INTER-DECADAL VARIABILITY OF SEASONAL RAINFALL IN SRI LANKA WITHIN THE PERIOD OF 1951-2010

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INTRODUCTION

Sri Lanka is a country with an agricultural economy; therefore the seasonality of rainfall is very important. The success or failure of the seasonal rainfall significantly effects agriculture and water availability on a regional basis, and therefore is of great concern. Nevertheless, a marked variability of seasonal rainfall always contributes to a negative impact on irrigation, hydro-power generation, drinking water, and especially on farm lands.

The distribution pattern of rainfall within an average year can be divided into four rainfall seasons: first inter monsoon season (FIMS), Southwest monsoon season (SWMS), Second inter monsoon season (SIMS) and northeast monsoon season (NEMS). During the FIMS (from March to April), there is a distinct spatial pattern of rainfall over the island with only the southwest slopes of the central highlands receiving more than 1000mm of rainfall, whereas it varies between 80mm and 400mm in the rest of the country. The SWMS (from May to September), is the longest and most spatially differentiated in respect of rainfall. The highest rainfall (more than 3000 mm) is concentrated on the medium heights of the western and southwestern slopes of the central highlands, increasing up to an altitude at about 1,000m. Rainfall totals decrease steadily towards the rest of the country. The SIMS (October and November) is the most evenly balanced rainfall season in the country. During this season, the southwestern slopes of the central highlands receive an average rainfall of 750-1,000mm. This is the wettest season in the country, as a whole. During the NEMS (from December to February), the amount of rainfall over much of Sri Lanka varies widely between 300-1,500mm. The highest values are observed over the east and northeastern sectors, and the lowest values in the western and southern coastal areas. During this season, there is no large-scale orographically-originated rainfall differentiation compared with the southwest monsoon season due to leeward or rain shadow slopes of the highlands, which can be discerned (Ranasinghe 2002).

Three major climatic zones have been identified in Sri Lanka based on rainfall, soils, land used patterns and the distribution of forest species of the country. The 'wet zone' covers the southwest region, including the central hill country. The 'dry zone' consists of predominantly northwestern, northern, eastern and southeastern parts of the country and is separated by an 'intermediate zone' from the wet zone.

OBJECTIVES OF THE STUDY

The present study aims to analyze the inter-decadal variability of seasonal rainfall in Sri Lanka within the period of 1951-2010 and to identify whether there is marked variability of rainfall between the three climatic zones of Sri Lanka.

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METHODOLOGY

Data Used

Seasonal rainfall data of 23 locations in Sri Lanka (representing one location for each district) for 60 consecutive years (1951-2010) are used for the study. It is needed to mention that only two districts (Kilinochchi and Mulathivu) have not been considered for the study due to several years lapsing with missing data. Monthly rainfall data were obtained from the Department of Meteorology, Sri Lanka. The obtained monthly data was segregated into the four rainfall seasons. Furthermore, the considered time period was divided into six decades: 1951-1960, 1961-1970, 1971-1980, 1981-1990, 1991-2000 and 2001-2010.

Statistical Methods Used for the Study

Among many statistical tests available to detect the variability of rainfall, the coefficient of variability (CV) is considered to be a more robust approach and is a commonly used statistical tool to measure rainfall variability. Hence, the present study used the CV approach for the identification of inter-decadal variability of rainfall. CV refers to a statistical measure of the distribution of data points in a data series around the mean. It represents the ratio of the standard deviation to the mean. Generally, low rainfall variability is associated with lower CV values and vice versa. Being calculated as the ratio of standard deviation to the mean, the coefficient of variation is computed using the following equation:

$$(CV = SD \div Mean * 100)$$

Where, CV= Coefficient of Variability

SD=Sample Standard Deviation

75% Probable Rainfall

Calculating the reliability of rainfall can be taken into account as a satisfactory statistical tool to measure the variability of rainfall. Generally, there is a positive correlation between mean seasonal rainfall and the reliability of rainfall (Sirinanda 1970). Therefore, the spatial distribution of the reliability of rainfall positively coincided with the spatial pattern of the mean seasonal rainfall in Sri Lanka (as explained at the introductory section). Reliability of rainfall can measure using different probability levels, for example, 70, 75, 80, 85 and 90%. In the present study, a special focus will be on rainfall at 75% probability. The main justification for selecting this particular level is that it is considered to be the rainfall that is sufficient for most agricultural pursuits in Sri Lanka, which can be taken as the type of human endeavor most sensitive to the hydro-climatic environmental conditions (Alles 1970 and National Atlas of Sri Lanka 2007). The world Food and Agriculture Organization (FAO) has also recommended 75% probability as the most suitable level to measure the reliability of rainfall in agro-economy based countries. This level has been applied in several rainfall studies in Sri Lanka (Alles 1970; Domroes 1974; Panabokke 1996; Ranasinghe 2002; Sirinanda 1970 and 1983). This 75% reliable rainfall is equivalent to the lower quartile (Q_1 or the 25^{th} percentile) of an ascending sequence of data series and the formula can be written as follows:

$$P= m/(n+1)$$

(Ranasinghe 2002)

Where - **P** is the probability of a series being equaled or exceeded, **m** is the order of a rainfall series and **n** is the number in the sample.

RESULTS AND DISCUSSION

The minimum and maximum CV values that have been computed on FIMS, SWMS, FIMS and NEMS for each study location, in respect to the three climatic zones of the country, are considered for the discussion (Table 1 displays only for minimum CV values of FIMS).

Minima of CV during the FIMS is mostly confined to the decade of 1961-1970 in the dry zone (73%). The first two decades demonstrated a similar highest minima of CV in the wet zone (33% for each). In the case of the intermediate zone, 67% of minima is seen to be in the decade of 1971-1980. During the SWMS, different features could be seen in the three climatic zones. The decade of 1991-2000 stands out with highest number of minima for the wet zone, while in the case of the dry zone, the highest percentage appeared in the decade of 1981-1990. During the SIMS, the occurring minima of CV in the decades of 1951-1960 and 1961-1970 are followed by the wet zone (33% for each). The dry zone has signified the decade of 2001-2010 (55%), while both the 1961-1970 and 2001-2010 decades are followed by the intermediate zone. The higher number of minimum CV values during the NEMS have been confined to the decade of 1961-1970 for all three climatic zones, representing 78%, 45% and 33.5% for the wet, intermediate and dry zones, respectively. Table 1denotes the minimum CV values during the FIMS.

Maxima of CVs during the SWMS are different between the three zones. The highest number of stations with maxima in the wet zone corresponded in two decades; 1971-1980 and 2001-2010. However, the percentages are not that marked and represent only 27% for each. The decade of 2001-2010 was also signified by the dry zone, and denotes 45%. About 67% of maxima in CV of the intermediate zone was followed by the decade of 1991-2000. During the SIMS, for all the three zones, the majority of maxima in CV are exhibited by the decade of 1971-1980 representing 27%, 67% and 54% for the wet, intermediate and dry zones, respectively. The decade of 1981-1990 is more pronounced as having had a maxima of CVs during the NEMS, denoting 68%, 67% and 82% for the wet, intermediate and dry zones, respectively.

The minimum and maximum 75% probable rainfall value computed for the four rainy seasons for each study location, in respect to the three climatic zones of the country, are considered for the following discussion (Table 2 shows only for minimum 75% probable rainfall values of FIMS).

Table 1 - Minimum Coefficient of Variability Values during the FIMS

	Wet Zone		**Intermediate zone**		**Dry Zone**	
	Station	**Value (%)**	**Station**	**Value (%)**	**Station**	**Value (%)**
1951-1960	Kalutara Kekanadura Galle	37.9 37.3 29.6				
1961-1970	Undugoda Farm Kandy Nuwara-Eliya	17.3 16.7 22.2	Kurunegala	26.2	Humbantota Amparai Tank Batticaloa Trincomalee Polonnaruwa Anuradhapura Mannar Jaffna	44.4 30.3 53.5 57.3 32.6 27.7 49 47.4
1971-1980	Henerathgoda Rathnapura	24.7 17.1	Badulla Nalanda	29.3 36.7		
1981-1990	Colombo	37.4				
1991-2000						
2001-2010					Okkanpitiya Puttlam Vauvnia	26.8 37.5 34

Table 2 - Minimum 75% Probable Rainfall Values (mm) during the FIMS

Decade	Wet Zone		Intermediate zone		Dry Zone	
	Station	**Value**	**Station**	**Value**	**Station**	**Value**
1951-1960						
1961-1970						
1971-1980					Humbantota Batticaloa Jaffna	73.0 41.5 24.6
1981-1990	Kalutara Kandy Ratnapura Kekanadura	171 189.9 399.6 77.5	Kurunegala	303	Anuradhapura	149.3
1991-2000	Colombo Henerathgoda Undugoda Farm Nuwara-Eliya Galle	176.1 183.7 364.9 83.1 113.5	Badulla Nalanda	122.9 143.4	Okkanpitiya Amparai Tank Trincomalee Polonnaruwa Puttlam Mannar Vauvnia	139.8 34.9 28.3 27.0 103.7 41.6 79.4
2001-2010						

In terms of the minimum 75% probable rainfall, the results of the study revealed that during the FIMS, the three climatic zones are characterized with a similar pattern; the highest number of stations with the lowest reliable rainfall was demonstrated by the decade of 1991-2000 and the percentages shown were 56, 67 and 64 for the wet, intermediate and dry zones, respectively. During the SWMS, the lowest reliable rainfall was mostly confined to the decade of 2001-2010, with about 67% of the stations in the wet zone, 33.3% in the intermediate zone and 45% in the dry zone. During the SIMS, the decade of 1981-1990 demonstrated the highest number of stations with minima in the wet zone (89%) and dry zone (45%). The NEMS, too, exhibited a similar pattern to the SIMS, and the decade of 1981-1990 demonstrated 67% of minima in the wet zone and 54% of minima in the dry zone. The decade of 1991-2000 was signified by the intermediate zone (67%).

The maximum value of 75% rainfall probability of a season refers to the idea that the highest reliability of rainfall, or in other words the least variability of rainfall, within the period considered. During the FIMS, the majority of stations with maxima were found in the decade of 2001-2010, representing 44% of the wet, 67% of the intermediate and 36% of the dry zone. The three climatic zones have shown differences during the SWMS, and the decade of 1961-1970 is more pronounced for the wet zone and has covered 56% of maxima. The intermediate zone corresponded with the decade of 1971-1980 (67%) while the decade of 1991-2000 is more visible for the dry zone (36%). The decade of 1961-1970 has been signified by the SIMS, and has represented 33%, 67% and 36% of maxima for the wet, intermediate and dry zones, respectively. During the NEMS, in the wet zone, two decades (1951-1960 and 1961-1970) show a similar high percentage (44%). The decade of 1951-1960 was denoted as the highest percentage (45%) for the dry zone.

CONCLUSIONS

This study confirms that the lowest variability of seasonal rainfall is more pronounced in the decades 1951-1960 and 1961-1970, especially during the SIMS and NEMS, Relatively, the variability of seasonal rainfall is higher in the decades 1971-1980, 1981-1990 and 2001-2010, in terms of spatial distribution of decadal scale variability of seasonal rainfall, and contrasting features are marked during the SWMS. However, during the SIMS and NEMS' the wet and dry zones are mostly associated with similar patterns, while it is slightly less evident for the

intermediate zone. Finally, this study revealed that none of the rainy seasons have gone through a continuous increase or decrease in variability within the period of 1951-2010.

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