in both stations. Maximum numbers of extreme drought years have been identified in Ambalapperumalkulam station. Maximum number of severe droughts has been identified in Muththaiyankaddu. Maximum number of normal droughts has been identified in Nainathivu station.

1984 has been the key flood year for almost all stations. After that in 1993 floods occurred in many stations such as Vavunikkulam, Thirunelvely, Muththaiyankaddu, Murungan, Kanukkerny and Akkarayankulam.

1974 was the drought year for all the stations including Vavunikkulam, Muththaiyankaddu, Murungan, Kanukkerny, Karukkaikulam, Iranaimadu, Akkararaynkulam and Vavuniya.

**1.5.2. Seasonal Drought and Flood - Station Wise Analysis**

Spatial variation of flood seasons and drought seasons were also identified in the study area from 1972 to 2012 using the SPI analyze. There was no extreme drought in any of the stations in the study area during the first inter monsoon season. But some extreme floods have been recorded at various stations during various years. The following table indicates the extreme flood years and stations during the first inter monsoon season. Following table indicate the flood years during the first inter monsoon season (Table1.2).

**Table 1.2. Extreme Flood Occurrences during the FIMS**

| Station | Year |
|---|---|
| Akkarayankulam | 1984,2001 |
| Ambalapperumalkulam | 1984 |
| Iranaimadu | 1984,2008,2011 |
| Kanukkerny | 1984, |
| Karukkaikulam | 1984,2008 |
| Murungan | 2008 |
| Muththiayankaddu | 1984,2008 |
| Nainathivu | 1984,2008 |
| Pallavarayankaddu | 1984,2001,2009 |
| Pavatkulam | 2008 |
| Thirunelvely | 2008,2009 |
| Vavunikkulam | 1984 |
| Vavuniya | 1977,1984 |

A maximum number of three extreme floods have been identified in the Iranaimadu and Pallavarayankaddu station. Some severe floods, normal floods and droughts have also been identified in the study area. Only one severe drought has been identified in Pavatkulam station in comparative view of drought seasons in the study area. The following table gives the details of floods and droughts in every station in the study area during the FIMS (1.3).

**Table 1.3 Details of Flood and Drought of Every Station During the FIMS**

| Stations | No. of Floods | Severity of Times | No. of Droughts | Severity of Times |
|---|---|---|---|---|
| Akkarayankulam | 4 | 1 in 10 years | 3 | 1 in 14 years |
| Ambalaperumalkulam | 6 | 1 in 7 years | 7 | 1 in 6 years |
| Iranaimadu | 5 | 1 in 8 years | 6 | 1 in 7 years |
| Kanukkerny | 7 | 1 in 6 years | 1 | 1 in 42 years |
| Karukkaikulam | 6 | 1 in 7 years | 6 | 1 in 7 years |
| Murunkan | 4 | 1 in 10 years | 4 | 1 in 10.5 years |
| Muththaiyan kaddu | 8 | 1 in 5 years | 1 | 1 in 42 years |
| Nainathivu | 3 | 1 in 14 years | 2 | 1 in 21 years |
| Pallavaryankaddu | 5 | 1 in 8 years | 2 | 1 in21 years |
| Pavatkulam | 6 | 1 in 7 years | 7 | 1 in 6 years |
| Thirunelveli | 5 | 1 in 8 years | 3 | 1 in 14 years |
| Vavunikkulam | 6 | 1 in 7 years | 7 | 1 in 6 years |
| Vavuniya | 4 | 1 in 10 years | 7 | 1 in 6 years |

During the SIMS, some extreme droughts and extreme floods have been identified in the selected rainfall stations. In the Akkarayankulam station, extreme drought was identified in 2009. But there was no extreme flood in the Akkarayankulam station during the second inter monsoon season. In Ambalapperumalkulam station extreme flood occurred in 1979, and extreme drought was identified in 1989. In the Iranaimdu station neither extreme drought nor extreme flood was identified in 1981. In the Kanukkerny station, extreme flood occurred in 1993 and extreme drought was identified in 2009.

Maximum numbers of extreme droughts during the SIMS were identified in Murungan. Extreme flood in Murungan during SIMS was identified in 1993.

There were no extreme floods or droughts during the SIMS in the stations of Muththaiyankaddu and Nainathivu. In the Pallavarayankaddu station an extreme flood was identified in 2004 and an extreme drought in 2008. Extreme drought of Pavatkulam station was identified in 1990. In the

Thirunelvely station extreme flood was identified in 1985 and extreme drought was identified in 2007. In the Vavunikkulam station, extreme flood was identified in 1993 and extreme drought was identified in 2009. In Vavuniya station, extreme floods were identified in 1972 and 1979. No extreme drought had been recorded at this station for forty two years. Apart from these, there were many floods, severe floods, severe droughts and droughts identified in the selected stations of the Northern Region during the SIMS of the Northern Region. (Table 1.4)

**Table 1.4 Details of Flood and Drought of Every Station During the SIMS**

| Stations | No. of Floods | Severity of Times | No. of Droughts | Severity of Times |
|---|---|---|---|---|
| Akkarayankulam | 5 | 1 in 8 years | 7 | 1 in 6 years |
| Ambalaperumal | 5 | 1 in 8 years | 6 | 1 in 7 years |
| Iranamadu | 7 | 1 in 6 years | 6 | 1 in 7 years |
| Kanukkerny | 7 | 1 in 6 years | 5 | 1 in 8 years |
| Karukkaikulam | 4 | 1 in 10 years | 4 | 1 in 10 years |
| Murungan | 4 | 1 in 10years | 4 | 1 in 10 years |
| Muthaiyan kaddu | 6 | 1 in 7 years | 4 | 1 in 10 years |
| Nainathivu | 4 | 1 in 10 years | 5 | 1 in 8 years |
| Pallavaryankaddu | 6 | 1 in 7 years | 4 | 1 in 10 years |
| Pavatkulam | 6 | 1 in 7 years | 3 | 1 in 14 years |
| Thirunlveli | 6 | 1 in 7 years | 4 | 1 in 10 years |
| Vavunikulam | 5 | 1 in 8 years | 5 | 1 in 8 years |
| Vavuniya | 6 | 1 in 7 years | 4 | 1 in 10 years |

During the North East Monsoon season, a number of floods at various scales had their impact on the Northern Region of Sri Lanka (Table1.5). Throughout all seasons, the maximum number of flood, severe flood and extreme flood had been identified during the NEMS. The following table indicates the years of occurrence and the various scales of flood. Also it must be mentioned here, that there were no extreme droughts during the NEMS in the study area from 1972 to 2012.

**Table 1.5 Details of Flood During NEMS**

| Stations | Extreme flood | Severe flood | flood |
|---|---|---|---|
| Akkarayankulam | 1984,1998,2001 | 2002 | 1973,1993,2011 |
| Ambalapperumalkulam | 1973,1984 | 1983,2011,1998,2002 | 1979,2001 |
| Iranaimadu | 1984 | 1986,1998 | 1973,1983,1993,2001,2010 |
| Kanukkerny | 1984 | 1977, 1990, 2011, | 1973,1983,1988,1990, 1992,1998,2001,2012 |
| Karukkaikkulam | 1984 | 1983 | 1993,1998,2000,2001,2012 |
| Murungan | 1984,1993 | 1983,1998 | 1985,2000,2012 |
| Muththaiyankaddu | 2011,2012 | 1993,2001 | 1985,2000,2012 |
| Nainathivu | 1984 | 1996,1998 | 2009 |
| Pallavarayankaddu | 1984,1998,2012 | 1973 | |
| Pavatkulam | 1984,2012 | 1983 | 1973,2000,2011 |
| Thirunelveli | 1984,1998,2001 | 1990,1993 | 1975,1983 |
| Vavunikkulam | 1984 | 1983,2011,1993 | 1990,2001 |
| Vavuniya | 2011 | 1984,1998,2012 | 1983,2000,2008 |

The higher number of extreme floods during the NEMS was recorded in Akkarayankulam, Ambalapperumalkulam,Pallavarayankaddu and Thirunelvely, higher number of severe floods were observed in Ambalapperumalkulam and the maximum number of normal floods were recorded in Iranaimadu and Kanukkerny.(Table 1.6) The higher numbers of floods have been identified in Kanukkerny and also in

Iranaimadu station. A Number of droughts and severe droughts also have been identified during the NEMS. The following table shows the details of the droughts and floods during the NEMS.

**Table 1.6 Details of Droughts and Floods of Every Stations During the NEMS**

| Stations | No. of Floods | Severity of Time | No. of Droughts | Severity of Times |
|---|---|---|---|---|
| Akkarayankulam | 7 | 1 in 6 years | 3 | 1 in 14 years |
| Ambalaperumalkulam | 8 | 1 in 5 years | 4 | 1 in 10 years |
| Iranamadu | 8 | 1 in 5 years | 3 | 1 in 14 years |
| Kanukkerny | 12 | 1 in 3 years | 3 | 1 in 14 years |
| Karukkaikulam | 7 | 1 in 6 years | 5 | 1 in 8 years |
| Murunkan | 7 | 1 in 6 years | 5 | 1 in 8 years |
| Muthaiyan kaddu | 7 | 1 in 6 years | 2 | 1 in 21 years |
| Nainathivu | 4 | 1 in 10 years | 5 | 1 in 8 years |
| Pallavaryankaddu | 4 | 1 in 10 years | 3 | 1 in 14 years |
| Pavatkulam | 6 | 1 in 7 years | 3 | 1 in 14 years |
| Thirunlveli | 7 | 1 in 6 years | 3 | 1 in 14 years |
| Vavunikulam | 6 | 1 in 7 years | 4 | 1 in 10 years |
| Vavuniya | 7 | 1 in 6 years | 2 | 1 in 21 years |

Among all the seasons of the Northern Region, it will be seen that the higher number of drought occurrences have been identified during the South West Monsoon Season (Table 1.7). Two extreme floods have also been identified in this season due to unexpected extreme weather events such as depressions in the Bay of Bengal due to mini cyclones and the impacts of air masses.

The following table gives the details of droughts and floods during the SWMS in the study area.

**Table 1.7 Details of Drought and Flood of the SWMS of the Northern Region**

| Stations | Extreme Drought | Severe Drought | Drought |
|---|---|---|---|
| Akkarayankulam | Nil | 1976 | 1986, 1994, 1999, 2002, 2008, 2009, 2011, 2012 |
| Ambalapperumalkulam | Nil | Nil | 1991, 2008, 2009, 2012 |
| Iranaimadu | Nil | Nil | 1973, 1976, 2002, 2008, 2009, 2011 |
| Kanukkerny | Nil | Nil | 1991, 2011, 1994, 2009, 2012 |
| Karukkaikkulam | Nil | 1976 | 1987, 1991, 2005 |
| Murungan | Nil | 1976, 1991 | 1999, 2002, 2005, 2006, |
| Muththaiyankaddu | Nil | Nil | 1994, 2012, 1991, 2009 |
| Nainathivu | Nil | 1991 | 1997, 2002, 2005, 2008, 2012 |
| Pallavarayankaddu | Nil | 1979 | 1989 |
| Pavatkulam | Nil | Nil | 1986, 2005, 2011, 2012 |
| Thirunelveli | Nil | Nil | 2009, 2011, 1976 |
| Vavunikkulam | Nil | 1976 | 1997, 2007, 2009, 2009, 1999, 2008 |
| Vavuniya | 1976 | | 1978, 1986, 1999, 2005, 2011, 2012 |

During the SWMS, higher a number of droughts have been identified in Akkarayankulam station as well as at Iranaimdu, Murungan,Nainathivu and Vavunikkulam stations (Table 1.8).

**Table 1.8 Details of Drought and Flood of Every Station During the SWMS**

| Station | No. of Floods | Severity of Times | No. of Droughts | Severity of Times |
|---|---|---|---|---|
| Akkarayankulam | 2 | 1 in 21 years | 9 | 1 in 5 years |
| Ambalaperumalkulam | 3 | 1 in 14 years | 4 | 1 in 10 years |
| Iranamadu | 2 | 1 in 21 years | 6 | 1 in 7 years |
| Kanukkerny | 3 | 1 in 14 years | 5 | 1 in 8 years |
| Karukkaikulam | 3 | 1 in 14 years | 4 | 1 in 10 years |
| Murungan | 3 | 1 in 14 years | 6 | 1 in 7 years |
| Muthaiyan kaddu | 2 | 1 in 21 years | 4 | 1 in 10 years |
| Nainathivu | 3 | 1 in 14 years | 6 | 1 in 7 years |
| Pallavaryankaddu | 3 | 1 in 14 years | 2 | 1 in 21 years |
| Pavatkulam | 3 | 1 in 14 years | 4 | 1 in 10 years |
| Thirunlveli | 3 | 1 in 14 years | 3 | 1 in 14 years |
| Vavunikulam | 3 | 1 in 14 years | 7 | 1 in 6 years |
| Vavuniya | 4 | 1 in 10 years | 6 | 1 in 7 years |

Flood and Drought occurrences have been identified in the study area using the Standardized Precipitation Index (SPI). During these flood and drought occurrences, normal floods and droughts as well as severe floods and droughts did not make any socio economic impact on the study area. Only extreme floods (over +2.00) and extreme droughts (over -2.00) had their impact on the socio economic sectors of the Northern Region of Sri Lanka during the last forty years.

According to the SPI, higher number of flood was identified in the NEMS & SIMS and higher number of drought was identified in SWMS. According to the climatic pattern of the Northern Region of Sri Lanka, NEMS gets much amount of rainfall, because the North East monsoon wind burst starts in this season and high moisture wind blows from the Bay of Bengal and creates the intensity of the rainfall during the latter part of the month of November and the intensity of the rainfall increases in the middle or later part of December. Above high intensity of rainfall occurs within a short period, which does not exceed more than 10 days, creates the flood vulnerability during the NEMS and SIMS in the Northern Region of Sri Lanka.

In addition a number of cyclones have occurred during these seasons. According to Thambaiyapillai (1967) and Suppiah (1972), this is the cyclone season in Northern Region of Sri Lanka. During the cyclone periods, study area received much amount of rainfall, within a short period. For example, Nisha Cyclone in 2008, Neelam Cyclone in 2012. According to Thambaiyapillai (1967), in the 100 years history of Sri Lanka, more than 71% of the cyclones have occurred during the month of November and December. Due to this fact heavy rainfall creates flood vulnerability in the Northern Region of Sri Lanka. Therefore SPI is also over +1.00 and a large number of flood related SPIs were recorded during this seasons in the Northern Region of Sri Lanka.

During the SWMS, higher numbers of drought have been identified using the SPI analysis. According to the climate history of the Northern Region of Sri Lanka, SWMS get very little amount of rainfall, this is not more than 75mm. Some months in this season do not get even o1 mm rainfall in the study area. But, in some years, this area gets much rainfall in this season and creates the flood vulnerability during SWMS due to depression in the Bay of Bengal. There are some evidences for it. This is a rare event. This heavy rainfall occurs after two or three drier months. Due to this, flood impact during the SWMS in the study area is much less. Generally this season is the driest season in the Northern Region

During the First Inter Monsoon Season (FIMS) there are some flood situations identified in the study area using the SPI analysis. During this season, study area is under the influence of the Inter Tropical Convergence Zone (ITCZ). Movement of the ITCZ and the cold air masses from the Bay of Bengal are the major reasons for the heavy rainfall and the flood vulnerability of the study area during the FIMS. This heavy rainfall is within a short period in the study area and creates flood valunarablity. Due to it, SPI of the FIMS is in flood level in some months and normal level in some months and drought is rare in the study area.

There are also, some drought identified in the NEMS, SIMS and FIMS. Delay of the rainfall is the main reason for the drought during the SIMS, NEMS and FIMS in the Northern Region of Sri Lanka. Annually there are some years, which get less rainfall than average. These years will be the drought years and some years get much more, than average and these years will be the flood years. This has been the trend in all seasons and all stations.

Spatially maximum numbers of floods (annual and all seasons) have occurred in Kanukkerny Thirunelveli, , Pavtkulam, Vavuniya, and Iranamadu and maximum number of drought(annual and all seasons) occurred in Karukkiakulam, Nainathivu, Murungan and Vavunikkulam during the past 42 years in the study area from 1972 to 2012.

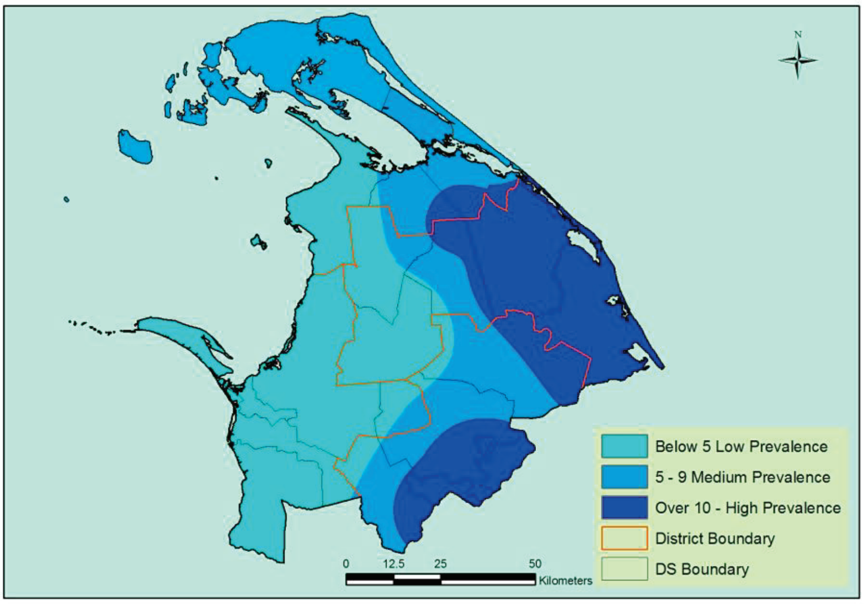



**Figure: 3.133 Spatial Pattern of Flood Occurrences in the Northern Region of Sri Lanka During the last 42 years (1972 to 2012)**

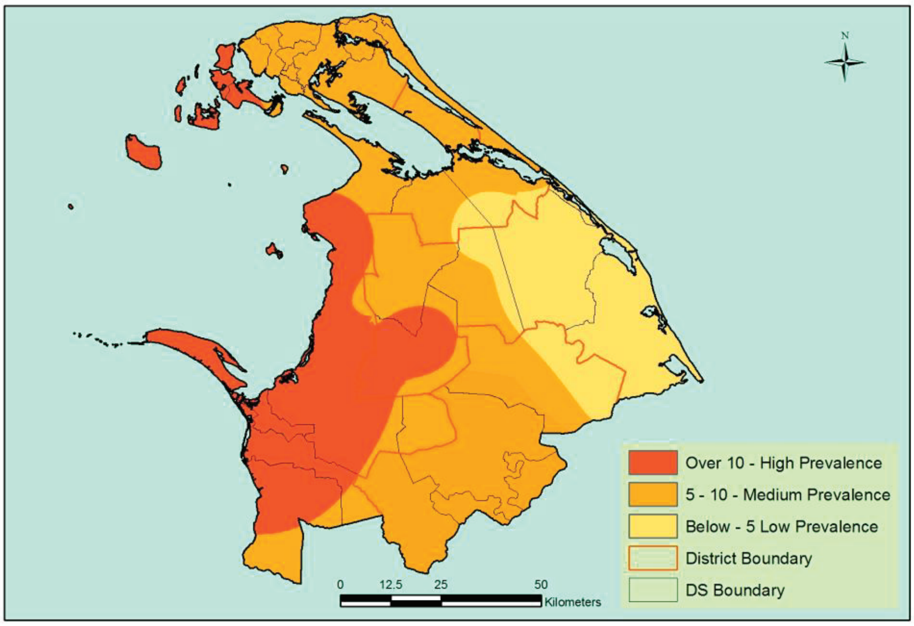



**Figure: 3.134 Spatial Pattern of Drought Occurrences in the Northern Region of Sri Lanka During the last 42 years (1972 to 2012)**

## 1.6. Conclusion

According to the annual(12 months), seasonal and monthly (01 month) SPI analysis of flood and drought occurrences of the Northern Region of Sri Lanka, There are some spatial variations in the pattern of drought and flood hazards. Based on the number of annual and seasonal (all seasons) drought and flood hazards of the Northern Region of Sri Lanka, in the western Part of the study area had higher number of drought and eastern part had higher number of flood. The reason for this is that, eastern part has direct face of the Bay of Bengal and western part is in the shadow area of the Bay of Bengal. Drought areas have increased from east towards west and flood areas have been increased from west towards east based on the number of drought and flood. For example when compared to Kanukkerny station, Muththaiyan kaddu station had maximum number of drought events and Vavunikkulam station had maximum number of drought than Muththaiyankaddu station. Compared to Iranaimadu station, Akkarayankulam station had greater number of drought and Ambalapperumal had greater number of drought than Akkarayankulam station. When compared to Ambalpperumalkulam station Pallavaraykaddu had greater number of drought and Murungan station had greater number of drought than Vavuniya station in the study area. Thus, doughtiness moves from east towards west.

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