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IMPACT OF TEMPORAL CHANGES OF RAINFALL ON MAJOR CLIMATIC ZONES OF SRI LANKA

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ABSTRACT

Historical and predicted rainfall records and spatial interpolation of temporal trends were analyzed to identify its impact on major climatic zones of Sri Lanka. Data from GHCN version 2.0 of monthly precipitation from 1930 - 2000 of 15 gauging stations in Sri Lanka were used in this study. Annual and four temporal seasons: Southwest monsoon (SWM), Northeast monsoon (NEM), First Inter-monsoon (FIM) and Second Inter-monsoon (SIM) were used for the analysis. Regression models and the Mann-Kendall test were employed to build the linear and non-linear long term annual and seasonal models. From 2001 to 2100, monthly rainfall values were simulated from GCMs predictions by using LS-SVM. Then the annual and seasonal spatial distributions of trend statistics were mapped by using the inverse distance weighted interpolation method (IDW). The results suggest that the current boundaries of the wet zone of Sri Lanka have to be broadened and current intermediate zone could be expanded further in the next century. A semi-arid region can be developed around Batticaloa and the eastern coastal belt of the country. Current semi-arid regions may remain unchanged.

***Key words*:** climate change, climatic zones, rainfall, trend analysis

INTRODUCTION

Global climate has been changing mainly due to rapid increase of atmospheric concentration of greenhouse gases through the anthropogenic activities and expected to continue. The nature of the impacts may differ geographically depending on the exposure and development status across the regions and their ability to respond and adapt to the changes (IPCC, 2007). There is sufficient evidence to suggest that Sri Lanka's climate has also changed with the global scenario (Chandrapala, 1996; Ampitiyawatta and Wijeratne, 2014). Rainfall and temperature are major variables among them. Past studies on the long-term trends of the rainfall have shown spatially and temporally variable trends across many parts of the Sri Lanka (Wickramagamage, 2015; Ampitiyawatta and Guo, 2009; Madduma and Wickramagamage, 2004; Malmgren *et al*. 2003; Senevirathna *et al*. 1997). The significant changes in the climate are mainly decided by the temporal and spatial variations of rainfall, which have a strong impact on agriculture, water resources, and hydropower (Weeraratna and Weerasinghe, 2006). Sri Lanka, being predominantly an agricultural country, it is vital to analyze the temporal changes of rainfall and its impact on major climatic zones, which would help make decisions on future planning of agricultural activities. Therefore, the objective of this study is to analyze the historical and predicted rainfall records of Sri Lanka and spatial interpolation of temporal trends which would help identify its impact on major climatic zones.

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MATERIALS AND METHODS

Lying in the equatorial and tropical zone, the climate of Sri Lanka is predominantly governed by the seasonally varying monsoon sys-

tem and characterized as a tropical monsoon climate. Two principle monsoon rainfall seasons; southwest monsoon (SWM) from May to September and northeast monsoon (NEM) from December to February and two inter-monsoon rainfall seasons; first inter-monsoon (FIM) from March to April and second inter-monsoon (SIM) from October to November can be clearly identified due to changing monsoon systems and their associated winds (Domroes, 1974). During inter-monsoon seasons, convectional type rainfall is predominant and tropical depressions originating in the bay of Bengal also brings heavy rainfall to the country (mainly during SIM). The seasonal cycle of monsoon rainfall and its association with regional and local topographic characteristics lead to highly variable spatial and temporal rainfall patterns over the country. Accordingly, two major climatic zones can be distinguished as Wet Zone and Dry Zone (Figure 1) based on annual rainfall and its seasonal variation. Since both southwest and north east monsoons are blowing across the country, two small regions in southeast and northwest corners of the country, do not receive substantial amount of rainfall from those monsoons. Further, convectional rainfalls are not prominent during the inter-monsoon seasons due to flat terrain of these regions. Therefore these two regions are currently considered as semi-arid regions.

Global Historical Climatological Network (GHCN) is a comprehensive global surface climate database designed for monitoring and detecting the climate change. It is designed and operated jointly by the National Climatic Data Center, Arizona State University and the Carbon Dioxide Information Analysis Center at Oak Ridge National Laboratory in the USA and comprised of monthly observations for precipitation, temperature and pressure for over 20000 stations worldwide and provides good basis for systematic analysis. Therefore, data from GHCN version 2.0 of monthly precipitation from 1930 - 2000 of 15 gauging stations in Sri Lanka (Figure 1) were used in this study. Precipitation series were tested with Kolmogorov-Smirnov method and found to be normally distributed ($\alpha = 0.05$). Rainfall records were categorized into four temporal seasons: Southwest monsoon (SWM), Northeast monsoon (NEM), First Inter-monsoon (FIM) and Second Inter-monsoon (SIM) according to Domroes, 1974, and annual records were also considered. Linear regression models were used to detect the long term linear trends, the Mann-Kendall test; as a non-parametric test to detect nonlinear trends and distribution of the test statistic. From 2001 to 2100 monthly rainfall values were simulated from GCMs predictions by using Least Square Support Vector Machine (LS-SVM). Then the annual and seasonal spatial distributions of trend statistics were mapped by using the Inverse Distance Weighted interpolation method (IDW), which is based on the assumption that the interpolating surface should be influenced most by nearby points and less by more distant points (Gemmer *et al*., 2004).

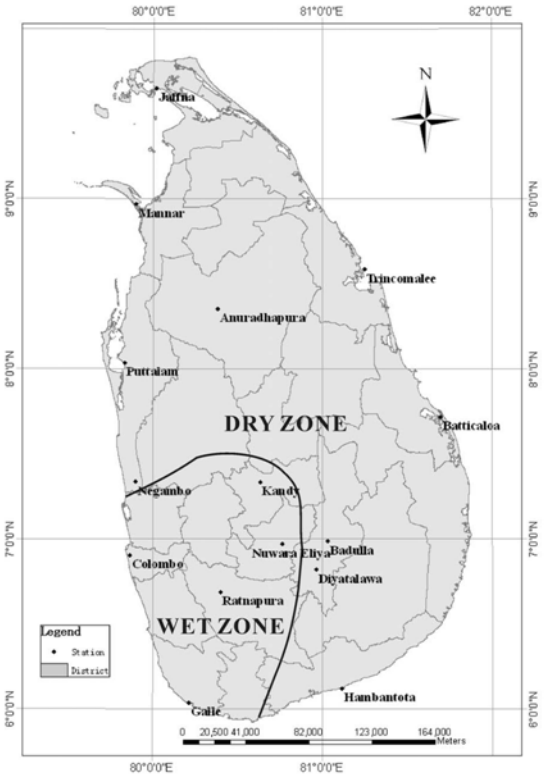

Figure 1: Locations of main meteorological stations used in this study

RESULTS AND DISCUSSION

Spatial distribution of annual and temporal trends for historical (from 1930 to 2000) and predicted (from 2001 to 2100) rainfall in Sri Lanka are shown in Figure 2 and Figure 3. Accordingly, the results of both linear regression and Mann- Kendall methods are very similar for both historical and predicted rainfall data. Historical trend distributions indicate that there is no upward or downward trend in most parts of Sri Lanka ($\alpha = 0.05$). However, both methods show a clear downward trend in the Jaffna peninsula and a small region around Kandy. Seasonal trend distributions during NEM and FIM are similar to those of annual trend distributions. During SIM, no significant trend is found anywhere in the Island. A prominent downward trend can be identified in the central part of the country: around Kandy, during the SWM season.

Annual and seasonal predicted rainfall trends show a rich spatial distribution pattern as compared to the historical trends. Most parts of the country show a significant upward annual trend except a considerable locality in the Eastern region. Hambantota and Mannar, regions with lowest annual rainfall which are currently considered as semi-arid, seem to remain unchanged in the future too. The predicted temporal rainfall distribution during the SWM season is similar to that of annual distributions showing an upward trend in many parts of the country. This verifies that southwest monsoons may bring heavy rainfall in the future and mainly govern the spatial distribution patterns of rainfall in the country. However, a substantial part around Batticaloa undergoes a significant downward trend and may experience a severe drought during the SWM season. The predicted rainfall trend distribution during FIM is also similar to the annual trend distributions. Most parts of the country may receive a considerable amount of rainfall and only a substantial part around Batticaloa undergoes a moisture deficiency. SIM is characterized by a prominent downward trend in northern, eastern and southeastern regions whereas the other parts of the country

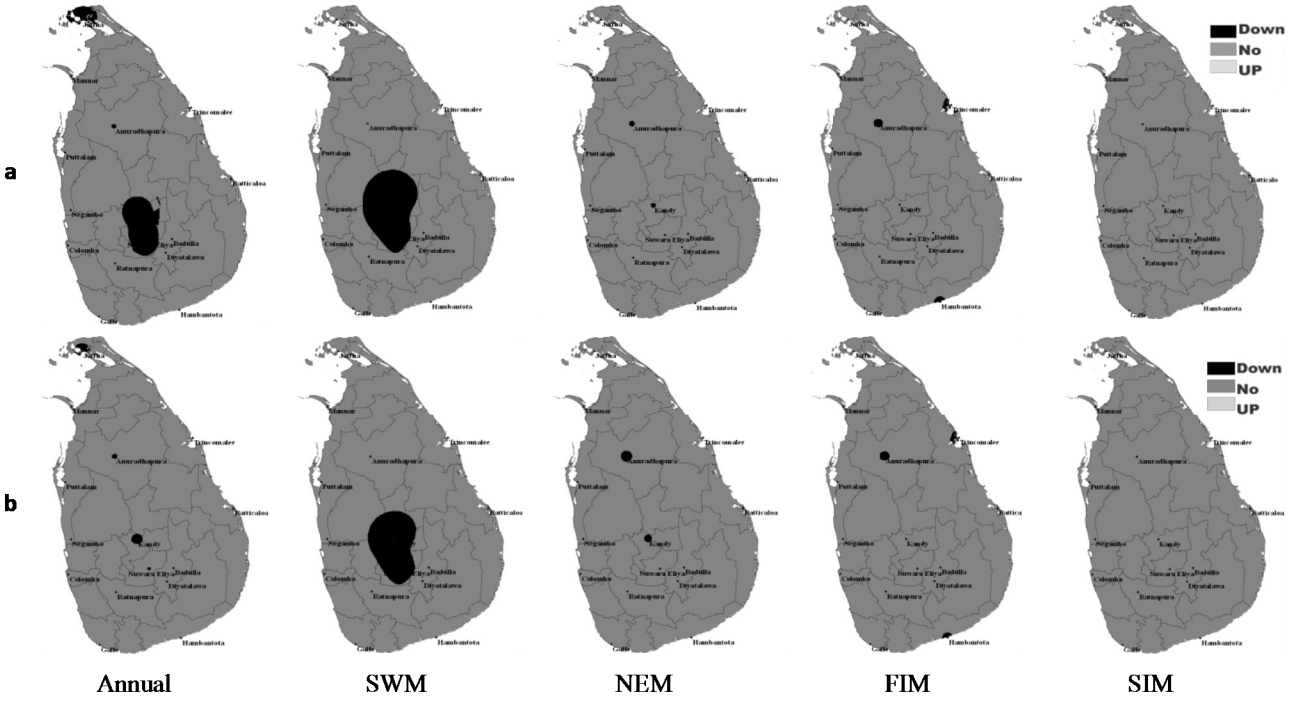

Figure 2. Spatial distribution of annual and seasonal rainfall trends as measured by the linear regression (a) and Mann-Kendal (b) tests at the =0.05 significance level

show an upward rainfall trend. An expanded downward rainfall trends could be seen in western, northwestern, northern, northeastern and eastern during the NEM season. The north-east monsoon rainfall is the main moisture carrier to the country during this season. Therefore, a clear reduction in northeast monsoon rainfalls can be expected in the future as well. However, a considerable part of the country; from central highlands to southeast coast has an upward trend in rainfall during the NEM season. Although SWM is a wet season for most parts of the country, NEM may be distinctly a dry period.

The results of historical and predicted annual and seasonal trend distributions across Sri Lanka show a clear change of the current climatic zones. During SWM, FIM and SIM seasons, there are upward predicted trend distributions for many parts of the country bringing heavy rainfalls. Furthermore, these three (3) seasons cover about nine months of the year and foam a long wet period. Therefore, the current boundaries of the wet zone could be expanded towards the dry zone and the boundaries of the current intermediate zone could also be expanded. Muthuwaththa and Liyanage (2013) have also suggested some confirming results in their studies too. Further, a considerable location around Batticaloa has a significant downward trend during all four seasons verifying a severe reduction in rainfall throughout the year. Therefore, there is a threat of developing a semi-arid region around Batticaloa and the eastern coastal belt of the county. Current semi-arid regions seem to remain unchanged in the future scenario.

CONCLUSION

Spatial distribution of predicted rainfall trends revealed that current boundaries of the wet zone of Sri Lanka may be expanded towards the dry zone and the boundaries of the current intermediate zone may also be expanded further too. A semi-arid region can be developed around Batticaloa and the eastern coastal belt of the country. Current semi-arid regions may remain unchanged in the future times.

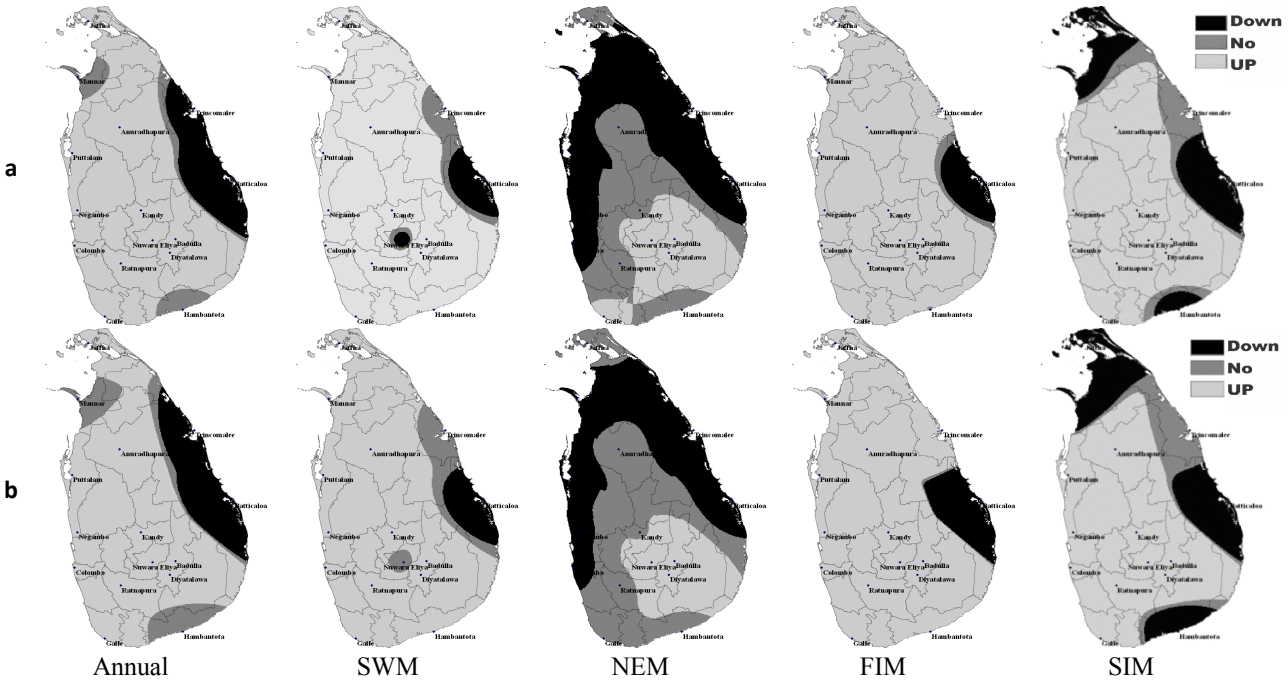

Figure 3. Spatial distribution of annual and seasonal rainfall trends as measured by the linear regression (a) and Mann-Kendal (b) tests at the =0.05 significance level

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