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Rainfall and Paddy Production in Sri Lanka

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Abstract

Sri Lanka experienced severe droughts and floods during the recent years which resulted much crop losses in the paddy production. Effective rainfall periods for the major paddy producing seasons, Maha and Yala seasons are determined according to the crop calendar of the Districts. Here, the impact of rainfall on the paddy production is analysed for each Districts of Sri Lanka during the period from 1961 to 1980. Significant correlation coefficients reveal the clear effect of rainfall on the paddy production, especially in harvest acreage in the Wet and Dry zones. The regions in the Wet Zone have significant positive relationship in the Southwest monsoon season and the Dry Zone in the second intermonsoon and Northeast monsoon seasons as their principal cropping seasons. The Maha rain effects on the sown extent and harvest acreage not only in the same Maha season, but also in the subsequent Yala season sometimes. The excess rainfall amount does not increase the paddy acreage and causes floods even in the drier parts of the country, indicating a negative relationship between rainfall and sown or harvest acreage. Therefore, we can recognize four types of relationships between rainfall and paddy production: (1) significant positive relationship, (2) significant negative relationship, (3) no significant relationship and (4) others, for instance, there is a significant positive relationship below certain critical values and no relationship above the values.

1. Introduction

Sri Lanka is located within ten degrees north of the equator (5°55′ – 9°51′ N), separated by narrow Palk Strait from the Indian sub-continent. The country's major subsistence agriculture is predominantly influenced by rainfall variations, rather than the other climatic elements. Mainly the paddy cultivation is most liable to be effected by large scale aspects of droughts and floods. As Robertson (1975) stated, the main environmental characteristic which sets rice apart from other cereal crops is its water requirements. Therefore, the island's rainfall basically controls the paddy production and these aspects could be noticed by statistical approach.

Though the country's paddy production increased sharply, since independence (Johnson *et al.*, 1981; Yoshino *et al.*, 1983c), its greater interannual variability is inevitable. Looking at the actual figures of the total paddy production in busheles and in acreages, one can conclude that the upward trend in paddy production is mostly attributed by the increase of paddy lands, rather than the yield functions. This fact is similar to Indian paddy cultivation. Farmer (1981) noted, even in India, especially in Tamil Nadu, the 'Green Revolution' is not successful in paddy cultivation compared with other crops, such as wheat. Though, the other paddy producing factors such as guaranteed price scheme, the fertilizer, agricultural credit, paddy land acts, crop insurance, improved varieties, extension services and other technological factors (Farmer, 1977) contribute to the year to year increase in paddy production, its high interannual variability is attributed by rainfall variations.

The rainfall amounts, seasonal distribution, intensity, frequency of occurrence, spatial and temporal variations are more important in case of tropical agriculture (Jackson, 1977). The impor-

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tance of rainfall in paddy production in Sri Lanka have been studied by various authors, for example, Domrös (1974), Okamoto (1976), Sirinanda (1983) and Thambyahpillay (1960). These aspects have been also treated generally to some Asian countries (Fukui, 1982), especially in India (Saha and Mooley, 1978), SE Asia (Maruyama, 1978), Bangladesh (Mowla, 1978), Africa (Agnew, 1982) and Malaysia (Nieuwolt, 1981). Recent study on selective Districts in Sri Lanka (Yoshino *et al.*, 1983a) showed the direct and indirect influence of rainfall on paddy production, indicating positive or negative relationships between rainfall and paddy acreage data. In the present study, the same method and data have been applied for each District of the entire island in order to study the relationship between rainfall and paddy production.

2. Data and method

The entire country is analysed according to the 22 Administrative Districts in 1977. The rainfall and paddy acreage data have been collected from the source by Yoshino *et al.* (1982). One climatological or rainfall station has been chosen in each District to show the crop-climate relationship. Rainfall data for few stations have been obtained originally from the records of the Department of Meteorology, Colombo. Though new Districts have been promulgated in 1978, paddy acreage do not show greater difference, except Nuwara Eliya.

The major paddy producing seasons in Sri Lanka are named as the Maha and Yala season and were generally divided as follows (Domrös, 1974): Maha season—October to March, and Yala season—April to September. As the durations of these two seasons are too longer, it is needed to determine the shorter period in order to explain the accurate relationship between the paddy acreage and rainfall variations in the respective seasons. Therefore the effective rainfall period of growing season is taken according to the crop calendar presented by Ichikawa *et al.* (1982) and Yoshino *et al.* (1983c): The period from October through February for the Maha season and from May to August for the Yala season. Apart from this division, the effective rainfall periods for the Maha season and Yala season in Badulla and Moneragala Districts are given separately. Those are from January to May for the Maha season and from August to November for the Yala season.

The direct relationship between the actual values of rainfall and paddy production is generally uncertain or not easily predictable (Domrös, 1978; Harriss, 1977) and show significant correlation only in some Districts of Sri Lanka. Variations in agricultural production, however, are generally related to deviations from the normals or the long year tendencies as has been made clear in the previous studies (Yoshino *et al.*, 1983a, c). These have been best described also in term of the 'growing season concept' (Smith, 1975). Therefore, initially the regression line was fitted to find the paddy acreage increase during the period from 1961 to 1980. Next the deviation values of paddy acreage from the regression line (positive or negative) were taken as a reliable measure for the analysis. In case of rainfall the actual and deviation from the mean of the time series were taken for the study. The Pearsonian correlation coefficient which is commonly used to describe the relationship between two time series, was adapted to show the relationship between rainfall and paddy acreage. Calculations were done according to the procedure given by Hammond and McCullagh (1978). Besides these the paddy acreage is analysed on the basis of sown extent and harvested acreage. Figure 1 indicates the names and locations of the Districts and climatological or rainfall stations.

3. Rainfall and paddy: A general view

In this section, general descriptions of the rainfall and paddy are given in order to come for the detail analysis of the relationship between rainfall and paddy production.

(a) Annual rainfall

Figure 2 illustrates the mean annual rainfall distribution of Sri Lanka. It reveals a clear contrast in spatial pattern. The maximum rainfall regions are located on the windward slopes of the central highlands. The region which located on the western flanks is influenced by Southwest monsoon, while the eastern flanks are influenced by Northeast monsoon. Besides these phenomena, disturbances within the Intertropical Convergence Zone (ITCZ), thunderstorms, tropical depressions and cyclones do influence on the rainfall distribution of Sri Lanka. The mean annual rainfall decreases from southwest to northwest, north,

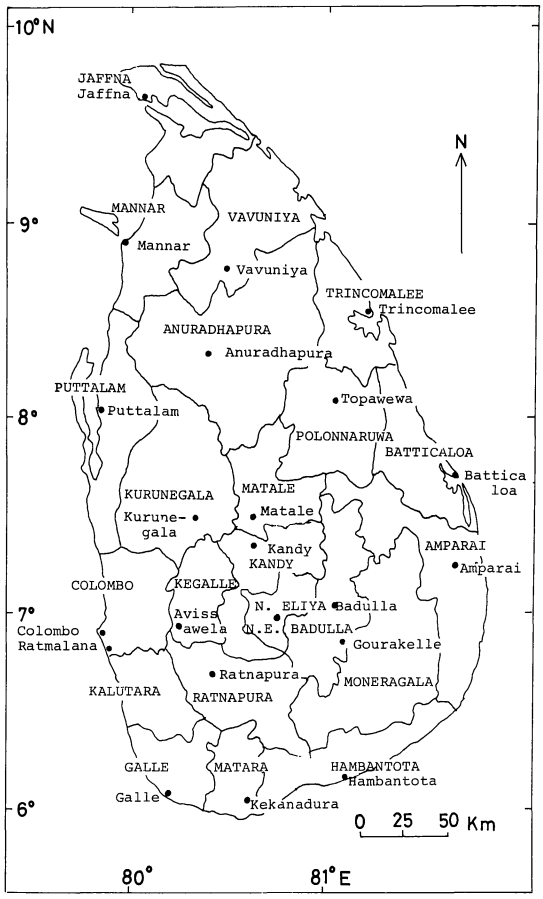

Fig. 1. Names and locations of the Districts and climatological or rainfall stations (shown as black circles) used in this study.

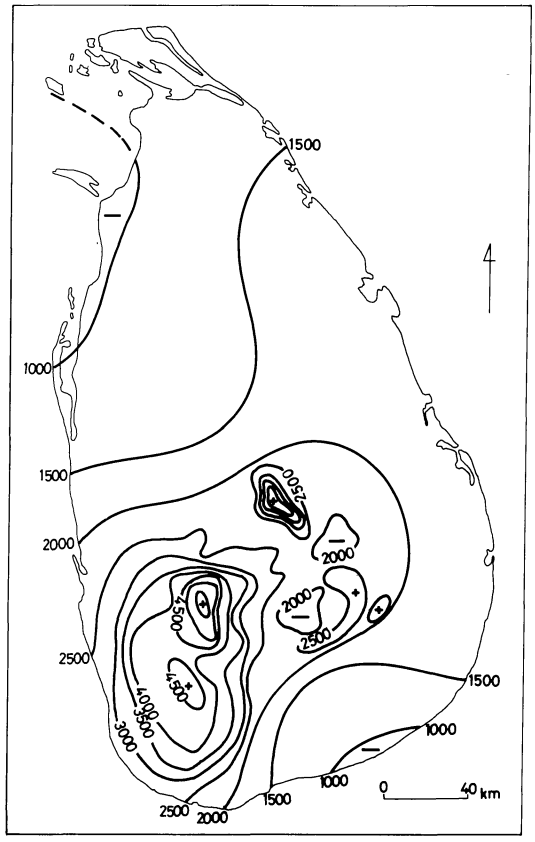

Fig. 2. Mean annual rainfall of Sri Lanka in mm. Average of 1931–1960.

northeast, east and southeast with variation from 5,700 mm to 1,000 mm. Therefore the southwestern part of the island is called as "Wet Zone" and the other parts are characterized as "Dry Zone". Generally rainfall decreases towards southeast and northwest suddenly, while it decreases gradually towards the other directions. Besides these aspects the central highlands show greater meso-scale effect on rainfall distribution. The Uva Basin and Dumbara Valley could be taken as examples to show such effects.

(b) Seasonal rainfall

Seasonal rainfall and its variations in the climatological standpoint have been studied by Domrös (1974), Sirinanda (1983) and Thambyahpillay (1960) and the climatic seasons by Thambyahpillay (1954). Here, the seasonal rainfall and its variations related to the paddy cultivation are dealt with from the agro-climatological standpoint. Figures 3 (a) and (c) show the seasonal distributions of rainfall for the Maha season and Yala season and Figures 3 (b) and (d) their variabilities for the respective seasons. Looking at the rainfall distribution for the Maha season, the seasonal amount varies from 700 mm to 1,400 mm. Generally speaking, period from October to November (second intermonsoon season) is a rainy season all over the island. The period from December to February (Northeast monsoon season) give little or no rain to the entire country except the east coast regions and the east flanks of the central highlands. The second intermonsoon season is least liable to drought conditions (Jayamaha, 1976), especially the month of November. Incidently this is the principal storm period over Sri Lanka. The Maha season crop coincides with the two climatic seasons mentioned above. The southwest quadrant and the eastern regions experience more rainfall than the other regions.

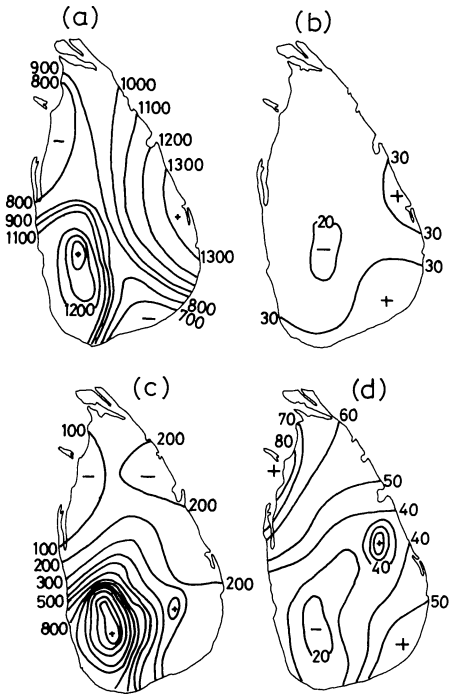

Fig. 3. Seasonal rainfall of Maha (a) and Yala (c). Coefficient of variation (standard deviation is divided by the mean of the time series and expressed in percentage) for Maha (b) and Yala (d), 1961–1980.

Mannar and Hambantota Districts receive less than 800 mm of rainfall. Besides these the contrast in the rainfall pattern is not clear in this season.

The rainfall distribution of the Yala season coincides with the Southwest monsoon season (late May to late September), showing a clear contrast in its pattern. The seasonal amount varies from 100 mm to 1,300 mm. The heaviest falls are found to be located on the western slopes of the central highlands. The Southwest monsoon brings heavy rain to its windward slopes and blows as the warm and dry fall wind, kachchan, over the Dry Zone of Sri Lanka (Yoshino, *et al.*, 1983b) and this wind has a strong influence on agricultural activities in this Zone. The region around Mannar receives least rainfall during this season. The gradual decrease towards other directions, is seen in this season too.

The variability of rainfall for the Maha season ranges from 20% to 30%. The maximum values are found on the east, southeast and south coasts and the lowest values are in the western slopes of the central highlands. In the Yala season the values range from 18 to 80% (18% at Ratnapura and 80% at Mannar and Topawewa). The minimum values confined to the western slopes and generally lower values cover the Wet Zone. Variability increases toward all directions from southwest.

(c) The Wet Zone and Dry Zone

Conventionally, Sri Lanka is divided into two major climatic zones, Wet and Dry Zones as mentioned above. Various criteria have been put forward based on annual or the Southwest monsoon rainfall to demarcate the boundary between these zones and the factors have been extensively discussed by various scholars; for example, Domrös (1971) and Thambyahpillay (1965). The Dry Zone covers 65% of the total land area and the rest are occupied by the Wet Zone. The major paddy producing season in the Dry Zone comes during the Maha season while in the Wet Zone during the Yala season. The Wet Zone does not show greater difference in land-use between the two cropping seasons, while the Dry Zone shows greater difference due to the seasonal drought.

(d) Paddy lands

There is a marked difference in the land-use pattern between the two distinct zones in Sri Lanka. The Wet Zone Districts are mainly fulfilled with rainfed and minor irrigation lands. Especially in the lowlands most of the paddy lands are under the rainfed conditions. The highland paddy fields in the Wet Zone mostly come under the minor irrigation, but due to seasonal drought, under major irrigation in the Dry Zone. The rainfed paddy fields are comparatively smaller in percentage. The minor irrigation lands too, play an important role in the total land-use in the Dry Zone. The paddy lands increased sharply in the Dry Zone since independence due to the governmental process and reconstruction of irrigation schemes. Generally the areal expansion and year to year increment in the paddy lands in the Dry Zone is much more greater than in the Wet Zone. This fact was noticed by Fukui (1982), too. Although the highlands account for the paddy lands, its terraced paddy fields are basically irrigated by the minor irrigation systems such as anicuts (anicut (English), anaikattu (Tamil), means small dam or weir across a stream) and elas (ela (Sinhalese) canal or small stream), which means

small dams and canals respectively.

4. Rainfall and paddy acreage relationship

The statistical results of the relationship between rainfall and paddy acreage are dealt with in this section. Figure 4 shows the distributions of the Districts with the significant levels of correlation coefficients between the respective parameters for the Maha season. The actual values of rainfall R, its deviation RD, the actual sown extent acreage S, its deviation SD, the actual harvest acreage H and its deviation HD are taken to show the relationships. The significant relationship between the actual values of rainfall and sown extent acreage is not clearly shown, but the deviation values of those parameters show better results. Badulla and Moneragala Districts, which lie in the rain shadow area for its Maha crop indicate negative correlation coefficients. Amparai District too shows a negative relationship during the cultivation season.

The significant level is higher between rainfall and harvest parameters. Jaffna, Mannar and Puttalam Districts, which have more paddy lands in the drier parts, the actual values of rainfall and harvest relationship is very high. Vavuniya and Kurunegala Districts show significant positive correlations at 5% level, but Amparai, Badulla, Matale, Matara and Moneragala Districts show negative correlations. This is also true between RD and H. Looking at the results between the deviation values, the relationships are much more clear. Most of the Dry Zone Districts (Anuradhapura, Hambantota, Jaffna, Mannar and Puttalam Districts) indicate higher significant relationships at 1 or 5% levels. The region comprising Galle and Matara Districts shows a negative relationship. Generally speaking, the impact of rainfall on

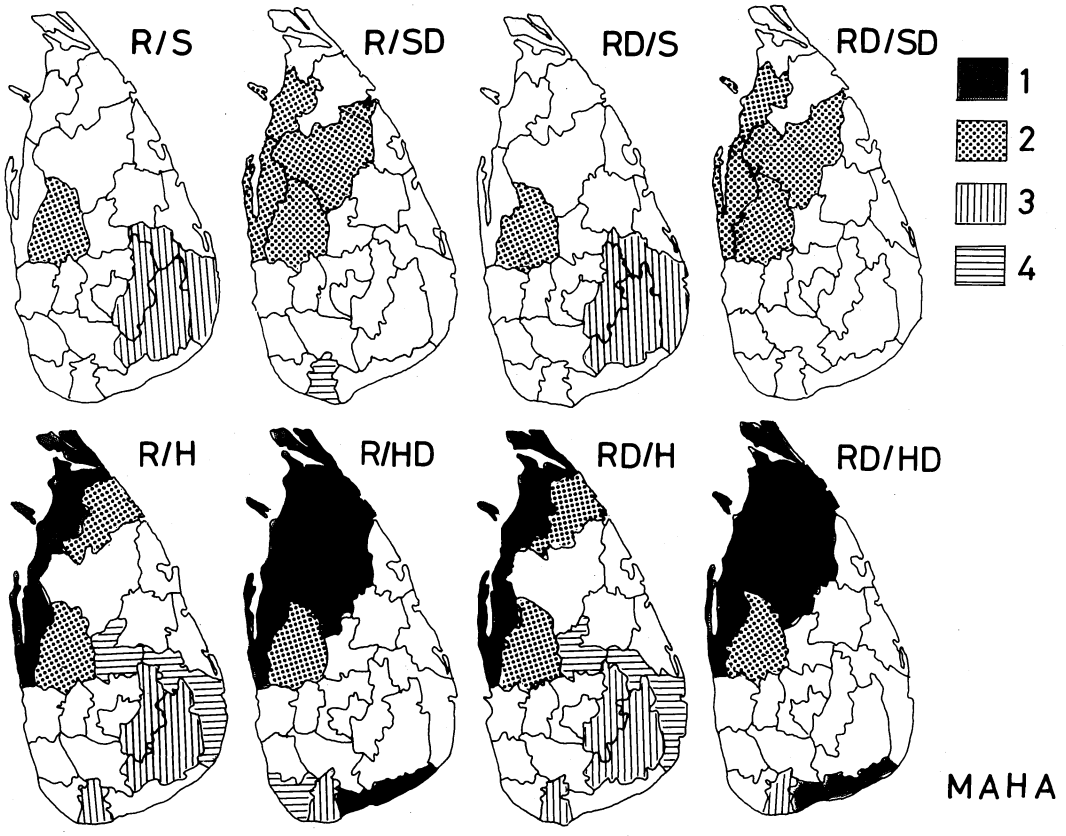

Fig. 4. Significant levels of correlation coefficients between the respective parameters for the Maha season. 1= positive 1%, 2= positive 5%, 3= negative 1% and 4= negative 5%. R: rainfall, RD: rainfall deviation, S: sown extent, SD: sown extent deviation, H: harvest acreage and HD: harvest acreage deviation.

harvest acreage is much clearer than sown extent acreage. The reason why there are some Districts in the Dry Zone showing the positive relationship and the negative relationship, is difficult to explain at present. It seems, however, that there might be some climatic conditions, because the negative relationship Districts are located in the eastern part of the islands and the Maha season cultivation begins and ends later than the other Districts (Yoshino *et al.*, 1983c). In Figure 5, the positive relationship between rainfall and paddy acreage on the basis of their deviation values in Anuradhapura District is shown as an example. Most of the Dry Zone Districts show similar pattern, while Galle, Matara, Badulla, Moneragala and Amparai Districts have a different one. In order to express appropriately the regional difference in absolute values in the interannual variation of rainfall anomalies, the deviations in Figures 5, 9 and 11 are indicated in percentage. Figure 6 shows an example of negative relationship between the rainfall values and harvest acreage at Matara District. The reason of such relationship is not clear as stated above. A further study is needed. In the driest parts, so-called arid regions of Sri Lanka have a unique relationship between rainfall parameters and harvest acreage deviations, as shown by an example in Jaffna District as shown in Figure 7. The anomalous negative departure of rainfall below −10 cm causes much damage to the crops, but the anomalous positive departure does not increase the harvest acreage beyond the value −10 cm. The excess rainfall does not mean the increase of harvest and causes flood conditions even in the drier parts during the Maha season.

Another interesting fact is that the hysterical aspect of rainfall influences on the paddy cultivation in Sri Lanka. The anomalous negative departure in rainfall for more than a year influence the following Maha crop, even the particular year has normal or above normal rainfall. This is a striking phenomenon in the Dry Zone Districts. This fact was noticed during the Maha season of 1976/77 followed by low rainfall values in 1974 and 1975 Maha seasons (see Figure 5). The above mentioned phenomenon does not arise in the Wet Zone Districts.

Significant levels of correlation coefficient between rainfall and paddy acreage parameters for the Yala season are illustrated in Figure 8. As the Yala season coincides with the Southwest monsoon rainfall, the Districts in the Wet Zone show higher significant levels between rainfall and paddy acreage in the correlation coefficients. Roughly

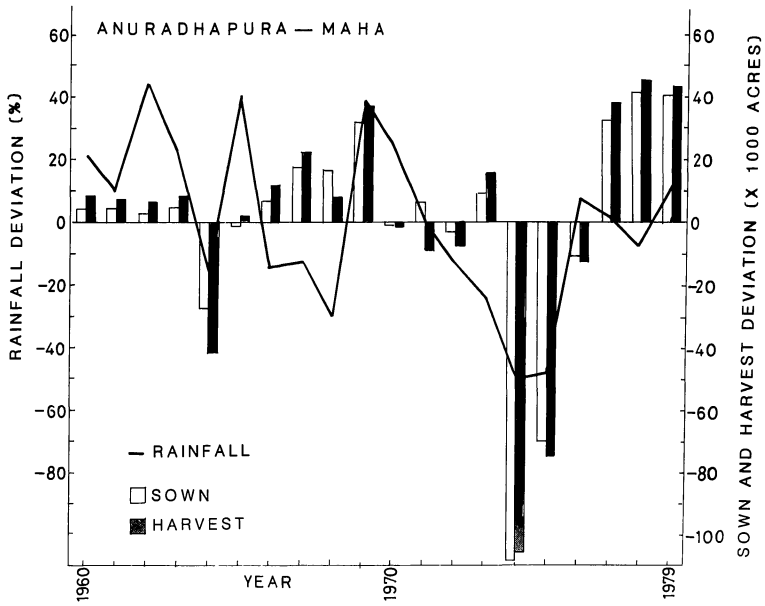

Fig. 5. Deviation values of rainfall and paddy acreage for the Maha season in Anuradhapura District.

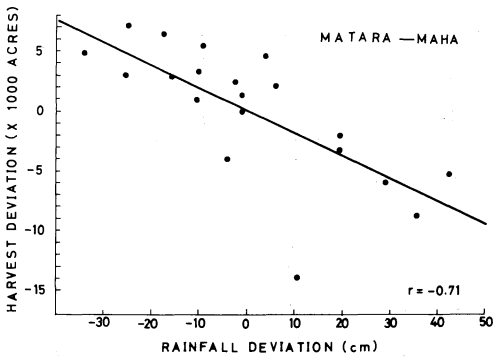

Fig. 6. Relationship between rainfall deviation and harvest acreage deviation for the Maha season in Matara District.

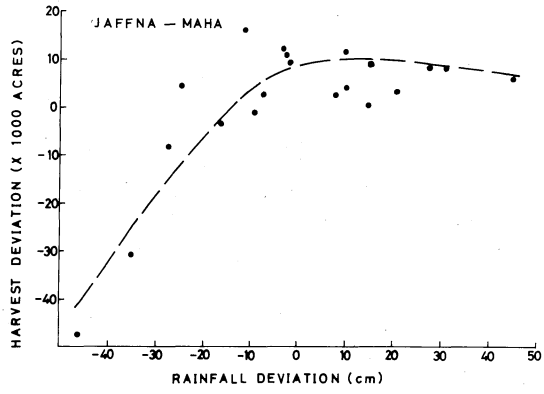

Fig. 7. Relationship between rainfall deviation and harvest acreage deviation for the Maha season in Jaffna District.

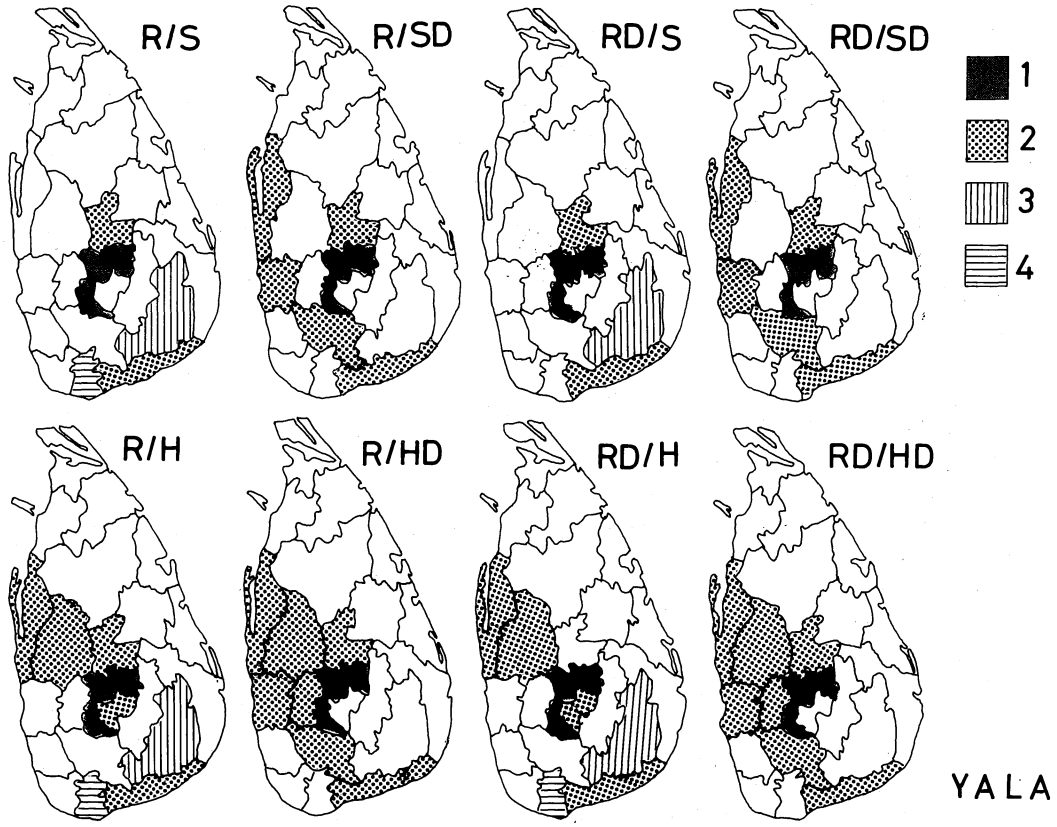

Fig. 8. Significant levels of correlation coefficients between the respective parameters for the Yala season. Explanation for 1 to 4 and parameters as in Figure 4.

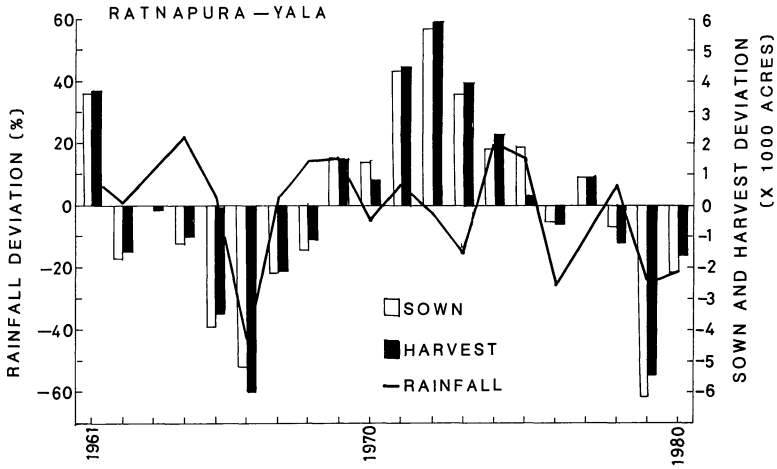

Fig. 9. Deviation values of rainfall and paddy acreage for the Yala season in Ratnapura District.

speaking, the relationships between rainfall and sown extent or harvest acreage show positive in the Districts mainly in the Wet Zone, except Matara and Moneragala Districts. Among others, the positive correlation is the strongest in Kandy District, where the all cases are significant at 1% level as shown in Figure 8. Most of the Wet Zone Districts show positive relationship. The significant level between rainfall and harvest parameters in the Yala season is more clearly evident as has been analysed in the Maha season.

An example of secular changes of rainfall, sown extent and harvest acreage in Ratnapura District for the Yala season is shown in Figure 9. Kandy District accounts for higher correlation coefficients among all selected parameters, as stated above and Figures 10 (a) and (b) illustrate the relationships between rainfall and deviation, sown extent and harvest acreage in Kandy District.

The Southwest monsoon causes water deficit conditions particularly in the Wet Zone. This is a serious problem in the highlands than in the Wet Zone lowlands, because the minor irrigation schemes often become insufficient for irrigation due to lower stream flow, below the anicut. Such conditions have been observed in the 1966 and 1976 Yala seasons in Kandy, Kegalle and Ratnapura Districts. Apart from this, floods during the Southwest monsoon too, they effect the paddy production in the lowlands as waterlogging in the paddy fields.

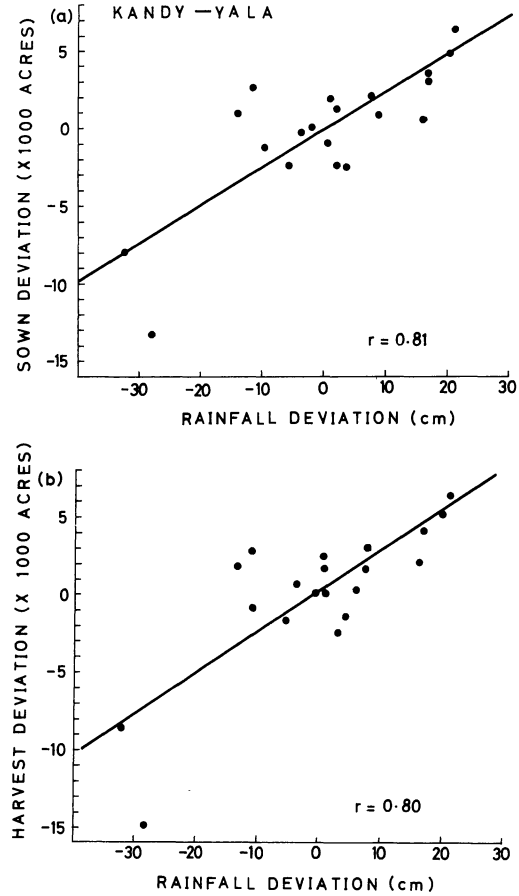

Fig. 10. Relation between rainfall deviation and sown extent deviation (a) and between rainfall deviation and harvest acreage deviation (b) for the Yala season in Kandy District.

In the Dry Zone, the Yala crop entirely depends on irrigation from the tanks. Here, the excessive rainfall in the Maha season or water deficit conditions influence the following Yala crop. The availability of water resources stored in tanks are basically fed by Maha rains. Excess rainfall in the Maha season and early land preparation for the Yala crop increase the yield and reduce crop losses (Alles, 1967). The effect of Maha rain on the following year Yala crop have been noticed by Gooneratne (1978) too. Yoshino *et al.* (1983c) made clear that such a climatically critical event occurs in the case when the Maha season rainfall is lower than the value, mean minus standard deviation as an average of whole Sri Lanka. Figure 11 illustrates an example of the relation between Maha rains and the following Yala paddy acreage in Jaffna District on the basis of their deviation values. This is a striking phenomenon in the drier parts of the country, because of available water.

5. Climatic hazards

Among the climatic hazards only the principal droughts and floods are discussed in this section. As the interannual variation of air temperature is relatively small all over the island, abnormal climatic conditions are caused by rainfall variations, as has been discussed generally for the tropics (Nieuwolt, 1968). A partial drought can effect the growth of the plant but an absolute drought can cause a complete crop failure. The rainfed paddy cultivation is most liable to be effected by droughts and floods. The paddy cultivation which depends on major irrigation schemes is least liable to short-term droughts or partial droughts. But large or absolute severe drought conditions effect on all the paddy cultivation. The effect of drought conditions is much more striking in the Dry Zone Districts than in the Wet Zone Districts. Generally, low rainfall during the months between October and January results much crop losses in the country. The absence of tropical depressions and cyclones during this period causes 'water deficit' conditions in the Dry Zone of the country (Thambyahpillay, 1965). These events have been noticed in 1964, 1968, 1974 and 1975 during the period 1961 – 1980. On the other hand, late arrival and early retreat of Southwest monsoon cause droughts in the Wet Zone in the Yala season. The Wet Zone highlands are most liable to be effected by low rainfall during the Yala season, because the minor irrigation schemes are easily effected by low rain-

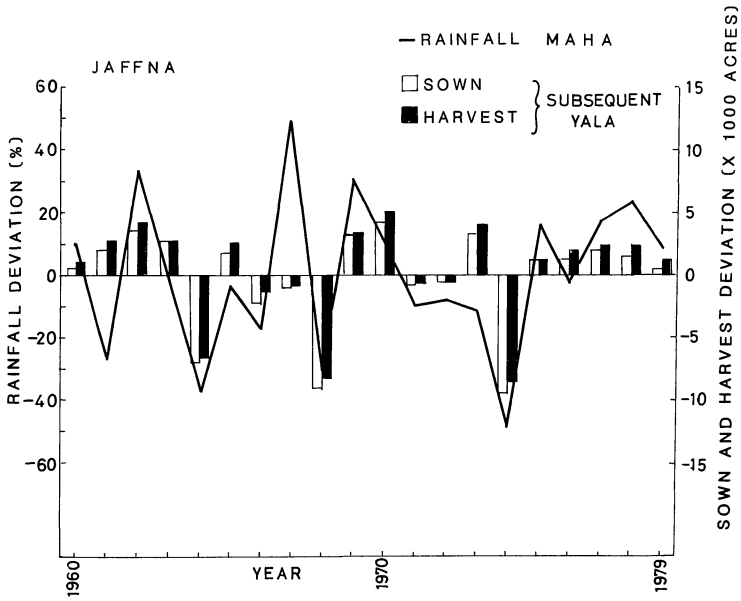

Fig. 11. Deviation values of rainfall in the Maha season and paddy acreage deviation in the subsequent Yala season in the Jaffna District.

fall. Such cases were found in the 1966 and 1976 Yala seasons, which resulted in much crop losses in the Wet Zone highland paddy cultivation.

As stated earlier, floods also cause much damage to crops in the country. During the Maha season torrential rain causes waterlogging and flood conditions in the lowland paddy fields. This problem is very common in the Wet Zone lowlands, for example, Colombo, Galle, Kalutara and Matara Districts. In the Dry Zone Amparai, Batticaloa, Polonnaruwa and Trincomalee Districts are liable to be effected by flood conditions. It could be proved by statistical analysis too. Heavy rains are basically attributed by depressions and cyclones, which cross over Sri Lanka during the Maha season. For example, 60% of the paddy lands at Batticaloa District had been destroyed by the severe cyclonic storm in November 1978 (Suppiah, 1982). In addition heavy rainfall due to Northeast monsoon or under the influence of ITCZ causes floods in the east coast regions. Continuous heavy rainfall during the Southwest monsoon season and second intermonsoon season destroy more crops in the lowland Wet Zone.

6. Conclusion

The relationships between rainfall and paddy sown extent or harvest acreages are clearly evident in Sri Lanka. Most of the Dry Zone Districts show significant relationship with the Maha season rain while the Wet Zone Districts with the Yala season rain. But there are some Districts which show significant relationship in both seasons, because those Districts have paddy lands under the two zones and effected by both monsoons. The deviation values from regression line, calculated from 20 years data, show higher levels in correlation coefficients than the actual values. The low rainfall, lower than the value mean minus standard deviation, in the Maha season causes severe crop losses in the country and in the subsequent Yala season and in some cases in the following Maha season in the Dry Zone of Sri Lanka. The Southwest monsoon failure results water deficit conditions in the Wet Zone highland paddy lands and excessive rainfall in both seasons cause floods and waterlogging conditions in the lowlands of the country. The regions comprising Badulla and Moneragala Districts have different effective rainfall period in their paddy producing seasons. These regions should be studied in detail in future.

Generally, the impact of rainfall on harvest acreage is clear than sown extent acreage. There are many Districts in the Dry Zone showing the positive relationship between the Maha rainfall and sown and harvest acreage, but it is interesting to note that there are also Districts showing the negative relationship. Furthermore, the rest of the Districts show no significant relationship. In the Yala season, there are three kinds of Districts, but only two Districts have negative relationship. The reason for these is not clear. In the driest part of Sri Lanka, there is a unique relationship: In the range of anomalous negative departure of rainfall below −10 cm, the relationship is positive, but above −10 cm, the rainfall has no effect on the harvest acreage.

References

1) Agnew, C. T., 1982: Water availability and the development of rainfed agriculture in south-west Niger, West Africa. *Trans. Inst. British Geog.* N.S., **7**, 419–457.
2) Alles, W. S., 1967: Soil and water conservation in the Dry Zone. In *The Development of agriculture in the dry zone* ed. by O. S. Peries. Sri Lanka Association for the Advancement of Science, Colombo, 29–36.
3) Domrös, M., 1971: "Wet Zone" und "Dry Zone" möglichkeiten einer kilomaotologischen Raumgliederung der Insel Ceylon. In *Landschaftsökologische Forschungen auf Ceylon.* Erdkundl. Wissen, **27**, 205–232.
4) Domrös, M., 1974: *The agroclimate of Ceylon.* Geoecological Research, Franz Steiner Verlag, Wiesbaden, **2**, 266p.
5) Domrös, M., 1978: Aspects of recent rainfall fluctuations with regard to land utilization in Sri Lanka. In *Climatic change and food production* ed. by K. Takahashi and M. M. Yoshino. University of Tokyo Press, Tokyo, 101–110.
6) Farmer, B. H., (Ed.), 1977: *Green Revolution? Technology and change in rice-growing areas of Tamil Nadu and Sri Lanka.* MacMillan, London, 429p.
7) Farmer, B. H., 1981: The "Green Revolution" in South Asia. *Geography,* **66**, 202–207.
8) Fukui, H., 1982: Variability of rice production in tropical Asia. In *Drought resistance in crop with emphasis on rice,* IRRI, 17–37.

9) Gooneratne, W., 1978: Recent climatic fluctuations and food problems in Sri Lanka. In *Climatic change and food production* ed. by K. Takahashi and M. M. Yoshino. University of Tokyo Press, Tokyo, 111–123.
10) Hammond, R. and McCullagh, P. S., 1978: *Quantitative techniques in geography: An introduction.* Clarendon Press, Oxford, 364p.
11) Harriss, B., 1977: Paddy and rice statistics in Sri Lanka. In *Green Revolution? Technology and change in rice-growing areas of Tamil Nadu and Sri Lanka* ed. by B. H. Farmer. MacMillan, London, 20–29.
12) Ichikawa, T., Yoshino, M. M., Urushibara, K., and Nomoto, S., 1982: Long term fluctuations of paddy harvest during the Southwest and Northeast monsoons. *Proc. Ass. Japanese Geogr.,* **21**, 252–253 (in Japanese).
13) Jackson, I. J., 1977: *Climate, water and agriculture in the tropics.* Longman, London, 248p.
14) Jayamaha, G. S., 1976: An analysis of droughts in Sri Lanka. *Proc. Indian Nat. Sci. Acad.,* **42**, 133–148.
15) Johnson, B. C. L. and Scrivenor, M Le M., 1981: *Sri Lanka: land, people and economy.* Heinemann Educational Books Ltd., 154p.
16) Maruyama, E., 1978: Fluctuations of paddy yield and water resources in Southeast Asia. In *Climatic change and food production* ed. by K. Takahashi and M. M. Yoshino. University of Tokyo Press, Tokyo, 155–166.
17) Mowla, K. G., 1978: Relation between climatic fluctuations and rice productions in Bangladesh. *Ibid,* 137–146.
18) Nieuwolt, S., 1968: Uniformity and variation in an equatorial climate. *Jour. Trop. Geog.,* **27**, 23–29.
19) Nieuwolt, S., 1981: Tropical rainfall variability – The agroclimatic impact. *Agricul. Environ.,* **7**, 135–148.
20) Okamoto, T., 1976: *Some agro-climatic aspects of paddy cultivation in Sri Lanka.* Central Agricultural Research Institute, Peradeniya, Department of Agriculture, Sri Lanka, 368p.
21) Robertson, G. W., 1975: *Rice and weather.* World Meteorological Organization, Tech. Note No. 144, Geneva, 40p.
22) Saha, K. R. and Mooley, D. A., 1978: Fluctuations of monsoon rainfall and crop production. In *Climatic change and food production* ed. by K. Takahashi and M. M. Yoshino. University of Tokyo Press, Tokyo, 73–80.
23) Sirinanda, K. U., 1983: Rainfall variability patterns and agricultural production in Sri Lanka. *Climat. Notes,* **33**, 83–110.
24) Smith, K., 1975: *Principles of applied climatology.* McGraw-Hill Book Company (UK) Ltd., 233p.
25) Suppiah, R., 1982: Some aspects of the cyclone over Sri Lanka, November 23/24, 1978. *Climat. Notes,* **30**, 126–139.
26) Thambyahpillay, G., 1954: The rainfall rhythm in Ceylon. *Univ. Ceylon Rev.,* **12**, 224–273.
27) Thambyahpillay, G., 1960: Agro-climatological significance of the rainfall variability in Ceylon. *Agriculture,* **3**, 13–23.
28) Thambyahpillay, G., 1965: Dry zone climatology. *Jour. Nat. Agricul. Soc. Ceylon,* **2**, 88–130.
29) Yoshino, M. M. and Suppiah, R., 1982: Climatic records of Monsoon Asia. Part Ic and IIa with appendix. *Climat. Notes,* **31**, 1–80.
30) Yoshino, M. M. and Suppiah, R., 1983a: Climate and paddy production: A study on selective Districts in Sri Lanka. *Climat. Notes,* **33**, 33–50.
31) Yoshino, M. M., Urushibara, K. and Nomoto, S., 1983b: Kachchan, a local wind in Sri Lanka. *Climat. Notes,* **33**, 191–206.
32) Yoshino, M. M., Ichikawa, T., Urushibara, K., Nomoto, S. and Suppiah, R., 1983c: Climatic fluctuation and its effects on paddy production in Sri Lanka. *Climat. Notes,* **33**, 9–32.

スリランカにおける降雨量と米作

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要　　約

スリランカは近年ひどい干ばつや洪水によって米作にいちじるしい被害を受けている。主要な米作期間であるマハ季とヤラ季の県別の作物カレンダーによってまず有効な降雨期間を決定した。ここでは 1961年～1980年の

資料について分析を行った。米作に及ぼす降雨量の明らかな影響はウェットゾーンとドライゾーンの収獲面積について特にはっきりと認められた。有意な正の相関は，南西季節風季におけるウェットゾーンと第2中間季節風季と北東季節風季におけるドライゾーンにみられる。マハ季の雨はそのマハ季の播種面積と収獲面積に影響を及ぼすばかりでなく，それに続くヤラ季の播種面積や収獲面積に影響を及ぼす。余分な降雨量は収量を増加させず，かえって減少させることが乾燥した地域の県で明らかである。すなわち降雨量と播種面積または収獲面積とは負の相関が見出される。それ故，降雨量と収獲量との間の関係は4つの型がある。つまり(1)有意な正の相関，(2)有意な負の相関，(3)有意な相関がみられない，(4)その他，例えば，ある限界値までは正の相関があって，それ以上になると無関係になる，の4つの型である。