WATER BALANCE AND THE IRRIGATION NEED OF RICE IN DIFFERENT AGRO ECOLOGICAL REGIONS OF SRI LANKA

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ABSTRACT

Daily rainfall and pan evaporation in 22 locations of Sri Lanka for more than 35 consecutive years were analyzed to assess the Agro climatic potential of different regions in respect to moisture availability, for which the computer program "first " was developed . In the program Markov chain procedure is employed to analyze dry and wet spells; forward and backward rainfall accumulation probability curves are incorporated to decide upon the crop establishment time and the point at which two curves are bisected was considered as the probability at which the particular crop could be grown. Water balance of the localities were assessed using the Hargreave's Moisture availability index (MAI) and Troll's criteria. The program CROPWAT was used to estimate irrigation need to plot the rainfall, evaporation, water balance, crop performance probability and irrigation need maps.

From the stand point of the water balance approach for Yala and Maha seasons two hydrologic regions, namely humid and semi-arid regions are identified for the Maha season (fig.3) and three hydrological regions viz. Humid, Semi-arid, and Arid regions, in Yala season. The entire dry zone remains arid in the Yala season (Fig.4) Crop commencement in these regions could be done in 42nd - 43rd weeks.

Performance probability of rice in the "Maha" season appeared to be lowest in Hambantota and Puttalam, and highest at Batticaloa, Trincomalee and Polonnaruwa areas. It was established that irrigation need in Maha and Yala seasons as 597-1000 mm, (except Hambantota area) and 1200-1300 mm.

INTRODUCTION

Sri Lanka is a tropical island with an area of 65610 sq. km, where the double cropping of rice is practiced for centuries using the rainfall of north-east and south -west monsoons. The monsoon regime demarcates two distinct seasons for cropping practices namely "Maha" (major) and "Yala" (minor) seasons.

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The minor season doesn't carry sufficient moisture for a pure rain fed crop in many parts of the island. Thus in respect to the rainfall distribution pattern, Sri Lanka is divided into wet, intermediate, and dry zones which are further sub-divided into 21 agro-ecological zones. Accordingly eleven agro-ecological regions have been identified for the wet zone, four in the intermediate zone and six in the dry zone (National Atlas of Sri Lanka)

The wet zone covers 1.54 mln ha, where annual precipitation ranges from 2300-5100 mm. The intermediate zone is spread over 0.85 mln ha where annual rainfall is 1600-2300 mm. The major part of the island is covered by the dry zone (4.17 mln ha) where annual rainfall ranges from 900-1500 mm.

Present agricultural policies of the government are geared to settle the farmers in the north-central and eastern dry zones with the aim of intensifying paddy cultivation by means of irrigation in the additional land of 364200 ha and 60000 ha in north-central and south-eastern dry zone respectively. It is also envisaged to increase the rice production up to 4.5 t/ha in the long term by expanding water management programs (National policy frame work, 1995). Therefore the realistic estimates of the water need for rice irrigation, suited to the Agro - Pedo- Climatological potential of dry areas is of paramount need to meet the future challenges in rice intensification programs.

Correct assessment of water need, onset and duration of the season and risk associated with dry and wet spells are important aspects in this regard.

The objective of the present paper is to assess the moisture availability and the agro-climatological risk in different agro-ecological regions for rice farming. An attempt was made to identify the different hydrological regions of the country based on water balance.

MATERIALS AND METHODS

Daily rainfall and pan evaporation of 22 locations in the dry, intermediate and wet zones, which represent all agro-ecological regions of Sri Lanka were used for the present analysis. The geographical locations, annual rainfall and pan evaporation of the selected locations are given in table 1.

Table.1 Annual rainfall (1950-1990) and the respective Agro-ecological zones of the selected stations.

Station	Long	Latitude	Rainfall (mm)	Agro-ecological zone*
1. Anuradhapura	80.27	8.20	1282	DL1
2. A'pelessa	80.90	6.15	1092	DL1
3. Badulla	81.05	6.99	2384	IM1
4. Batticaloa	81.70	7.72	1765	DL2
5. Charley Mount	80.28	6.00	2761	WL4
6. Colombo	79.86	6.90	2345	WL4
7. Dandeniya	80.39	6.00	1724	WL2
8. Denagama	80.79	6.06	1903	IL1
9. Hambantota	81.13	6.12	1041	DL5
10.Jaffna	80.02	9.65	1213	DL4
11. Kalawewa	80.35	8.00	1120	DL1
12.Maha Iuppallama	80.47	8.12	1379	DL1
13. Mannar	79.92	8.95	958	DL3
14. Mapalana	80.57	6.07	2354	WL2
15. Mawarella	80.36	6.11	3067	WL1
16. Nuwara Eliya	80.77	6.97	2328	WU3
17. Polonnaruwa	81.00	7.93	1669	DL1
18. Puttalam	79.83	8.03	1226	DL3
19. Thihagoda	80.34	6.01	1830	WL4
20. Trincomalee	81.21	8.58	1522	DL1
21. Vavuniya	80.50	8.57	1420	DL1
22. Watawala	80.60	6.95	5241	WU1

A computer program named "first", was created (Weerasinghe, Sabatier Grandgean Luc, 1990) to assess the rainfall probabilities and statistics at a desired level in monthly, weekly ten-day or five-day periods. The rainfall probability of the period is calculated by the ranking order method. The program allows probability levels to be selected by the user. Probability of rains in monthly and weekly intervals at 75% probability were taken as the assured rains in the present study.

In the program, the Markov chain procedure is employed to analyze dry and wet spells; the method of backward and forward accumulation described by Morris and Zandstra (1979) is incorporated to calculate onset and termination of the rainy season. By choosing a certain date during the calendar year, usually the peak of the dry season, the rainfall of the selected period could be summed forward or backward until a certain amount is accumulated. This process is repeated for all years of the data file and the probability of having received given amount of rain can be given for each time interval chosen.

As suggested by Morris and Zandrsta (1979), 75mm accumulation of rainfall at the 75% probability was taken as the onset time for the growing season for dry seeded crops, and 200mm accumulation for wetland preparation of rice.

The termination of the wet season is determined by the backward summing of rainfall data. According to Morris and Zandstra (1979), 500mm of accumulated rains after the planting would be sufficient to raise wetland rice. This criteria is used by Oldemen and Frere (1982), to determine the onset and termination of rice growing seasons in South East Asian countries.

In the present work, forward and backward moisture accumulation curves were employed to decide upon the crop establishment period and the satisfaction of the rainfall to meet crop water demand. The probability level at which two curves of a given crop is bisected is considered to be the probability at which the particular crop could be raised (crop performance probability).

Forward accumulation of 200 mm rains from March 1st for Yala and September 1st for Maha seasons, and the backward accumulation of 500 mm rains from July 1st and September 31st for two respective seasons were computed. Based on those accumulations crop performance probability of the rice was assessed.

Water balance of the localities were assessed using the Hargreave's (1971) moisture availability index (MAI). The Program CROPWAT was used to estimate irrigation need to eliminate the climate risk in both Yala and Maha seasons. Irrigation requirements of rice for the different locations were simulated considering the transplanted paddy in LHG soils. The GIS program UNIMAP was used to plot the rainfall, evaporation, water balance, crop performance probability, and irrigation need maps.

RESULTS AND DISCUSSION

The rainfall map clearly demonstrates that Sri Lanka has number of rainfall zones. The central mountainous region against the south-west winds during the wet monsoon makes a clear climatic divide. High precipitation areas are found along the windward slope of the south-west monsoon. The sharp contrast to the leeward side is clear. Most arid regions lie in north-eastern and south-western boundaries of the country (fig.1). The highest evaporation 2400 – 2500 is observed in Trincomalee. The other parts of the dry zone have an annual evaporation over 2100 mm.

The number of consecutive months with Moisture Availability Index (MAI) above 0.34 in the annual cycle and in the Yala and Maha seasons are given in fig 2,3 and 4 (Weerasinghe, 1991)

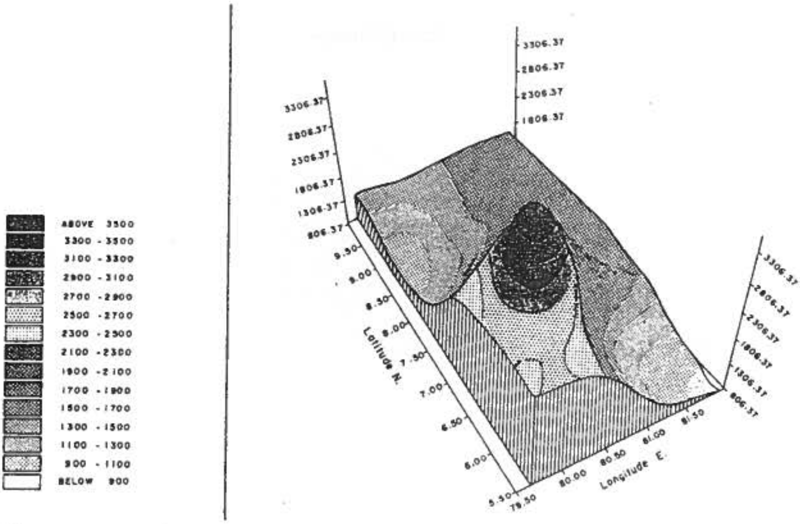


Figure 1. Annual Rainfall – Sri Lanka (mm)

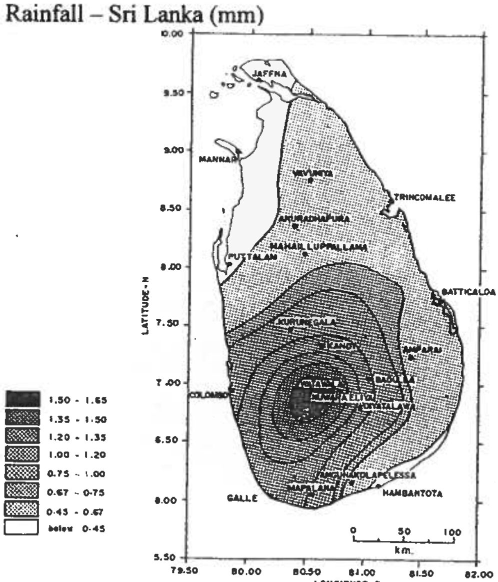


Figure 2. Annual Moisture Availability Indices (MAI),Sri Lanka according to Hargreave's Classification

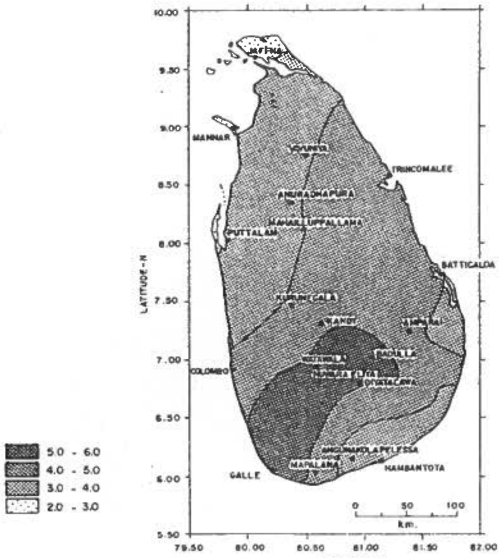


Figure 3. Number of Consecutive Months with MAI above 0.34 in Maha Season

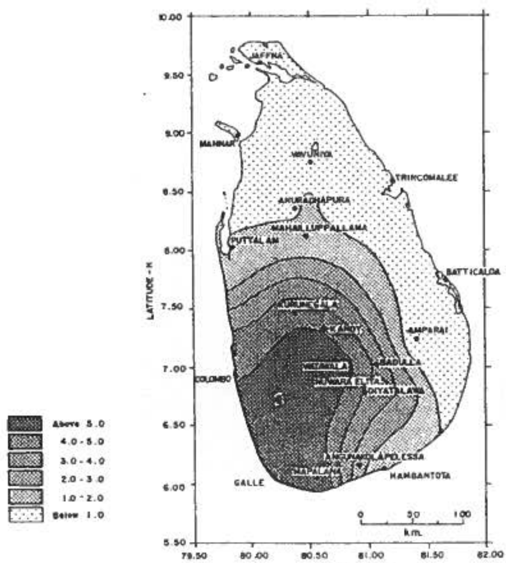


Figure 4. Number of Consecutive Months with MAI above 0.34 in Yala Season

According to annual MAI, part of the dry and intermediate zone of Sri Lanka could considered to be in moderately deficient moisture regions. However Jaffna, Mannar, Puttalam, Trincomalee, Amparai and Hambantota areas have less moisture availability, compared to other moisture deficient regions.

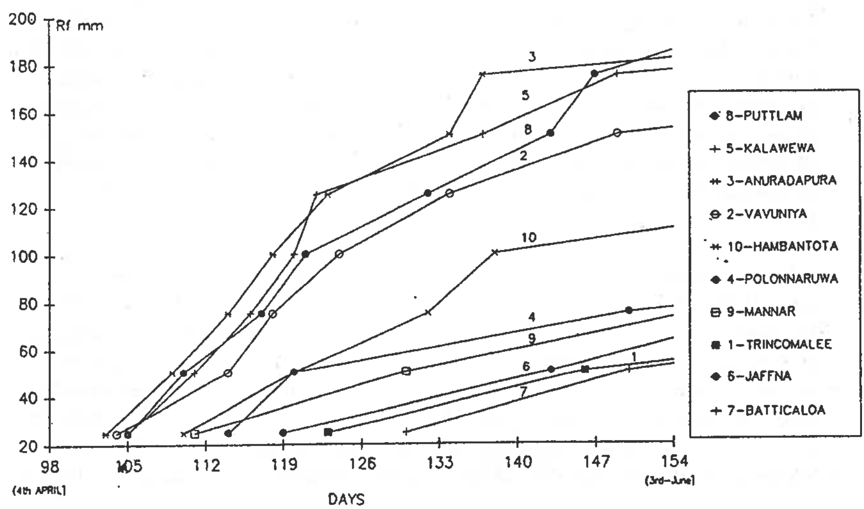
From the stand point of the water balance approach for Yala and Maha seasons, two hydrologic regions namely humid and semi-arid regions are identified for the Maha season (fig.3) and three hydrological regions viz. Humid, semi-arid and Arid regions, in Yala season. The entire dry zone remains arid in the Yala season (fig.4)

The selection of proper sowing dates constitutes the central strategy in the optimum exploitation of the rainfall resources. According to Panabokke and Walgama (1974), the main strategy in selection of cropping season is to tailor the crops to rainfall, and adjust their management to available sequence of soil moisture.

Farmer's cropping strategies are influenced by the variability they have experienced in the onset of the cropping season. This could be examined by judging the forward rainfall accumulation probabilities from the date of the commencement of the rainy season.

Dates that the forward accumulation of 25 to 200 mm rains from the beginning of the Yala and Maha seasons (from March 1st and September 1st) at ten selected stations in the dry areas of the country are at 75% probability level are given in figures 5 and 6.

FORWARD ACCUMULATION OF RAINFALL AT THE BEGINING OF 'YALA' SEASON IN 3 OUT OF 4 YEARS(.75P) FIG 5



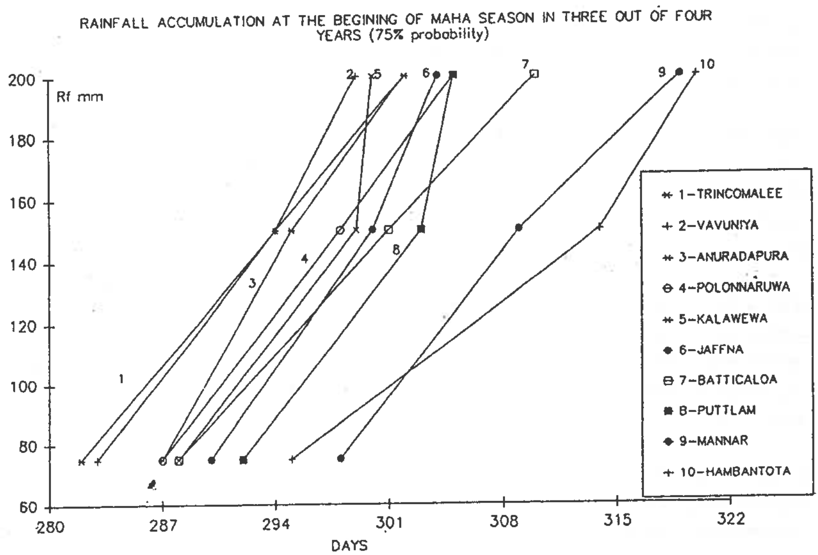


Figure 6.

In three out of four years, 200 mm rainfall accumulation which is needed for wetland preparation in Maha could be expected in the 42nd to 43rd weeks in all locations except Hambantota and Mannar where accumulation is delayed by about two weeks (fig. 5) Accumulation of 75mm rainfall for dry land crops in Maha could be expected in Trincomalee and Vavuniya on the 41st week which is about one week earlier than Anuradhapura, Polonnaruwa, Kalawewa, Jaffna and Batticola, and two weeks earlier than Hambantota and Mannar. This agrees with the earlier findings of Panabokke and Walgama (1974), where authors have identified the sowing dates for southern wet zone around the 41st week and for the area around Hambantota and Thissamaharama approximately 7 to 10 days later.

In our earlier work we have shown that in the sufficient moisture regions for wetland rice, the forward and backward moisture accumulation curves of 200 and 500 mm meet at a level above 75% probability. Where rainfall is inadequate the two curves meet at a low probability level (Weerasinghe 1989) Furthermore in order to achieve the possible probability, the crop has to be sown prior to the date indicated at the meeting point of the two curves. Table 2 indicates the crop performance probabilities and latest date of crop commencement at different locations of the dry areas. Probability map of the Maha rice crop is given in fig 7.

Table 2. The performance probability of the rain fed Maha rice in Dry Areas

Location	Probability of Maha crop	Last date of Crop Commencement (Week)
1. Batticaloa	75	45
2. Trincomalee	75	43
3. Polonnaruwa	70	44
4. Jaffna	70	43
5. Kalawewa	65	43
6. Vavuniya	60	43
7. Anuradhapura	55	42
8. Mannar	40	43
9. Puttalam	40	42
10.Hambantota	18	42

It is evident that the probability of Maha rainfed rice exceeds 75% in Galle, Colombo, Kandy Nuwaraeliya and Rathnapura areas. Analogicaly success is above 70% in Kurunegala, Polonnaruwa, Trincomalee and Batticloa areas. In rest of the country performance probability of rice seems to be lie around 50% except Hambantota and Puttalam which are the driest of the country (Fig.7).

PROBABILITY MAP OF THE 'MAHA' RICE CROP

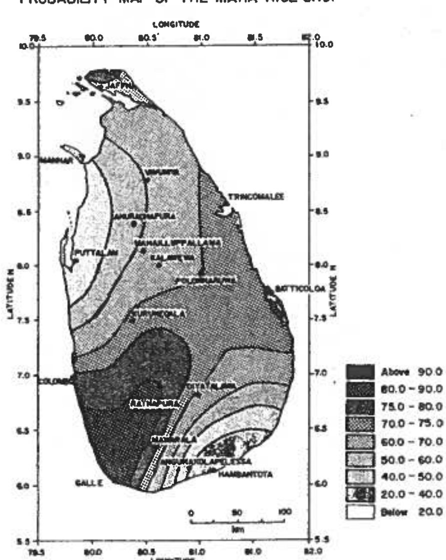


Figure 7.

The Irrigation Requirement of Rice as calculated by the program "Cropwat" varies from 1200-1500 mm in Yala season and 597-1000mm in Maha season except Hambantota where the irrigation demand is around 1200-1300 mm (Fig. 8 and 9).

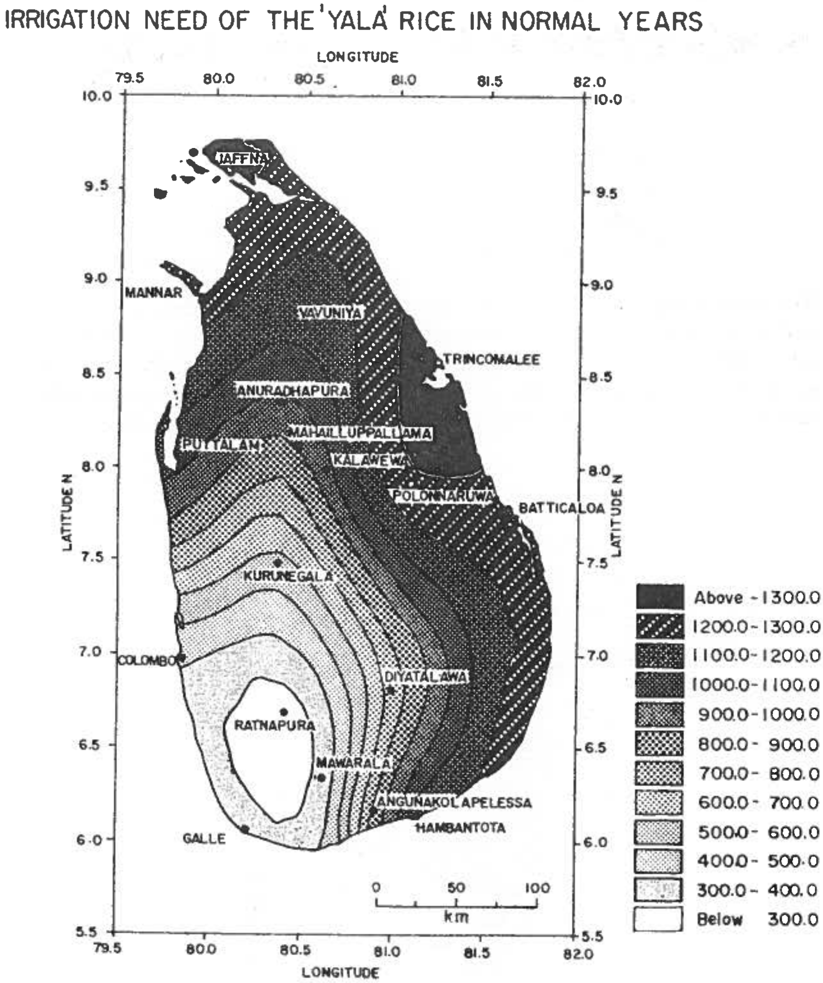


Figure 8.

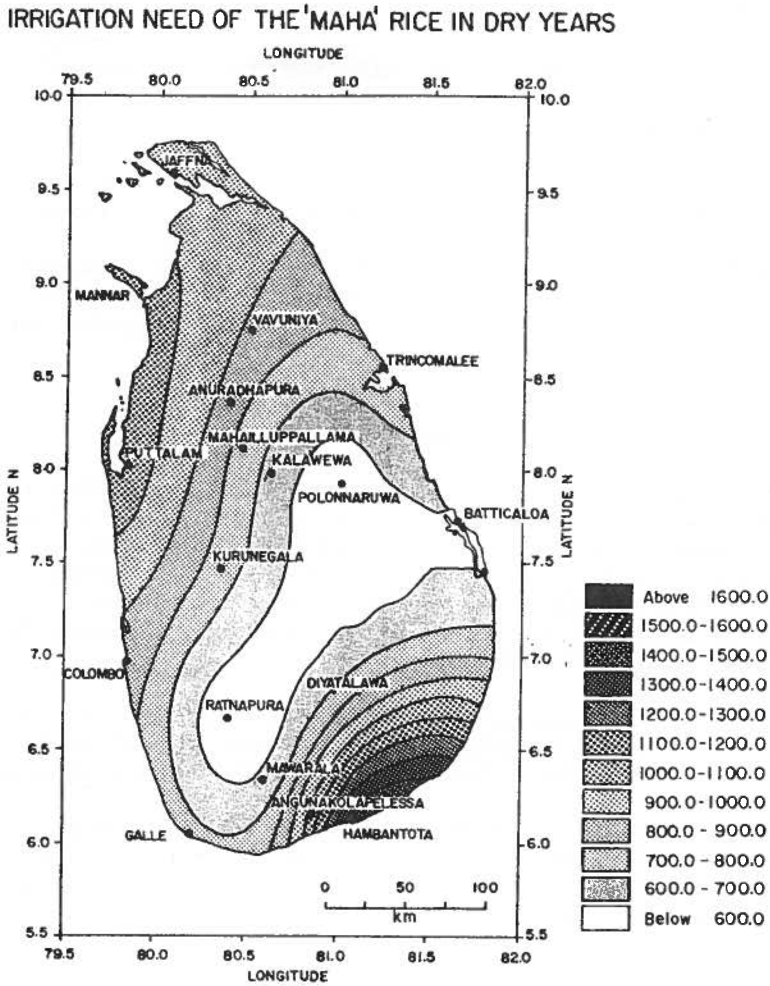

IRRIGATION NEED OF THE 'MAHA' RICE IN DRY YEARS
LONGITUDE
LATITUDE N
JAFFNA
MANNAR
VAVUNIYA
TRINCOMALEE
ANURADHAPURA
MAHAILLUPPALLAMA
PUTTALAM
KALAWEWA
POLONNARUWA
BATTICALOA
KURUNEGALA
COLOMBO
DIYATALAWA
RATNAPURA
MAWARALA
ANGUNAKOLAPELESSA
HAMBANTOTA
GALLE
0 50 100
km
Above 1600.0
1500.0-1600.0
1400.0-1500.0
1300.0-1400.0
1200.0-1300.0
1100.0-1200.0
1000.0-1100.0
900.0-1000.0
800.0 - 900.0
700.0 - 800.0
600.0 - 700.0
Below 600.0

Figure 9.

It is clear that Maha irrigation need is much less in north-east and north-central dry zones compared to other dry areas. Low irrigation need in many locations in the November / December period coincides with the availability of sufficient amounts of rainfall from the north-east monsoon. However irrigation need in Hambantota is more than doubled that of Batticola and Polonnaruwa in Maha season. This associates with the comparatively high dryness in Hambantota even in the Maha season.

Present analysis indicates high water need and risk associated with rice production in Hambantota, Mannar, and Puttalam areas where the irrigation systems may have to supply more water during the Maha season. The rehabilitation of abandoned tanks, proper water management, and adaptation of timely crop practices and water conservation by minimizing the wastage are some of the practical measures to be taken to minimize the high irrigation need in different locations.

CONCLUSIONS

The dry zone of Sri Lanka can be differentiated into two distinct hydrological regions according to Hargreave's MAI namely, "moderately deficient" and some what deficient moisture regions. From the stand point of the water balance approach for Yala and Maha seasons, two hydrological regions, namely humid and semi-arid regions can be identified for the Maha season, and three hydrological regions viz.humid, Semi-arid, and Arid regions, in Yala season. The entire dry zone remains arid in the Yala season.

In most locations of the dry zone, forward accumulation of 200 mm rains for the commencement of the wetland rice in Maha at 75% probability level could be expected on 42-43 weeks with an exception of Puttalam and Hambantota areas.

The highest irrigation need in Maha seems to be in the Hambantota (1000-1200 mm) district followed by Puttalam and Mannar. The irrigation requirement at Yala accounts for 1200-1500 mm in the northern dry zone and 900-1000 mm in the north-central dry zone.

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