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IDENTIFICATION OF THE POTENTIAL OF GROWING SEASONS BY THE ONSET OF SEASONAL RAINS: A STUDY IN THE DL_1 REGION OF THE NORTH CENTRAL DRY ZONE

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Abstact: Although rainfall in the Dry Zone of Sri Lanka is highly variable spatially and temporally, years with favourable rainfall distribution could occur and it is necessary to strive for agricultural product maximizing strategies in such years. Recent studies have shown that there is a possibility of predicting the potential of the rainy seasons ahead using the correlation structure of the onset of rains and subsequent seasonal characteristics. Nevertheless, non-availability of long sequences of data limit the appropriateness of parameters of such stochastic models due to the relatively low number of extreme events found in a short data series. Under these circumstances, stochastic simulation of long sequences of rainfall data provide a better estimate of the frequency of infrequent notable events simply by providing an increased number of such events in long sequences of simulated rainfall records. Hence, a study was undertaken to find the relationship between onset time of the seasonal rains in DL_1 agro-ecological regions and subsequent seasonal characteristics such as withdrawal of rains, length of the season and amount of seasonal rainfall. The data used for the study was simulated using a stochastic rainfall generator developed for the Dry Zone's environment. Results revealed that the withdrawal of the Maha rains occurs at the end of January and hence, late onset of the Maha rains in the DL_1 region reduces the length of the effective Maha season. However, there was no strong evidence to suggest that the onset of the Maha season has an impact on the amount of total rainfall during the Maha season. Irrespective of the onset of the season, Yala rains paused around 5-6 weeks from their onset. However, it was clearly evident that the onset of the Yala rains cannot be used as a predictor for the amount of seasonal rainfall during the Yala season.

Key words: Onset, seasonal characteristics, simulated data, Yala and Maha

INTRODUCTION

Many agronomic experiments conducted in the Dry Zone for decades have taken only little account of the variation in climatic potential in the region. This has led to slow progress in exploiting the agricultural potential of the Dry Zone. Even under highly erratic rainfall regimes, years with favourable rainfall distribution could occur and it is necessary to strive for product-maximizing strategies in such times. Hence, early identification of the "potential" of a season is very important in designing appropriate strategies for increased food production in the Dry Zone. Recent studies of rainfall from 18 countries in Asia, Africa and North America, suggest that

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prediction of the rainy season potential could be possible using correlation between onset and seasonal characteristics such as total seasonal rainfall and the time of the withdrawal of rains.[1] If any association between start of the season and seasonal characteristics is to be found, it could be used to predict the behaviour of upcoming seasons in advance. Such information has very significant practical implications especially in the DL_1 agro-ecological region of the Dry Zone where upland crop production during both Maha and Yala seasons is mostly rainfed. For example, it enables farmers to minimise the effects of drought by making the most efficient use of the scarce rainfall in a poor (dry) season, and to maximise the production in good seasons by exploiting the rainfall.

Nevertheless, the association between the start of rains and seasonal characteristics has not been comprehensively and adequately studied for the Dry Zone's environment mainly because of the restricted availability of a long series of historical data. When the input data cover only a limited time of the historical data, appropriateness of the parameters of such deterministic models become limited only to average situations. Under these circumstances, use of stochastically simulated long sequences of rainfall data is more appropriate as it provides a better estimate of the frequency of infrequent notable events simply by providing an increased number of such events in long sequences of simulated rainfall records.

The objective of this study was to find a relationship between onset time of the seasonal rains and subsequent seasonal characteristics such as withdrawal of rains, length of the season and amount of seasonal rainfall using simulated rainfall data for the DL_1 region of the North Central part of the Dry Zone.

METHODS AND MATERIALS

The weekly rainfall data for this study was generated using a weekly stochastic rainfall generator/model.[2] This rainfall generator simulates weekly data of rainfall by using a first order Markov chain and four theoretical probability distributions, namely, Exponential, Log-Normal, Gamma and Weibull, upon providing historical data for parameter estimations. Fifty one years (1945-1995) of weekly historical rainfall data from Maha-Illuppallama (DL_1 agro-ecological region[3]) was used for parameter estimation and iterative running of the rainfall model simulated weekly rainfall data for 1,000 years.

Time of onset, withdrawal of rains and length of the rainy season: Three key parameters, which characterize the rainfall season for crop production, have been identified as time of the onset, withdrawal of rains and the length of the rainy season.[4] Various definitions of the onset of the rains exist in literature depending upon the time scale of the data used and the geographical location of the study.[5-9] In order to decide a criterion for the onset of the season, which is favourable for the commencement of cultivation operations, two basic requirements have to be satisfied.[10] First, that a sustained rain spell, which more or less represents the transition from dry season to wet season, should be identified. Secondly, in the spell so chosen, the rain that falls should percolate into the soil up to a reasonable depth and also build a moisture profile therein after loss through evaporation. Keeping in view the above requirements in association with physical properties such as water holding capacity, expected evaporative conditions in the atmosphere and normal depth of seed placement of the major soil group of the DL_1 region, Reddish Brown Earth (RBE) soils, the following criterion was chosen to define the onset of the seasons in terms of rainfall; a spell of at least 30 mm of rain per week in three consecutive weeks after a pre-specified week for the Maha (standard week 35) and Yala (standard week 9) seasons. If a three weeks criterion was not satisfied, the condition was relaxed up to two consecutive weeks with rainfall equal to or greater than 30 mm. This relaxation was particularly important for the Yala season where the continuity of the rains is always uncertain. In the literature, the criterion for onset does not consider continuity up to two or three weeks. For example, the growing season in Maharashtra, India is defined as the first appearance of a week with cumulative rainfall of 25 mm without considering the post-conditions.[9] But under the Dry Zone's conditions where the rainfall is patchy and intermittent in nature, an evaluation of the continuity up to two to three weeks is necessary to avoid a false start of the seasons. Similarly, the first occurrence of a long dry spell (three consecutive weeks with less than 30 mm of rainfall after a pre-specified week, standard week 50 and 16 for Maha and Yala seasons, respectively) was used as the criterion for the end of a season. Length of the season was taken as the number of weeks between the end of the season and the onset of the season. Using these criteria, onset and withdrawal of the rainy season and the amount of the rainfall within each season were determined from the simulated data. Such a large number of simulation data ensured the inclusion of all possible extreme values of the rainfall process. Once these attributes are determined for each simulated year, a linear regression analysis was performed between onset and withdrawal, length of the season and amount of seasonal rainfall. Moreover, some simple probability calculations were also carried out on the onset time of the seasonal rains using simulated data.

RESULTS AND DISCUSSION

Relationship between the onset of rains and the characteristics of the Maha season

The computed average onset of rains during the Maha season was around mid October, the standard week number 42, and these rains remain effective until late January of the following year, the standard weeks 4 and 5 (Table 1). The coefficient of variation of the onset of the Maha rains (CV = 0.06) was relatively lower than that of the onset of the Yala rains (CV = 0.30). The relationship was opposite for the end of rains where the withdrawal of the Maha rains (CV = 0.53) was more variable than the Yala rains (CV = 0.27). The highest probability of the occurrence of onset was on the standard week 40 while the cumulative probability of the weeks 40 and 41 accounted for 44 per cent (Table 2). Thus, unlike the Yala season, it is likely that the Maha season should start within the first couple of weeks of October. The average length of the Maha season was around 14 weeks being longer than the Yala season. The amount of Maha seasonal rainfall was also less variable than the rainfall in the Yala season. These comparative statistics between the Yala and Maha seasons confirm the general rule: rainfall variability is the highest and its reliability the least where the total rainfall is the lowest.[12]

Table 1: Descriptive statistics of the Maha season rainfall in the DL_1 region of the Dry Zone, Maha - Illuppallama, with 1,000 years of simulated data.

	Mean	SD	CV	Minimum	Maximum
Onset (week No.)	42.0	2.9	0.06	3.0	50.0
End (week No.)	4.2	2.2	0.53	1.0	20
Length of the season (weeks)	14.2	3.5	0.25	1.0	43.0
Amount of rainfall (mm)	800.0	278.8	0.35	24.4	1937.4

SD= standard deviation CV= coefficient of variation

Table 2: Probability of a week being the onset of the Maha season in the DL_1 region of the Dry Zone, Maha-Illuppallama.

Onset week	Probability
Absence of a season	0.000
On or before week number 38	0.031
Week number 39	0.031
Week number 40	0.234
Week number 41	0.204
Week number 42	0.146
Week number 43	0.123
Week number 44	0.118
Week number 45	0.024
On or after week number 47	0.089

Any significant correlation between onset of the rains and its withdrawal was not evident in the Maha season ($r^2 = 0.001$). However, the suggested regression equation consists of a constant, namely, the intercept of 5.1 which was highly significant ($P < 0.01$). This again confirms that the end of the season should occur after the standard week 5, last week of January, and it is common for any year irrespective of the onset time of Maha rains. There was an interesting relationship (equation 1) between the onset and the length of the Maha season which was highly significant ($r^2 = 0.40$; $P < 0.01$).

$$L = 46.7 - 0.776\,S \quad \text{[1]}$$

where,
L = length of the season in weeks
S = starting standard week

The above relationship suggests that the later the onset, the shorter the season's length because the end of the season is almost constant in any year. But the correlation of determination (r^2) of this relationship was only 0.40, which implies that the strength of the relationship is 0.63. It has been suggested that any relationship having a correlation coefficient value greater than 0.70 alone is worthwhile to be considered for any predictive purposes because it can explain at least 50% of the total variation.[12] Hence, as the correlation is weak, the onset time of the Maha rains cannot be used for predicting the duration of the Maha season without wide margins of error.

There was no evidence to suggest that the onset of the season has a significant impact on the amount of rainfall received during the Maha season. The correlation coefficient between the two parameters was only 0.44, which is not strong enough to draw any useful conclusions. This implies that even a late season could produce the same rainfall as an early season. A previous study conducted for the Dry Zone of Sri Lanka with limited years of actual data has drawn a similar conclusion.[1] But it does not provide a meaningful explanation for this unusual behavior of the Dry Zone's rainfall compared to other tropical countries in the world. Thus, it can be hypothesized that:

* late seasons always bring heavy downpours causing the seasonal average to push towards the long term seasonal average or;

* early seasons may have fluctuations in rainfall which cause the seasonal average to be around the long term seasonal average and/or;

* late seasons bring moderate amounts of rainfall consistently throughout the season making the average closer to the long term seasonal average.

But it should be cautioned that these explanations are neither complete nor definitive, but are simply intended to describe the extraordinary behaviour of rainfall in the Dry Zone compared to other tropical regions.

Relationship between the onset of rains and the characteristics of the Yala season

The average time of the onset of the Yala season was in late March, standard week 13, while the end of the season was in late April (between standard weeks 18 and 19). The average length of the season was around 5 weeks. (Table 3). The Coefficient of Variation (CV) of the start and end of the seasons is 0.30 and 0.27 respectively. Thus, the variability of the start and end of the Yala season is almost similar. With 1,000 years of weekly simulated data, a significant positive correlation was evident (equation 2) between the onset and the withdrawal of the Yala season rains ($r^2 = 0.64$, $p < 0.01$).

$$E = 4.70 + 1.05\,S \quad [2]$$

where,
E = standard week number of the end of the season
S = standard week number of the start of the season

Table 3: Descriptive statistics of the Yala season rainfall in the DL_1 region of the Dry Zone, Maha-Illuppallama, with 1,000 years of simulated data.

	Mean	SD	CV	Minimum	Maximum
Onset (week No.)	13.0	3.8	0.30	0.0	22.0
Withdrawal (Week No.)	18.2	5.1	0.27	0.0	25.0
Length of the season (week)	5.3	3.1	0.58	0.0	19.0
Amount of rainfall (mm)	265.3	165.4	0.62	0.0	1022.9

SD= standard deviation CV= coefficient of variation

This relationship confirms the underlying trend that would account for an average five-week period for the end of the season from the start of the season. The correlation between the start of the season and the length of the season was very poor ($r^2 = 0.003$). This indicates that irrespective of the start of the season, the Yala rains pause around five to six weeks from the onset. The relationship between the seasonal rainfall during the Yala season and the onset of the rains was also very weak ($r^2 = 0.02$), implying that the onset time cannot be used for predicting the seasonal rainfall. The probabilities of different weeks to be the onset week were calculated using simulated data (Table 4). It shows that even the average start of the Yala season, the standard week 13, has only

18% probability to be the onset week. The following week also has a similar chance to be the onset week. There is also 4% probability of not having a Yala season at all and 20% probability of the season becoming extremely late, after the standard week 16 (Table 4). There is a cumulative probability of 18% for the season to become effective as early as standard weeks 11 and 12. The above analysis confirms that agricultural planning in the Dry Zone during the Yala season cannot be formulated from the alternatives based on the onset time of the Yala rains.

Table 4 : Probability of a week being the onset of the Yala season in the DL_1 region of the Dry Zone, Maha-Illuppallama.

Onset week	Probability
Absence of a season	0.042
On or before week number 8	0.071
Week number 9	0.016
Week number 10	0.010
Week number 11	0.084
Week number 12	0.098
Week number 13	0.180
Week number 14	0.192
Week number 15	0.093
Week number 16	0.066
On or after week number 17	0.148

CONCLUSION

In general, the onset time of the rains as a predictor for the amount of rainfall and the duration of the season in either the Maha or Yala season at DL_1 region was not clearly evident in this simulation study. In practical terms, failure to predict the Maha rains by the onset time may not be so serious because of the proven reliability of the total Maha rains, especially as the region is equipped with an excellent network of small and large tanks and canals, thus ensuring at least one annual cropping season for the farmer. It was also apparent that the withdrawal of Maha rains takes place at the end of January and hence, late onset may always result in a shorter season. In the light of weak correlation between onset time and the rainfall of the Maha season, it can be assumed that irrespective of the onset time, the Maha rains bring fairly equal amount of rainfall per season every year.

With regard to the Yala season, the existence of a reliable rainfed Yala cultivation season has always been debatable. Although this study has failed to demonstrate a predictable rainy Yala, it has nevertheless served to further define the nature of the Yala rains. Analysis has confirmed that Yala rains are highly variable and most probably the length of the season may not exceed five weeks of duration from onset time.

References

1 Stewart J.I. (1988). *Response farming in rainfed agriculture*. The Wharf Foundation press, Davis, California, USA.

2 Punyawardena B.V.R. (1998). *Assessment of growing season characteristics in the Dry zone of Sri Lanka based on stochastic simulation of rainfall and soil water*. Ph.D Thesis. Lincoln University, New Zealand.

3 Panabokke C.R. & Kannangara R.P. (1975). The identification and demarcation of the agro-ecological regions of Sri Lanka. *Proceedings of Section B. Annual Session of Sri Lanka Association for the Advancement of Science*. **31**(3): 49.

4 Sivakumar M.V.K. (1990). Exploiting rainy season potential from the onset of rains in Southern Sahelian Zone of West Africa. *Agriculture and Forest Meteorology* **51**: 321-332.

5 Sivakumar M.V.K. (1988). Predicting rainy season potential from the onset of rains in Southern Sahelian and Sudanian climatic zones of West Africa. *Agricultural and Forest Meteorology* **42**: 295-305.

6 Stern R.D., Dennett M.D. & Dale I.C. (1982). Analyzing daily rainfall measurements to give agronomically useful results. I. Direct methods. *Experimental Agriculture* **18**: 223-236.

7 Benoit P. (1977). The start of growing season in Northern Nigeria. *Agricultural Meteorology* **18**: 91-99.

8 Virmani S.M. (1975). *The agricultural climate of Hydrebad region in relation to crop planning*. ICRISAT, Patancheru, Andra Pradesh, India.

9 Raman C.R.V. (1974). *Analysis of commencement of monsoon rains over Maharashtra state for agricultural planning*. Published scientific report No.216. India Meteorological Department, Poona. India.

10 Mavi H.S. (1986). *Introduction to agro-meteorology*. 98-126 pp. Oxford & IBH Publishing Co. New Delhi, India.

11 Kalma J.D., Lyons T.J, Nunez M. & Pitman A.J (1991). Advances in understanding meso-scale climatic variability. In *Climatic risk in crop production. Models and management for the semi arid tropics and subtropics.* Eds. R.C. Muchow, and J.A. Bellamy. pp. 445-464. C.A.B International.

12 Chatfield C. & Collins A.J. (1992). *Introduction to Multivariate analysis*. P 41 Chapmann and Hall, London., New York.