Seasonal Variation of Rainfall at Attanagalu Oya Basin

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ABSTRACT

Weather patterns in the country seem to be gradually changing affecting rainfall patterns. Understanding climate change induced variations of extreme events would allow implementation of suitable adaptive measures. Therefore, a study was conducted in Attanagalu Oya basin with the objective to analyze extreme rainfall events and to assess frequency of occurrence of extreme climatic events. Daily rainfall data from Chesterford, Vincit, Pasyala, Kirindiwela, Nittambuwa and Henerathgoda were collected from Meteorological Department for 20 years from 1991 to 2010. Rainfall frequency analysis for monthly average rainfall for two monsoons and two inter-monsoons were done employing Weibull frequency analysis model for calendar year and rainy seasons. Results revealed that the average rainfall has decreased during 2001 to 2010 compared to 1991 - 2000 in the two monsoons and two inter monsoons. Seasonal rainfall frequency analysis shows a change in rainfall pattern in the study area.

INTRODUCTION

Changes in climate occur as a result of both internal variability within the climate systems and external factors (both natural and anthropogenic) (IPCC, 2001).The United Nations Framework convention on climate change (UNFCC) defines climate change as a change that is attributed directly or indirectly to human activity, that alters the composition of global atmosphere, and that is in addition to natural climate variability over a comparable period of time (UNFCCC, 2008).

Climate change is a major environmental threat the world community faces today. Climate variability has been, and continues to be the principal source of fluctuations in global food production in the arid and semi-arid tropical countries of the developing world. Sivakumar *et al.* (2005) stated that since the effect of climate change is experienced by the humans in a longer time scale, consequences of these changes are difficult to convince the civil society. The subject of climate change has not been directly addressed in almost all the existing policies. However, a series of scientific studies and number of press reports show that climate change is well underway. While the subject of climate change is vast, there is at least one topic within climate change that deserves urgent and systematic attention, and that is the changing pattern of precipitation around the world (Dore, 2005).

The rainfall received in any region can vary with physical factors as well as human interactions. Recent observations indicate that there are significant changes in rainfall patterns in both dry and wet zones in Sri Lanka. Since average rainfall is highly influenced by the extreme cases of rainfall, it is very difficult to identify the significant changes of average rainfall but it appears that average rainfall remains unchanged. Rainfall fluctuations directly affect agricultural activities in any region (Senalankadhikara *et al.*, 2009).

Over the past several years, researchers have generated many new records of century-scale fluctuations in monsoon strength, which has allowedto develop a more comprehensive picture of the spatial and temporal fluctuations of the monsoon on this timescale (Morrill *et al.*, 2003).

There is a wide disparity in the magnitude of changes that have taken place in different rainfall seasons and different spatial locations. Although no significant changes in rainfall amount have been observed during the Southwest monsoon (mean 546 mm) and inter-monsoon 2 (mean 548 mm), rainfall in the Northeast monsoon (the *Maha* season when the majority of agricultural areas in the country receive mean rainfall of 459 mm) and inter-monsoon 1 (mean 260 mm) has reduced, with Northeast monsoon showing increased variability (Jayatillake *et al.*, 2005; Basnayake *et al.*, 2002).

Climatic changes associated with precipitation alterations may lead to more frequent occurrence of intense floods and droughts. Monsoonal patterns and precipitation frequencies are already changed or predicted to be changed. It has the potential to impose additional pressures on water availability and accessibility in various water use sectors including agriculture, livelihoods, economy and nature. Hence, this study was conducted to analyze rainfall frequencies in monsoon and inter- monsoon seasons and to assess frequency of occurrence of extreme climatic events in Attanagalu Oya basin.

METHODOLOGY

Study area

Attanagalu Oya is the major river basin in Gampaha District of the Western province of Sri Lanka with an extent of 727 km^2. It is margined by Kelani River to the South, Maha Oya to the North, mountainous zone of Kegalle District to the East and the Indian Ocean to the West. Attanagalu Oya flows through Gampaha District by providing water for irrigation and drinking water supplies.

Data collection

Daily rainfall data from five rainfall stations within the catchment area for the past twenty years from 1991-2010 (Vincit, Chesterford, Kirindiwela, Nittambuwa and Pasyala) and rainfall data from Henarathgoda station for the past fifty years from 1960-2010 were used in the study.The rainfall data were obtained from the principal government agency responsible for meteorology, the Rainfall Division of the Department of Meteorology, Colombo. Two of the six rain gauging stations, Vincit and Chesterford are located in the upper catchment; Pasyala, Nittambuwa and

Kirindiwela are located in the middle of the catchment and Henarathgoda is located at the lower part of the catchment (Figure 1).

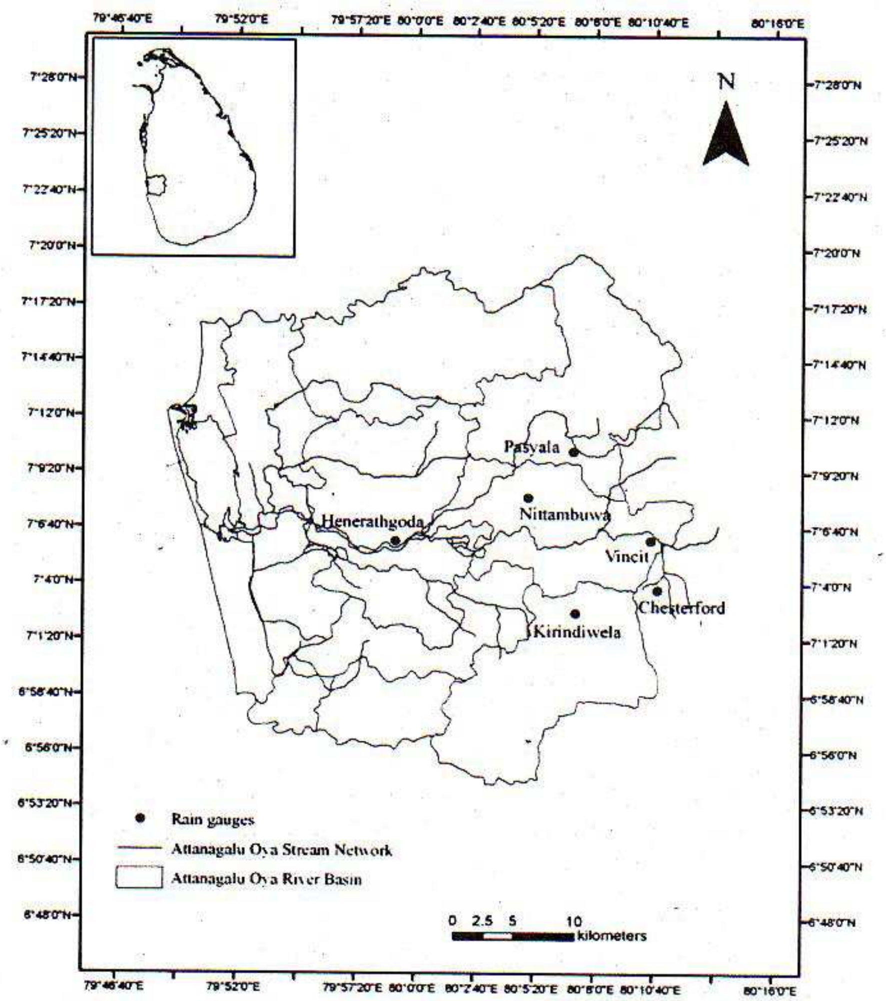

Figure 1: Stream network of Attanagalu Oya and the distribution of rain gauging stations

The purpose of the frequency analysis of a monthly series is to obtain a relationship between the magnitude of each event and its probability of exceedance. The probability analysis may be carried out either by empirical or by analytical methods. The exceedance of probability of the event obtained by the use of empirical formula is called plotting position. Weibull method was selected for the frequency analysis of rainfall data. The probability of exceedence of P is m/(N+1).

After obtaining the probability for average monthly rainfall data series, the return period of each event were calculated for each average rainfall values using the Equation 1.

$$T = \frac{1}{P} \qquad \text{(Eq. 1)}$$

where, the T is return period and P is probability of exceedance.

Having calculated the return period for all the events in the monthly annual series, the average values are plotted against the corresponding T values. Rainfall data and the return period were plotted by keeping the return period on the x axis and average rainfall on the y axis. Then the x axis was transformed to a logarithmic scale. Two trend lines were plotted for 1991 to 2000 and 2001 to 2010 periods for average rainfall for Chesterford, Nittabuwa, and Henerathgoda rainfall stations for the four rainfall seasons identified in Sri Lanka (1st Inter monsoon- March to April, Southwest monsoon - May to September, 2nd Inter monsoon - October to November, Northeast monsoon - December to February).

Rainfall analysis by weibull method

Average rainfall for each month was calculated for ten year periods (1991 – 2000 and 2001 – 2010) for each rainfall station. The average rainfall values which were calculated for ten year periods were arranged in descending order. These average rainfall values were assigned an order number m, thus for the first entry m=1, for the second entry m=2 and so on till the last event for which m=N. Mean value ($\bar{x}$) and the ($x_i - \bar{x}$)values were calculated and variance (v) of the data set was calculated using Equation 2.

$$v = \left(\frac{(x_i - \bar{x})^2}{n - 1}\right)^{0.5} \qquad \text{(Eq 2)}$$

where x is average rainfall when m = i, $\bar{x}$is mean of average rainfalls and n is number of observations in the rainfall data series. Reduced variances of the average rainfall were calculated using Equation 3.

$$Reduced\ variance\ (y) = (x_i - \bar{x}) - \frac{0.45 * v}{0.7797 * v} \qquad \text{(Eq 3)}$$

Return period of the above dataset was obtained using the Equation 4.

$$RP = \frac{1}{\left[1 - \left(Exp\left(-(Exp)(-yi)\right)\right)\right]} \qquad \text{(Eq 4)}$$

RESULTS AND DISCUSSION

Rainfall frequency analysis in the rainy seasons

Four major rainy seasons, first inter-monsoon, South-West monsoon, second inter-monsoon and North-East monsoon rainfalls were analyzed for the six rain gauging stations. Figures 2, 3, 4 and 5 show the average rainfall frequency analysis during the first inter-monsoon, South-West monsoon, second inter-monsoon and North-East monsoon periods, respectively at the rain gauging stations.

First inter monsoon period is from March to April. Average rainfall at Chesterford (Figure 2a), (upper catchment area) has increased in 2001 -2010 comparative to 1991 – 2000. This has increased the water availability during land preparation and sowing period. This increase in water levels or rainfall has disturbed paddy cultivation so that farmers tend to give up paddy cultivation in *Yala* season due to the problems they face in land preparation and sowing. Increase in rainfall in the first inter monsoon could also lead to postpone the *Yala* cultivations. Nittambuwa (Figure 2c) and Henarathgoda (Figure 2e) also have shown some changes in average rainfall but the change has less than 5 mm for both short and long return periods. This shows the increased wetness during the first inter monsoon. The reduction in average rainfall for longer return periods is an indication for increased frequency of dry spells in the first inter monsoon period. Therefore, the tendency to face more extreme weather events in the first inter monsoon has shown an increase in the Attanagalu Oya basin.

Southwest monsoon period is from May to September. In almost all the rainfall stations, the average rainfall showed a decrease in the time period of 2001 to 2010 comparative to 1991 to 2000 (Figure 3). The decrease in average rainfall during the period 2001 - 2010 is only by a very small amount (< 3 mm) except at Henarathgoda station (Figure 3e). Henarathgoda is located at the lower catchment area. At Henarathgoda, the average rainfall has decreased by more than 5 mm for return periods greater than 10 years. This is an indication that lower catchment area, there could be more water availability compared to 1991 - 2000.

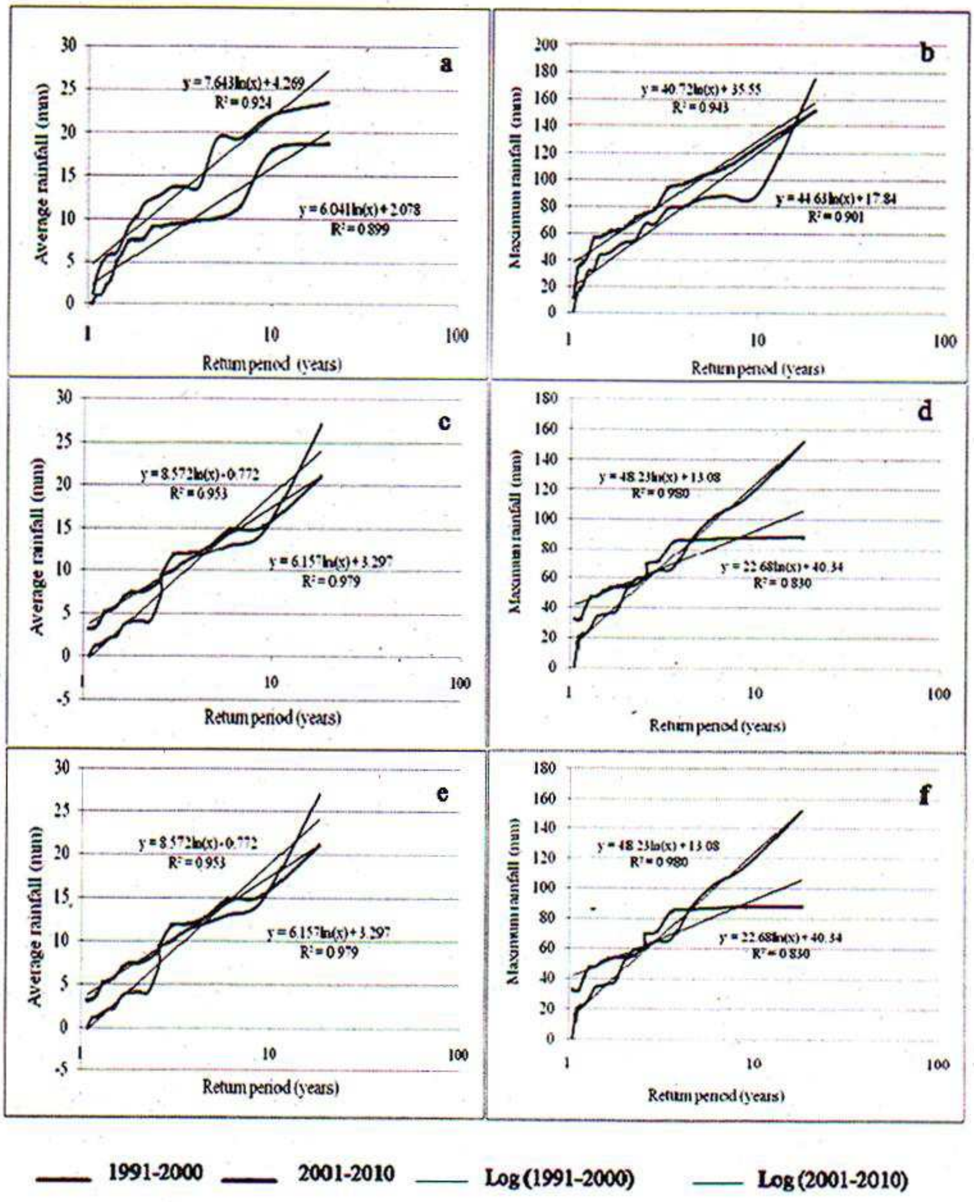

Figure 2: Average rainfall frequency analysis during the first inter-monsoon period at the rain gauging stations Chesterford (a, b), Nittambuwa (c, d), Henarathgoda (e, f)

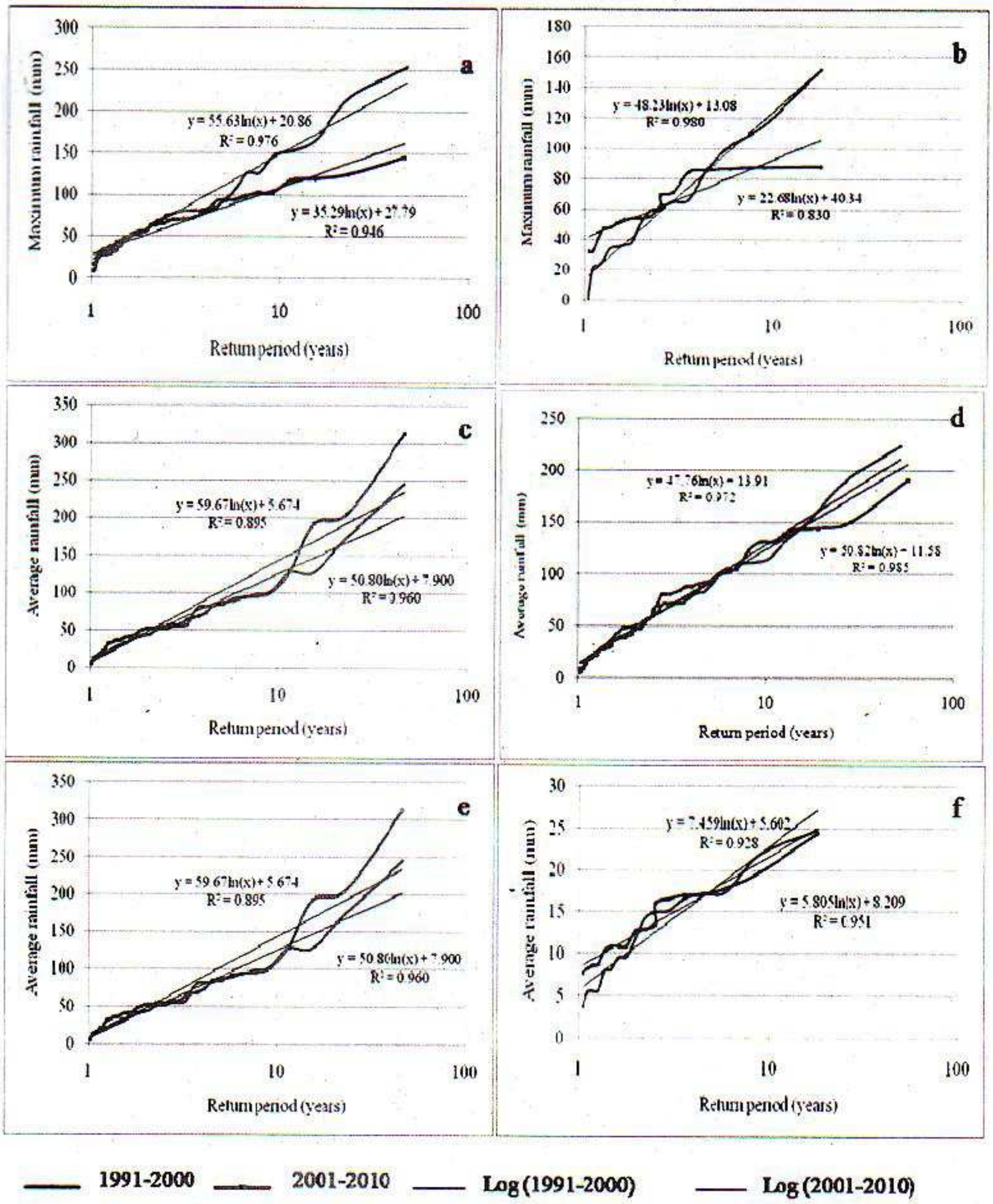

Figure 3: Average rainfall frequency analysis during the South-West monsoon period at the rain gauging stations Chesterford (a, b), Nittambuwa (c, d) and Henarathgoda (e, f).

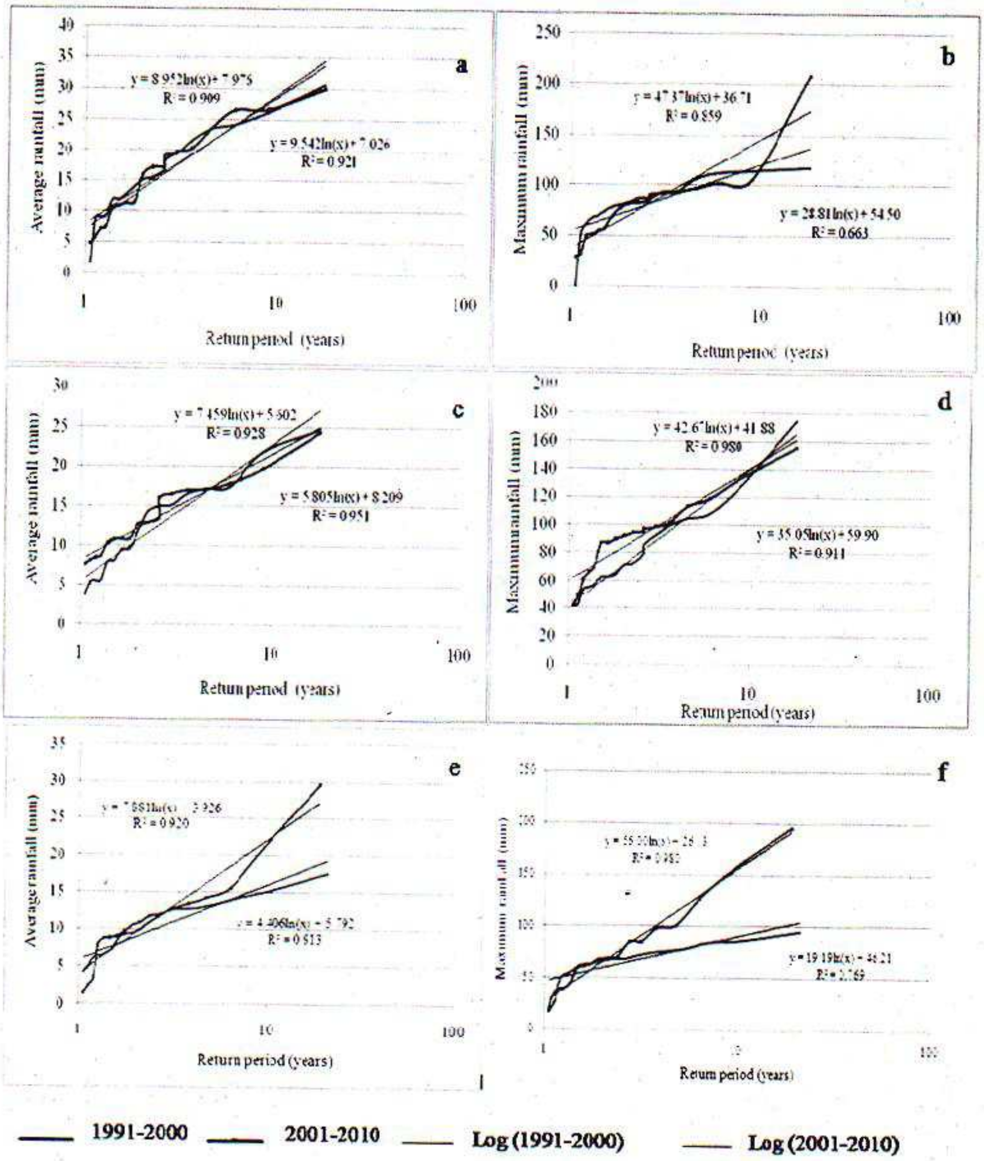

Figure 4: Average rainfall frequency analysis during the second inter-monsoon period at the study rain gauging stations Chesterford (a, b), Nittambuwa (c, d) and Henarathgoda (e, f).

Second inter monsoon period is from October to November. Average rainfall for the period of 2001 - 2010 has shown a slight decrease in stations Chesterford (Figure 4a), Nittambuwa (Figure 4c) and Henarathgoda (Figure 4e) for return periods less than 10 years compared to 1991 – 2000. The average rainfalls, therefore, at these stations do not show a significant variation. In terms of average rainfall, North East monsoon (Figure 5) shows the same trend as shown in the second inter monsoon.

Annual average rainfall over Sri Lanka has been decreasing for the last 57 years at a rate of about 7 mm per year. Southwest monsoon rainfall has not shown any significant change during 1931 to 1960 and 1961 to 1990 (Premalal *et al.*, 2009). But Jayatillake *et al.* (2005) states that there is no significant trend in Sri Lanka's Mean Annual Precipitation (MAP) during the last century although higher variability is evident. However, the MAP of Sri Lanka, estimated using Thiessen Polygon Method, has decreased by 144 mm (7%) during the period 1961 - 1990 compared to that estimated for the period 1931 - 1960 (Chandrapala 1996; Jayatillake *et al.*, 2005).

Rainfall data for the period of 1949 - 1980 at 13 stations reveal decreasing trends with steeper downward trends in recent decades (Jayawardene *et al.*, 2005). There is wide disparity in the magnitude of changes that have taken place in different rainfall seasons and different spatial locations. Although no significant changes in rainfall amount have been observed during the South-West monsoon (mean 546 mm) and Second inter-monsoon (mean 548 mm), rainfall in the North-East monsoon (the Maha season when the majority of agricultural areas in the country receive rainfall - mean 459 mm) and first inter monsoon, (mean 260 mm) has reduced, with North-East monsoon showing increased variability (Jayatillake *et al.*, 2005; Basnayake *et al.*, 2002).

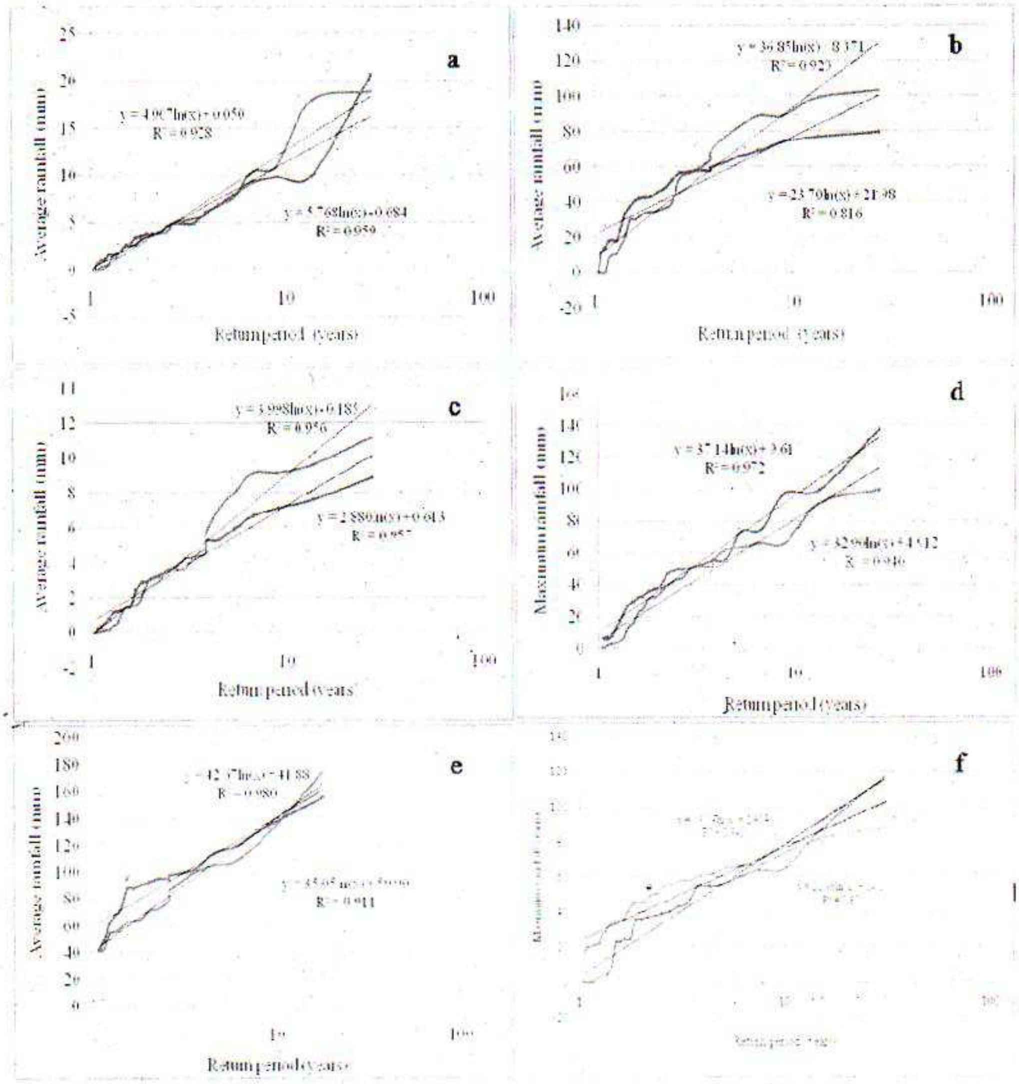

Figure 5: Average rainfall frequency analysis during the North-East monsoon period at the study rain gauging stations Chesterford (a, b), Nittambuwa (c, d), Henarathgoda (e, f).

There is little evidence for a long-term trend in Indian monsoonal rainfall, but there are multi-decadal variations. From 1906 to about 1960, monsoonal rainfall increased, then decreased through 1974 and has increased since. In Central America, for much of the period from the early 1940s to present, western Mexico has experienced an increasingly erratic monsoonal rainfall. Since 1976, increases in precipitation in the South Pacific have occurred to the northeast of the South Pacific Convergence Zone (SPCZ), while decreases have occurred to its Southwest. There have also been significant decreases in rainy days since 1961 throughout Southeast Asia and the western and central South Pacific, but increases in the north of French

Polynesia and Fiji. In long-term mean precipitation, a decreasing trend of about _4.1 mm/ month/100 years has been reported in boreal Asia. The past 10–15 years, however, precipitation has increased, mostly during the summer–autumn period. As a result of this increase in precipitation, water storage in a 1 m soil layer has grown by 10–30 mm (Dore, 2005).

In tropical Asia, hills and mountain ranges cause striking spatial variations in rainfall. Approximately 70% of the total annual rainfall over the Indian subcontinent is confined to the southwest monsoon season (June–September). The western Himalayas get more snowfall than the eastern Himalayas during winter. There is more rainfall in the eastern Himalayas and Nepal than in the western Himalayas during the monsoon season (Kripalani *et al.*, 1996). The annual mean rainfall in Sri Lanka is practically trendless though positive trends in February and negative trends in June have been reported (Chandrapala and Fernando, 1995).

CONCLUSIONS

In first inter monsoon period, average rainfall at upper catchment and middle catchment areas has increased in 2001 -2010 comparative to 1991 – 2000. In almost all the rainfall stations in South-West monsoon period, the average rainfall showed a decrease in the time period 2001 to 2010 comparative to 1991 to 2000. The decrease in average rainfall in the period 2001 - 2010 is only by a very small amount (< 3 mm). Average rainfall for the period 2001 - 2010 has shown a slight decrease for return periods less than 10 years compared to 1991 – 2000. The average rainfalls, therefore, at these stations do not show a significant variation. North East monsoon shows the same trend as shown in the second inter monsoon. Rainfall frequency analysis shows a change in monsoonal rainfall patterns in the study area.

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