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Dynamic Trends of Intensity of Rainfall Extremes in Sri Lanka

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Dynamic Trends of Intensity of Rainfall Extremes in Sri Lanka

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Abstract

Changes in extreme weather and climate events are among the most serious challenges to society in coping with a changing climate. Occurrence of extreme rainfall events with higher intensity accomplishing flash floods is becoming a common phenomenon. It is timely important, identifying spatial and temporal characteristics of intensity of extreme rainfall events by countries. Maximum 5 day rainfall (Rx-5day) is an effective index which leads to identify intensity of rainfall extreme events, recommended by World Meteorological Organization. This considers the highest total rainfall within a consecutive 5 day period. This study focuses on spatial and temporal characteristics of Rx-5day in Sri Lanka from 1981 to 2010. Daily rainfall data collected from Meteorological Department, Sri Lanka is used in the study and extremes are calculated using RClimDex 1.0 package, designed by Expert Team on Climate Change Detection and Indices (ETCCDI). IDW interpolation technique in GIS, non-parametric Mann Kendall test is used to analyze the significance of trends. Average maximum 5-day rainfall values ranges between 100mm-400mm. Among the severest extremes, Colombo is accounted by the highest value in 2010. Spatially, Rathnapura, Rathmalana, Colombo are highly affected by these extremes. Temporally there is an emergent increase of this index after 2002. Annual maximum consecutive five day rainfall predicates significant increasing trends in Batticaloa, Colombo, Hambanthota, Rathmalana and Trincomalee. Variation of Monsoonal regimes seems rely on variations of this index. These detections of trends of spatial and temporal patterns of rainfall extremes thus facilitate in decision making and planning related to disaster management and development in Sri Lanka. Keywords – Extreme rainfall events, ETCCDI, GIS, Non- parametric Mann Kendall trend test, spatial pattern, temporal trends

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1. Introduction

Extreme weather events have become a common and devastating phenomenon in the present. Among them the occurrence of extreme rainfall events with high intensity accomplishing flash floods is becoming a severe issue for most of the nations in the world (Intergovernmental Panel on Climate Change, 2007, p.30).It is generally accepted that these events would have profound impacts on both human society and the natural environment and this is an exigent challenge to the society to cope with this changing climate.

Sri Lanka is also frequently undergoing destructive impacts of these extreme rainfall related hazards. Recent years have recorded a significant number of extreme rainfall events caused large losses of life as well as a tremendous increase in economic losses from coincide weather hazards. When examining the Climate Risk and Adaptation Country Profile of the Sri Lanka 2011, it is evident that the number of extreme rainfall related hazards including floods and landslides have risen up (The World Bank Group, 2011, p.6) It further reports that floods and droughts has increased from 1974- 2004. The south-west monsoons (May to September) cause severe flooding in the western and south-western provinces and the north-east monsoons (December – February) cause flooding in the eastern, northern, and north-central provinces, while a huge part of the island undergoes drought from February to April and, if there is a subsidiary drought in the normal rainy season from May to June, drought can extend into September. In the past 30 years floods have affected more than 10 million people, while droughts have affected more than 6 million. Even though these catastrophic hazards stuck Sri Lanka even in its past history, it is currently apparent that frequency and intensity of these hazards have accelerated.

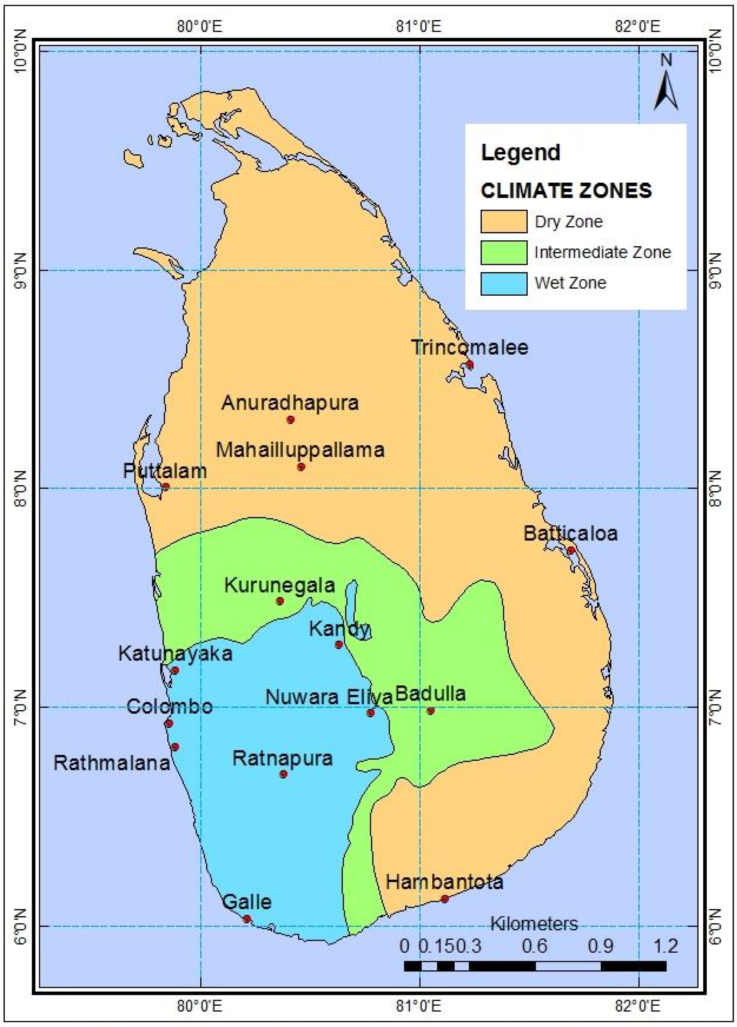
Identifying spatial and temporal variability of extreme rainfall indices is a timely important aspect. Since the extreme weather events are becoming a frequent and affecting adversely on livings and non-livings, World Meteorological Organization (WMO) emphasizes the importance of the studies relevant to the above stated phenomena and motivates the countries providing necessary indices and guidelines on analyzing these weather extremes (World Meteorological Organization, 2009, p.7).It’s the responsibility of the countries to identify the intensity of these weather extremes and their spatial and temporal characteristics in order to minimize the damages and adapt and mitigate the adverse impacts caused by the extreme rainfall events.

There are many indices to identify extreme rainfall events defined by World Meteorological Organization. Maximum 5 day rainfall (Rx-5day) is an effective index which leads to identify the magnitudes or intensity of rainfall extreme events. This considers the highest total rainfall within a consecutive 5 day period.

2. Methodology

2.1 Study Area

Entire country was considered for this study based on 15 meteorological stations. Sri Lanka is an island in the Indian Ocean. It is located between the latitudes of 5^0 55' N and $9^0$51' N and the longitudes of 79^0 41' E and $81^0$53' E as shown in the Figure 1.1. Sri Lanka lies in close proximity to the southeastern coast of India and narrow strip of water (Palk Straithas separated two countries. Sri Lanka possesses an area of 65,610 km^2 (Department of Survey, 2007, p.2).



Source: Prepared by the Author based on Arjunas' Atlas and Google Earth

Figure 1.1: Selected Meteorological Stations for the Study

2.2 Data collection

This research is entirely based on secondary data. Daily rainfall data for the period of 1981 to 2010 is collected from Department of Meteorology, Sri Lanka. Though .Department of Meteorology maintains 22 main meteorological stations island wide, conflictive conditions lasted for past decades have interrupted in recording continuous rainfall data. This problem mostly regards with the data of Northern and North Eastern Provinces. Lack of continuous rainfall data records disrupts in analyzing extreme rainfall events. Hence, only 15 meteorological stations were selected for the present study.

2.3 Data Processing

Data processing consists of few steps including data checking, missing value analyzing, missing value imputation, data arranging in required format, identifying rainfall extremes and mapping rainfall index.

Data checking is manually performed to find out the stations with a proper data base for the analysis. Hence, all the meteorological stations in Northern Province and Potuvil in Eastern Province is excluded in the study. Some of the meteorological stations contained randomly distributed missing values other than the above stated missing data sets. Missing value analysis is done using SPSS 17.0 version to identify quantity and distribution of missing values. Selected 15 meteorological stations consisted missing values less than 2%. More or less these missing values were frequently recorded regarding temperature values. Hence, those missing values were imputed using SPSS. And these missing values of temperature as rainfall indices are not influenced by the temperature values in the RClimDex package used in this study to identify extremes.

Maximum 5 day rainfall is an effective index which leads to identify the magnitudes of rainfall extreme events. This considers the highest total rainfall within a consecutive 5 day period. If it rains heavily for few days continuously, it may lead to floods or other disastrous impacts on the society. Based on the value of this index it is possible identify intensity of extreme rainfall events.

RX5day: highest rainfall amount in five-day period

"Let RR*kj*be the rainfall amount for the five-day interval *k* in period *j*, where *k* is defined by the last day. The maximum five-day values for period *j* are RX5day*j* = max (RR*kj*)"

In some cases Rx5day index may not be able to perform best in identifying the severest extremes, because higher rainfall may not occur in each consecutive 5day period. Instead the one day maximum value may be higher than the 5 day maximum rainfall amount.

Maximum 5-day rainfall events in Sri Lanka for the period of 1981 to 2010 are extracted using RClimDex 1.0 package. Calculated indices are mapped to indicate spatially referenced results. Inverse Distance Weighted (IDW) interpolation is used to indicate the spatial distribution of the indicators with time. Univariate plot (Box plot), basic statistics and above created maps are used to analyze the spatial and temporal pattern of rainfall extremes. Non parametric Mann Kendall trend test is used to detect the significance of trend of the index using XLStat software. This derives the trend of the indices as well as the hypothesis testing results. This tests whether there is a significant trend in the series.

Mapping the trends of indices is done using GIS. Trends are identified into four categories as,

1. Significant increasing trend
2. Non-significant increasing trend
3. Significant decreasing trend
4. Non- significant decreasing trend

3. Results and Discussion

Distribution of annual maximum 5 day rainfall is visualized in figure 1.2.It varies from 100mmto400mm. However, some exceptional rainfall events can be observed. They are the severest among these rainfall extremes. Highest 5 day maximum rainfall was reported in the year 2010.Colombo and Rathmalana accounted the highest and second highest rainfall values of 912.4mm and 780.5mmrespectively (Table 1.1).

Most of the 5-day maximum rainfall amounts range between 100mm and 300mm. Scatter gram shows overlapping of many points in this range. It further indicates that, 5- day maximum rainfall in Sri Lanka does not show a remarkable variation during the period of 1981 to 2007. However an increasing trend is clear after 2007. Higher extreme rainfall events are evident in 1982, 1984, 1986, 1989, 1992, 1995, 1996, 1999 and all the years after 2002 according to figure 1.2.

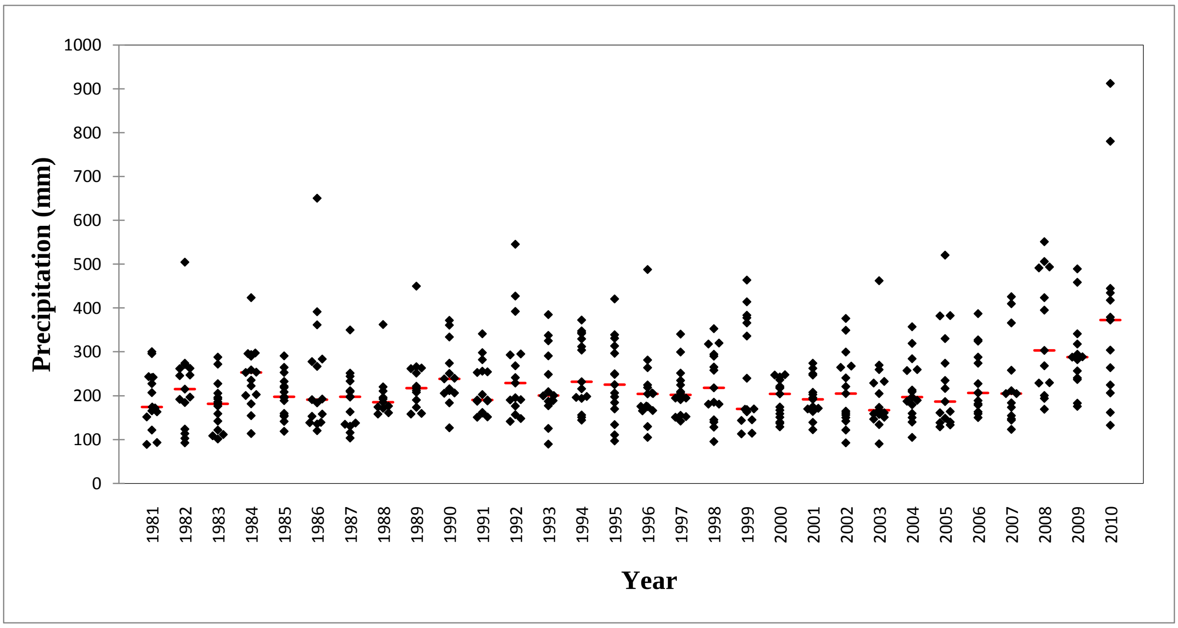


Figure 1.2: Annual maximum 5-day rainfall in Sri Lanka from 1981 to 2010

Table1.1: Summarized statistics of annual maximum 5-day rainfall for selected station

Station	Average (mm)	Maximum (mm)	Minimum (mm)	Slope
Rathnapura	304.2	504.9	191.6	1.803
Rathmalana	302.2	780.5	151.7	5.376
Colombo	283.3	912.4	158	1.85
Trincomalee	277.2	506.1	172.3	5.254
Batticaloa	273.2	489.2	142.1	2.721
Katunayaka	262.1	463.5	140.2	1.424
Galle	254.8	491.1	111.1	2.523
Kurunegala	235.9	550.9	122.9	1.685
Puttalam	196.9	423.5	112.9	-2.566
NuwaraEliya	194.3	391.6	90.6	-0.55
Badulla	194.2	650.5	96.5	3.556
Mahailluppallama	193.9	338.7	95.4	-1.724
Kandy	183.6	304.1	103.3	-0.763
Anuradhapura	178.6	272.2	88.5	1.571
Hambantota	146.4	232.2	89.7	5.996

Table 1.1 also derives spatial variability of5- day maximum rainfall values of each rainfall station. Among them, top three values are recorded in Rathnapura, Rathmalana and Colombo. Even though Rathnapura has been identified as an important region in case of

average values, particular region has not been identified with peaks when comparing the individual 5-day rainfall maximums. Maximum Rx 5-day rainfall values of the three stations, Colombo, Rathmalana and Kandy are reported in the same year, 2010.

Distribution of the maximum 5-day Rainfall of few selected years are mapped in figure 1.3 and it clearly visualizes the most vulnerable regions and years affected by these extreme events with high intensity. Among them, most of the years indicates similar spatial pattern. Figure 1.3 further implies whether there is an impact of Southern Oscillation on triggering the extreme rainfall events in the country.

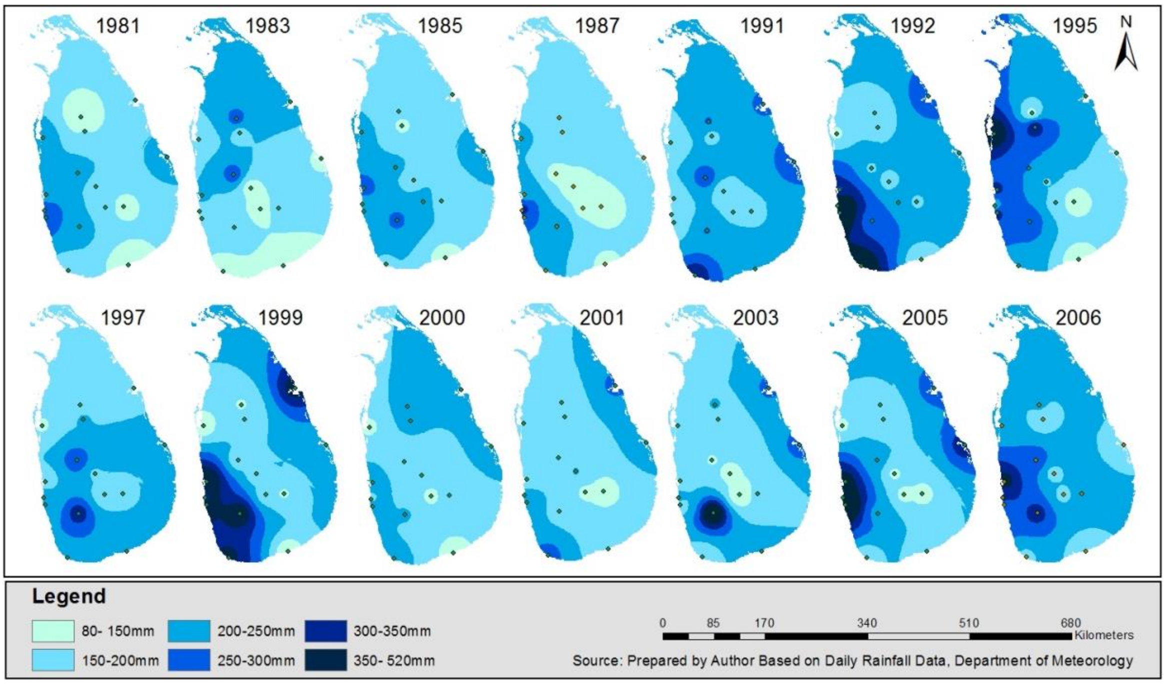


Figure 1.3: Monthly maximum consecutive 5day precipitation from 1981 to 2010

Moreover, the spatial distribution and temporal changes of these extremes with higher magnitude seems having a relationship with the two monsoon periods occurs in the country. The southwest monsoon does not come as a continuous air stream and there are fluctuations of southwest monsoon rain with so called “bursts” and “breaks” (Ranasinghe, 2004, p.51). Hence, during the bursts of monsoon winds, it generates higher rainfall in consecutive periods. These trends are further revealed by the figure 1.4 which summarizes the 5-day maximum rainfalls values by decades. The increasing trend of 5-day maximum rainfall in Baticaloa and Trincomalee is highlighting. There may be a correlation with the peaks of northeast monsoon regime that increasing trend of north east monsoon rain may generate incidence of increasing of 5 day maximum rainfall.

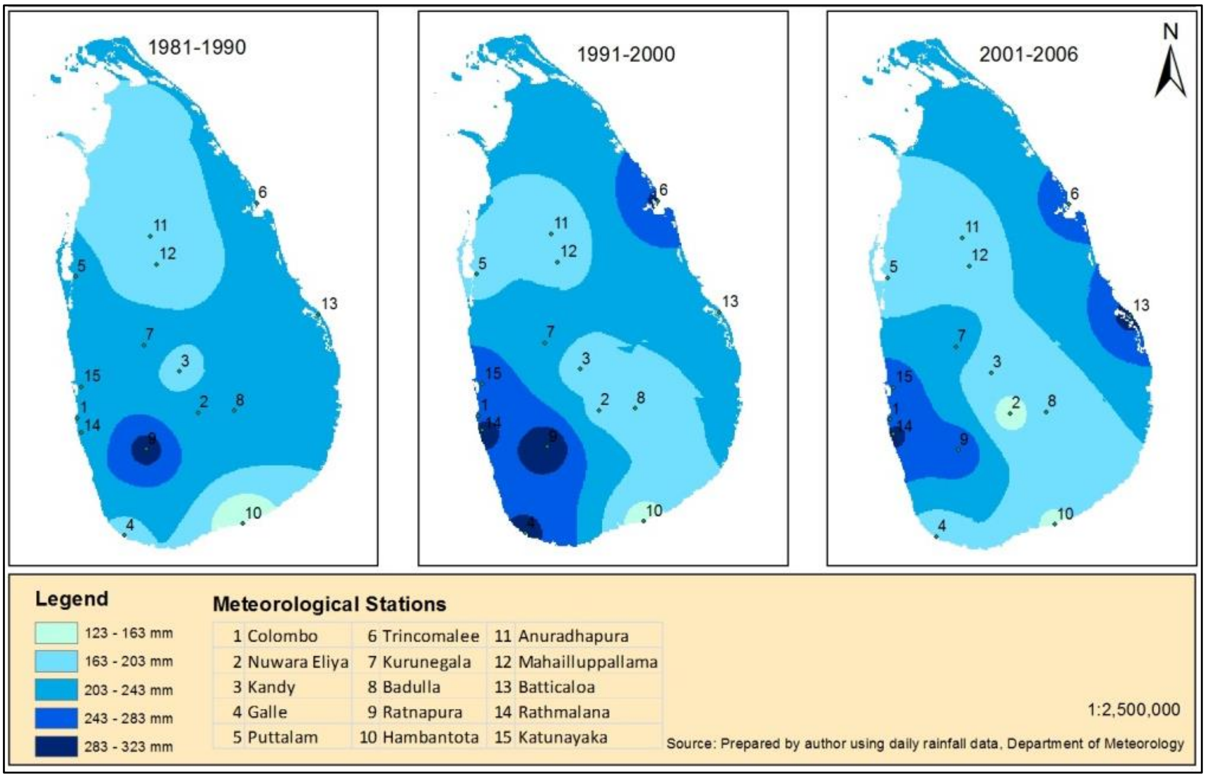


Figure 1.4 Annual maximum 5 day precipitation from 1981 to 20106

Decreasing of the maximum 5 day rainfall values in Rathnapura is an emerging point in case of intensity of extreme rainfall events. As Rathnapura is accounted by south west monsoon rains, it is under the influence of higher rainfall variability during southeast monsoon. It may be the possible reason for decreasing trend in Rathnapura. That tempts to predicate whether there is a tendency to aggregate these extreme events along southwestern coastal regions and neighboring parts of the region. Figure 1.4further ensures that south western part of the country is highly vulnerable for most of these extremes. It is rarely found that Puttalam has undergone higher amount of maximum 5-day rainfall. One such extreme is highlighted in 1995.

The pattern of monsoon regim seems to have profound influence on these extreme rainfall events. However, in some exceptional cases, this impact may vary spatially. As an example, there is a low impact from these rainfall extremes in the years 1983 and 1987. It may be due to the influence of El-Nino. Reversely La-Nina is affected in occurring maximum rainfall amounts for consecutive periods as recorded in 2010.

There are few noticeable consequences of the significance of the trends of Maximum 5-day Rainfall (Rx5day) in Sri Lanka from 1981 to 2010 as illustrated in Figure 1.5.

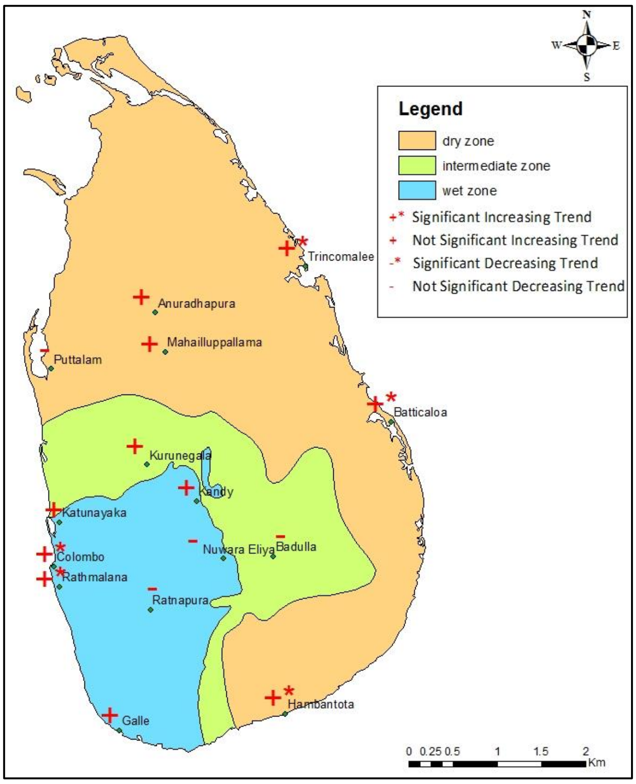


Figure 1.5: Trends of maximum 5-day rainfall (Rx5day) in Sri Lanka from 1981 to 2010

All selected stations indicate increasing trends excluding NuwaraEliya, Badulla, Puttalam and Rathnapura. None of the decreasing trends seem to be significant. Annual maximum consecutive five day rainfall predicates significant increasing trends in Batticaloa, Colombo, Hambanthota, Rathmalana and Trincomalee.

4. Conclusion

Rathnapura ranks first at the highest average value of Rx5day index followed by Rathmalana and Colombo throughout this period. But the maximum value of this series is recorded from Colombo. Annual maximum consecutive five day rainfall predicates significant increasing trends in Batticaloa, Colombo, Hambanthota, Rathmalana and Trincomalee. Decreasing trends can be seen in Rathnapura, NuwaraEliya and Badulla though these trends are not statistically significant. Accordingly Southwestern, Eastern and North Eastern parts of the country seem highly exposure to these extreme related hazards. These trends, patterns and vulnerable areas detected from this study can be prioritized when making decisions and plans by disaster management and other relevant authorities.

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References

Department of Survey. (2007). *National Atlas of Sri Lanka.* Colombo: Author Intergovernmental Pannel on Climate Change. (2007). *Climate Change 2007: Synthesis Report.* Retrieved from http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr.pdf

Ranasinghe, E.M.S. (2004). *Spatial and Temporal Pattern of Rainfall in the wet Zone of Sri Lanka (a comparative study for the periods of 1941-1970 and 1971-2000).* (Unpublished master's thesis). University of Brunai, Brunai

The World Bank Group. (2011). *Climate Risk and Adaptation Country Profile. (2011); Vulnerability Risk Reduction and Adaptation to Climate Change: Sri Lanka.* Retrieved from *http://sdwebx.worldbank.org/climateportalb/doc/GFDRRCountryProfiles/wb_gfdrr_climate_change_country_profile_for_LKA.pdf*

World Meteorological Organization. (2009). *Guidelines on Analysis of extremes in a changing climate in support of informed decisions for adaptation.* Retrieved from http://lacad.ciifen.org/ES/documents/WCDMP_72_TD_1500_en_1.pdf