Climate Change and Rain-fed Agriculture in the Dry Zone of Sri Lanka

C. R. Panabokke and B. V. R. Punyawardena

General Background

A study conducted by the International Rice Research Institute (IRRI) in collaboration with Sri Lanka's Rice Research Program of the Department of Agriculture (DoA) in 1981 was able to bring out the inherent degree of variability in rice production (both irrigated and rain-fed rice) in this country; and to make a comparative evaluation of this variability with other rice growing countries in the Asian region. A summary of the findings of this study is shown in Table 1, and the implications of these findings are discussed below.

Table 1. Variability in staple food production (1970-1980).

Country	Coefficient of variation (%)	Probability of actual production falling below 95 % of trend
Indonesia	5.4	18
Philippines	5.7	19
Bangladesh	6.4	22
India	6.4	22
Sri Lanka	9.3	29

Climatic Seasons of Sri Lanka

Climatologists have indentified four main seasons into which the climatic year of the country could be sub-divided, as shown in Table 2.

Table 2. Climatic seasons of Sri Lanka.

Season	Effective period	Rainfall (mm)	Percentage contribution
First Inter-monsoon	March to mid-May	368	14
South West monsoon	Mid-May to September	556	30
Second Inter-monsoon	October to November	558	30
North East monsoon	December to February	479	26

During the first inter-monsoon season the island is dominated by the diurnal rhythm of convectional air circulation associated with the Inter-Tropical Conveyance Zone (ITCZ), and it is also relatively free from the larger meso-regional transfer of air masses associated with global wind belts. The early stages of this season are dominated by dry weather in most parts of the country, except in the southeast where convectional circulations generate thunderstorms. As the season progresses, there is a gradual increase of rainfall, which can be attributed to the frequent occurrence of westerly air currents in the lower atmosphere; and this gives rise to what is described as the 'early surges of the South West monsoon' by Thambyahpillay (1955). These pre-monsoonal rains are largely confined to the southwestern parts of the country.

The onset of the South West monsoon usually in the latter half of May marks the commencement of enhanced rainfall in the southwest parts of the country. However, because of the pre-monsoon rains that precede this onset, the so-called 'burst' of the monsoon is less spectacular than in most parts of the Indian sub-continent. In the lower elevations of this country, this monsoon rain occurs in typical spells, but the intensity and duration of these rainy spells tend to increase in the higher elevations. By contrast, the north, north-central, eastern and southern segments of the country all fall within the rain shadow of the southwest monsoon during this period, and thereby experience dry to very dry conditions from mid-May to September. The dryness associated with the low rainfall in these areas is further enhanced by the desiccating föhn effects of the monsoonal air currents in the leeward aspects of the country's highlands. As a result, the sharpest regional contrasts of climatic conditions within the country are experienced within the season of the southwest monsoon from May to September.

Contrary to the popular perception that the South West monsoon is associated with the wettest period of the year, it is in the second inter-monsoon season that Sri Lanka records the highest monthly totals of rainfall. In the months of October and November, rainfall occurs almost uniformly across the whole country and regional contrasts in rainfall are thereby substantially reduced. The extensive occurrence of rain during this second inter-monsoon season is primarily due to the frequent movement of tropical depressions across the island, and also in part due to the air currents associated with the later surges of the southwest monsoon.

The depressional rains of October and November are a prelude to the commencement of the North East monsoon season. The heavier rainfall, which is confined to the eastern half of the country, gradually decreases from December to February. In December, the prevalence of easterly wind streams and cyclonic wind circulations could give rise to the spells of heavy rain on the eastern slopes of the highlands. The orography of the area also causes steady rains in the eastern slopes of the highlands. By February, which is the driest month of the whole country, there is a distinct waning of the effects of the North East monsoon, and a gradual re-establishment of weather conditions typical of the Inter-Tropical Conveyance Zone (ITCZ).

Variability of Seasonal Rains

In order to characterize the nature of variability of the four respective climatic seasons for the country, the coefficients of variation for two 30-year periods, namely, (a) 1930 to 1960 and (b) 1960 to 1990, were calculated, and the results are presented in Table 3.

Table 3. Variability of seasonal rains for two 30-year periods.

Season	Coefficient of Variation	
	1930-1960	1960-1990
First Inter-monsoon	31	42
South West Monsoon	23	27
Second Inter-monsoon	21	16
North East Monsoon	22	23
Annual	11	14

As can be seen in Table 3, the greatest change for the two respective 30-year periods took place during the first inter-monsoon season, which is associated with the ITCZ from the month of March to mid-May.

As discussed in the previous section of this paper, this first inter-monsoon season is strongly influenced by the nature of the convectional air circulation associated with the ITCZ and also by the pre-monsoonal rains of the southwest monsoon. Hence, it is susceptible to a greater degree of variability than the other three component seasons.

As can be seen in Table 3, it is the fourth season, namely the northeast monsoon season that shows the lowest degree of variability; and this is followed by the second inter-monsoon season.

Some Main Characteristics of Rain-fed Agriculture in the Dry Zone of Sri Lanka

Traditionally, and even from ancient times, rain-fed agriculture in the dry zone of Sri Lanka had been practiced during the 4-month period from October to January. This corresponds to (a) the second inter-monsoon season and (b) the northeast monsoon season, as shown in Table 2, which together account for 56 % of the annual rainfall. At the same time, as could be seen in Table 3, these two seasons also show a lower magnitude of change for the two respective 30-year periods. It is, therefore, reasonable that the traditional Maha cropping season in Sri Lanka has coincided with this favorable 4-month period from October to January.

Despite the foregoing conditions, agriculturists have long recognized the very high annual variation in the yield of rain-fed arable crops in the dry zone environment of Sri Lanka. Even prior to the advent of climate change in this country, the very high annual variation in the yield of rain-fed arable crops in the weakly poised rainfall systems of Sri Lanka’s dry zone had been recognized by several agricultural scientists, especially those stationed in the different districts of this country’s dry zone.

Abeyratne (1962) had clearly brought out the essential nature of this variation when he showed that over a 25-year period at Maha Illuppallama, rain-fed rice yields had ranged between 74 to 8 lb/acre, while over a 12-year unbroken period, rain-fed cotton yields had ranged between 1,120 to 220 lb/acre. He further showed that almost the whole of this variation could be ascribed to the chance of obtaining a satisfactory trend in soil moisture during the growing season.

In order to even out these wide fluctuations in yield, and to also stabilize rain-fed farming in the dry zone, Panabokke (1974) had proposed a stringent analysis of the real nature of the variability in the main maha season rainfall, and to then specify (a) proper choice of sowing dates, and (b) a selection of optimum ‘sowing-to-harvest’ duration or ‘age-class’ of the main crops so that there could be a maximum likelihood of the rainfall satisfying the ‘crop water’ demand at every stage of its growth and development.

Confidence Limits of Expected Rainfall and the Application of these Limits to Crop Water Requirements

In tropical regions in particular, it has been shown that the statistic of mean monthly rainfall even when derived from data compiled over a large number of years, is at best an unreliable guide to the variation in rainfall with which the agriculturist must contend. The arithmetic mean that is usually calculated directly from the rainfall figures does not take into account this inherent skewness of the raw data, and the fact that the data accounts for a disproportionately large amount of rain falling in heavy tropical downpours, thereby raising the level of the mean much above the normal amount of rain received or expected. Thus, unless account is taken of the skewness of the frequency distribution of the rainfall where the mode is lower than the mean, estimates of rainfall expectancy made directly from raw data could be quite misleading.

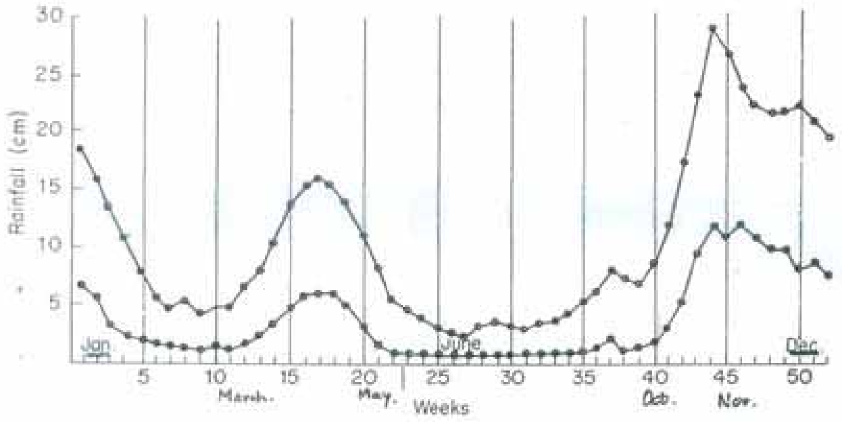
It has been show by Alles (1971), that for the months of October, November and December, both weekly and monthly rainfall values show a non-normal positively skewed distribution pattern. Clearly, any statistic derived from such distribution will give a distorted mean of the real values. Several methods are available for transforming skew data to give approximate normal distributions. The method proposed by Manning (1956) was used in this study, and the method provides a ‘completely objective and reliable estimate of rainfall to be expected, which is not apparent when means alone are used.’

By matching the crop water requirements against the 1:1 confidence limits of rainfall, it was possible to propose the age-class for any particular crop so that its water demand fitted as closely as possible with the probable seasonal supply of soil moisture.

The manner of fitting sowing data and the age-class of crops to rainfall expectancy will be outlined.

The confidence limits of the three weekly moving totals for Maha Illuppallama rainfall are shown in Figure 1. The minimum expectation for 3 years in 4 is given by the lower limit.

Figure 1. Confidence limits of three weekly moving totals of Maha Illuppallama rainfall.



Rain-fed Crop Performance for the Period 1978 to 1987 Compared with Period After 1989

Four rainfall stations in north-central Sri Lanka, which had an unbroken record of 25-years of rainfall, were selected for working out 3 weekly moving totals of 1:1 confidence limits of rainfall. Selection of optimum sowing dates, as well as optimum 'sowing-to-harvest' duration, of different crops was then proposed by Panabokke (1974). A field testing and validation of the proposed 'time-of-sowing' as well as the 'sowing-to-harvest' duration of the main coarse grain and grain legume crops, was carried out in collaboration with the Extension Division of DoA of the north-central province (NCP) in collaboration with the Regional Technical Working Group (RTWG) of the NCP over the period 1975 to 1979.

An adoption of these recommended dates of sowing as well as the age-class of the commonly grown rain-fed crops resulted in a significant stabilization of the seasonal performance of these crops throughout the 9-year period of 1978 to 1987.

However, from the year 1989, it was reported by Panabokke that an unprecedented aberration in the seasonal patterns of rainfall had been taking place to the extent that the August/September rainfall of 1986 had fallen even outside the 90 % confidence limits. Furthermore, as elaborated by Panabokke (1989) in his presentation titled 'Potential Impact of Climate Change on Agricultural Production in Sri Lanka,' it was stated that "up to 1987 it is observed that both 'within' season as well as 'between' season variation in rainfall could be statistically accommodated within the 1:1 confidence limits of expected rainfall on a weekly basis." However, after the year 1988, it is stated that the rainfall in the main season October-January was becoming more variable and more extreme, thus resulting in a destabilization of rain-fed agriculture, especially in the dry zone of the country. In effect, the popular dictum that 'the past is a key to the future' is no longer applicable because what will happen in the future is no more conditioned by what happened in the past.

The Contemporary Condition of Rainfall Variability in the Dry Zone

In order to bring out the contemporary condition in respect of rainfall variability in the dry zone, the 95 % confidence intervals of weekly rainfall for the years of 2006, 2007 and 2008 for two selected stations in the north central and southern dry zones, namely Maha Illuppallama and Weerawila, were analyzed. The results, which are presented schematically, show that for the period between the 40th and 52nd week, a drastic degree of aberration could be observed. In other words, extreme events are now the normal pattern, rather than the rare occasion they were in the past.

Correspondingly, severe aberrations in seasonal crop production in respect of the maize and cowpea crops have also been recorded.

References

Abeyratne, E. 1962. Proceedings Ceylon Association of Advancement in Science 18 (2) 58-72.

Alles, W. S. 1971. *Tropical Agriculturist* 77, 11-21.

Manning, H. L. 1956. Proceedings of the Royal Society, B, 144, 460.

Panabokke, C. R. 1974. *Journal of the National Science Council of Sri Lanka* 2 (2): 95-113.

Panabokke, C. R. 1989. Symposium on Climate Change, Ministry of Environment 45-49.

Thambyahpillay, G. 1955. The Rainfall Rhythm of Ceylon. University of Ceylon.