

IRRIGATION POTENTIAL OF MINOR TANKS AND THEIR AGRICULTURAL STABILITY

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ABSTRACT

Water conservation in small and medium sized tanks for agriculture in the dry and semi-dry zones of Sri Lanka had been the principal method of providing water for rice cultivation in these regions, from the early historic period. However, the experiences and observations during the last several decades show that agriculture under minor tank system has not been very productive. The irrigation potential of the minor tank system and the stability of agricultural production has been far below expectations. The stability of water supply to minor tanks, irrigation potential of the minor tank system, stability of agricultural production under minor tanks and the tank-catchment hydrologic relationships were investigated. The minor tank system was one of the most important factors that governed the stability of settlements in the dry zone of Sri Lanka. Up to very recent times, the settlement of the dry zone was always associated with tank irrigation. At present, minor tank water supply appears to be very unstable and the irrigation potential seems to be very low. Tank water supply depends on the rainfall, catchment characteristics and catchment size or tank density. The minor tanks with catchment sizes more than 9 ha per hectare metre of tank storage are found to have more stable water supply than those tanks with a lower ratio of catchment to storage capacity. Agricultural production under minor tank irrigation has a very high degree of year to year variation. The cropping intensities are low and production is most unstable in areas of high tank densities; every year, a high proportion of the irrigated land area remains unutilized; and there is an urgent need to improve the management of tank water supplies. New strategies are required in rehabilitation of minor tanks so that farmers are not subjected to unnecessary risks that arise from frequent crop failures.

KEY WORDS: Agricultural stability, Irrigation potential, Minor irrigation,
Tank-catchment size, Tank density

INTRODUCTION

Water conservation structures commonly referred to as tanks are a distinctive feature of the dry and semi-dry zones of Sri Lanka. However, such features are not unique or exclusive to Sri Lanka. A very large number of these tanks are found in semi-arid India

specially in the Tamil Nadu and Andra Pradesh States where tank irrigation is widespread. Whether it is in India or in Sri Lanka, these tanks have been formed by the construction of earthen dams across valleys of various orders and sizes to collect rain and runoff water.

The background of the minor tank irrigation systems has been examined by several authors (Brohier, 1934; Arumugam, 1957; Ponrajah, 1972).

The current estimates of all the water bodies in Sri Lanka is about 22,000. This would include large reservoirs as well as other water bodies not meant for irrigation. According to some estimates (Arumugam, 1957) there were 12,500 village tanks (minor tanks) in working condition and much more lie abandoned. According to the Agrarian Services Department there are about 8,500 minor tanks in working condition (Medagama, 1987). These estimates suggest the great importance of minor tanks in this country.

The distribution of tanks, specially their spacing (density) in a valley do not always appear to be related to the hydrologic conditions of the region. It is suggested that the selection of a site for a tank and its size depended more on social factors and site features rather than the hydrologic relationships of the catchment.

There is a considerable extent of lands developed for irrigation from minor tanks. However, the variability of tank capacities and catchment hydrologic conditions have affected the irrigation potentials of these tanks and the stability of agricultural production under them.

The objectives of this paper are (i) to examine the stability of the water supply of small tank systems in the development of irrigated agriculture, (ii) to assess the irrigation potential of the small tank systems, and (iii) to evaluate catchment/tank hydrologic relationships.

BACKGROUND

Importance of minor tank systems in the dry zone

According to current estimates, out of 520,000 ha of irrigated lands in Sri Lanka, about 192,085 ha are under minor irrigation systems (Implementation Programme of the Ministry of Agricultural

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Research and Development 1990/91, unpubl.). Nearly 70% of this area occurs in the dry zone and semi-dry intermediate zone, which implies that nearly 135,000 ha are under minor tank systems. This is a considerable portion of the country's agricultural lands, which is capable of contributing substantially to the gross national product (GNP). More importantly, a very large section of the rural population depend on minor tank irrigation for their livelihood. Furthermore, the minor tank was the focal point of the social, economic, cultural and religious lives of our people.

Physical environment and water conservation

It is not surprising that tank irrigation systems became a permanent feature in the dry zone landscape; the climatic, geologic, geomorphologic, soil and surface hydrologic conditions all favour the establishment of irrigated systems with surface storage facilities in the dry zone of Sri Lanka.

Climate

In terms of the classification of the world climate, Sri Lanka has a humid tropical climate. It is characterized by a seasonal rainfall, uniformly high temperature and evaporative conditions. However, in the region, where tank systems are dominant the climatic conditions range from semi-humid to semi-arid or arid. Nevertheless, the maha rainfall varies from about 400 mm to about 1100 mm. The monsoon rainfall, North-east in mid-November to mid-January and South-west in mid-May to mid-September periods occurs as a regional phenomenon. The inter-monsoonal, convectional rains effective during March-April and again during September-October occur as a local phenomenon. The inter-monsoon thunderstorms attain high intensities within these lowlands.

The mean temperature ranges from 27°C to about 38°C. The variation in mean monthly temperature throughout the dry lowland region is less than 10°C.

The relative humidities are quite high, but the values in the yala season are lower than those of maha season. The evaporation from a free water surface range from about 3—4 mm per day during maha

(late September to January) and 6—10 mm per day during yala or the rest of the year; the mean annual evaporation from a free water surface exceeds the mean annual precipitation.

Geology and geomorphology

Hard crystalline rocks of the Pre-Cambrian Era occur throughout the lowlands in the dry and intermediate zones, where tank irrigation systems are in use. These very old rocks have been classified into two principal series namely, Highland or Khondalite Series and Vijayan Series. Vijayan is the older of the two series. The area floored by the Highland Series consists of a distinct ridge and valley topography. Here the relief is low to moderate. The area floored by Vijayan Series consists of a subdued landscape where the relief is very low.

Geomorphology of the lowland dry zone surface (lower peneplain, currently referred to as low planation surface) consists of a gently undulating to undulating planation surfaces with few isolated erosional remnants of monadnocks and few conspicuous ridges rising sharply above the otherwise featureless plain surface. It is characterized by the occurrence of a large number of drainage basins. The overall drainage has the appearance of a radial type. This planation surface is a composite of a multitude of micro-catchments, with first and second order streams dominating the drainage network. These micro-catchments combine to form a large drainage basin which finally drains into sea by a 3rd or 4th order stream. The geology and geomorphology are highly suitable for establishment of small scale water collection and conservation devices.

Development of tank irrigated agriculture

The earliest (Sinhalese) settlers of the dry lowland plains in the north were a race with simple life-styles. Their diet, probably consisted of rice and coarse grains such as *Elusiana korakana* (Kurakkan). To satisfy the need for rice as the staple, priority was given to the cultivation of rice for which water conservation in tanks, a process of rainfall harvesting in community-owned structures, to irrigate rice fields was adopted as the main strategy. All efforts were

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directed to conserve every drop of water that fell as rain, thus not wasting a drop of water without being used for the benefit of man. The same sort of thinking continued to influence the policy decisions of the rulers of the period from the latter part of the 19th century to date.

In the early decades of this century, the main thrust was irrigated agricultural development by reconstruction, renovation and augmentation of larger tanks and the reconstruction of water delivery systems. Subsequent efforts were directed to harness the waters of larger rivers such as Gal Oya, Walawe Ganga and Mahaweli Ganga, the largest river in the country. At the same time, much importance has been given to the reconstruction and rehabilitation of small (Village Irrigation Rehabilitation Project and Integrated Rural Development Projects), medium, and large (Tank Modernization Project and Major Irrigation Rehabilitation Project) tanks. The remaining irrigation systems, that are at low levels of performance are likely to be renovated or rehabilitated in the near future (National Irrigation Rehabilitation Project).

METHODOLOGY

Analyses and interpretation of historical records, survey maps and interviews with settlers of the old villages were used to assess the stability of the settlements under small tank systems.

Cropping intensities under minor irrigation systems in five districts during the last two 10—year periods were evaluated to assess the stability of agricultural production.

The stability of small tank water supply for irrigation was examined by the analyses of the tank water balance of about 35 small tanks for a period of about 10 years, by measuring the main input-output components of the water balance model, developed earlier by Somasiri (1979). The locations of some selected tanks and rainfall stations are shown in Fig. 1.

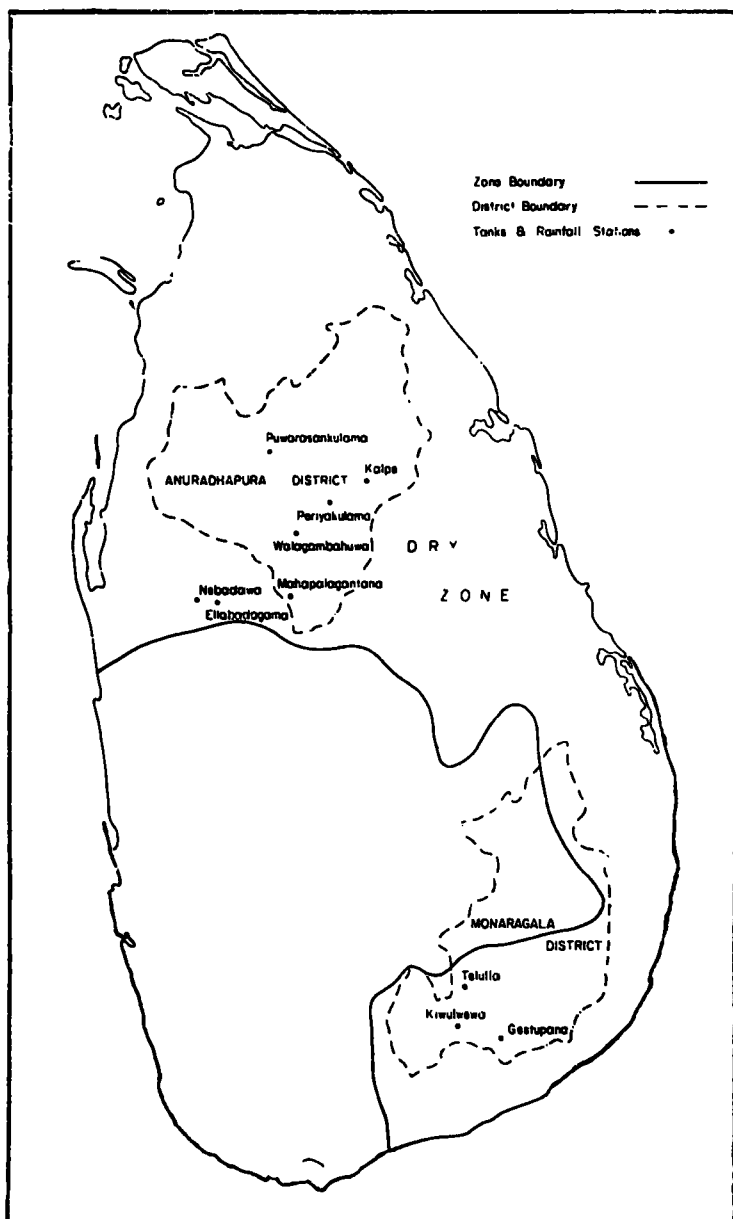


Fig. 1. Map of Sri Lanka showing rainfall stations and minor tanks investigated

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RESULTS AND DISCUSSION

Stability of minor tank water supply

The importance of a stable water supply for the purpose of irrigating the staple food crop, rice, needs no emphasis. It has been traditional to grow rice in puddled fields with standing water throughout its growth, which requires appreciable quantities of water. The approach taken at all times to meet this challenge has been the collection and conservation of rainfall runoff. Two principal methods have been in use for collecting runoff; one is the collection of runoff from the tank's own catchment and the other is diversion of water from a perennial stream into the tank.

In the dry zone, the water supply to minor tanks has been only runoff generated in their own catchments. Most of the runoff of minor catchments consists of overland flow, with small contributions of concentrated flow and sub-surface flow. Thus, the water supply for a minor tank is usually determined by the surface runoff during the rains from its own catchment and the direct rainfall on the tank surface. The stability of the water supply to minor tanks, therefore, depends on the rainfall conditions and the catchment characteristics.

The past experiences and present data (Table 1) show that there have been many years with rainfall far below the average. The year-to-year variation of the maha season's rainfall is very high; it

Table 1. Rainfall in maha seasons at some locations* in the dry and intermediate zones during the period 1981 — 1990

Season	Rainfall (mm)				
	Maha Palaganthana	Kalpe	Puwarasan kulam	Telulla	Walagambahuwa
1981/82	288	—	944	—	288
1982/83	651	708	1016	—	405
1983/84	1100	654	936	—	1505
1984/85	1000	988	724	650	1097
1985/86	886	1102	733	1000	1082
1986/87	434	698	527	341	606
1987/88	926	953	628	662	883
1988/89	401	505	357	720	460
1989/90	941	1034	824	539	791
1990/91	876	1053	974	848	889

* Locations of rainfall stations are shown in Fig. 1

could range from as low as 400 mm to as high as 1500 mm (Table 1). In low rainfall years, the catchment yields remain very low; sometimes it is as low as 5% of the season's rainfall (Somasiri, 1979). Most of the fluctuations observed in the tank water supply are closely related to the fluctuations of rainfall (Table 1 and Fig. 2). There were many instances of not having enough water in minor tanks for any irrigated agriculture. Even in the last century, at a time when the land area developed under a minor tank was very small in extent and population to be supported was small, the inhabitants of the tank villages had depended entirely on chena¹ produce for their subsistence (Brohier, 1934) because of the failure of tank irrigation.

The other factors that influence the tank water supply are catchment size and tank density, soil properties, land slopes, land use and water conservation measures adopted in catchment. The soil properties and catchment land slopes are not time bound variables, whereas others are subjected to change with time and therefore, will have some influence on the water supply. However, large catchments under low tank densities, generate large quantities of runoff which is able to stabilize the tank water storage at full supply level (FSL). On the other hand, in tanks with smaller catchments, the storage fluctuates more widely, or have very high amplitudes in the tank level attained, indicating the instability of the water supply.

An assessment of the ratio of catchment size to tank area size at full supply level for several thousand minor tanks in the northern dry zone showed that this ratio varied from one to about 20. A detailed study of catchment and tank storage capacity of 35 tanks (based on the tank data prepared for rehabilitation) showed that the catchment area available for one hectare metre of storage capacity ranges from about 3 ha to more than 18 ha. It is found that for higher values of this ratio, the water supply is more stable (Table 2 and Fig. 2).

¹Chena is a farming system practised under conditions following the slash and burn way of seed bed preparation.

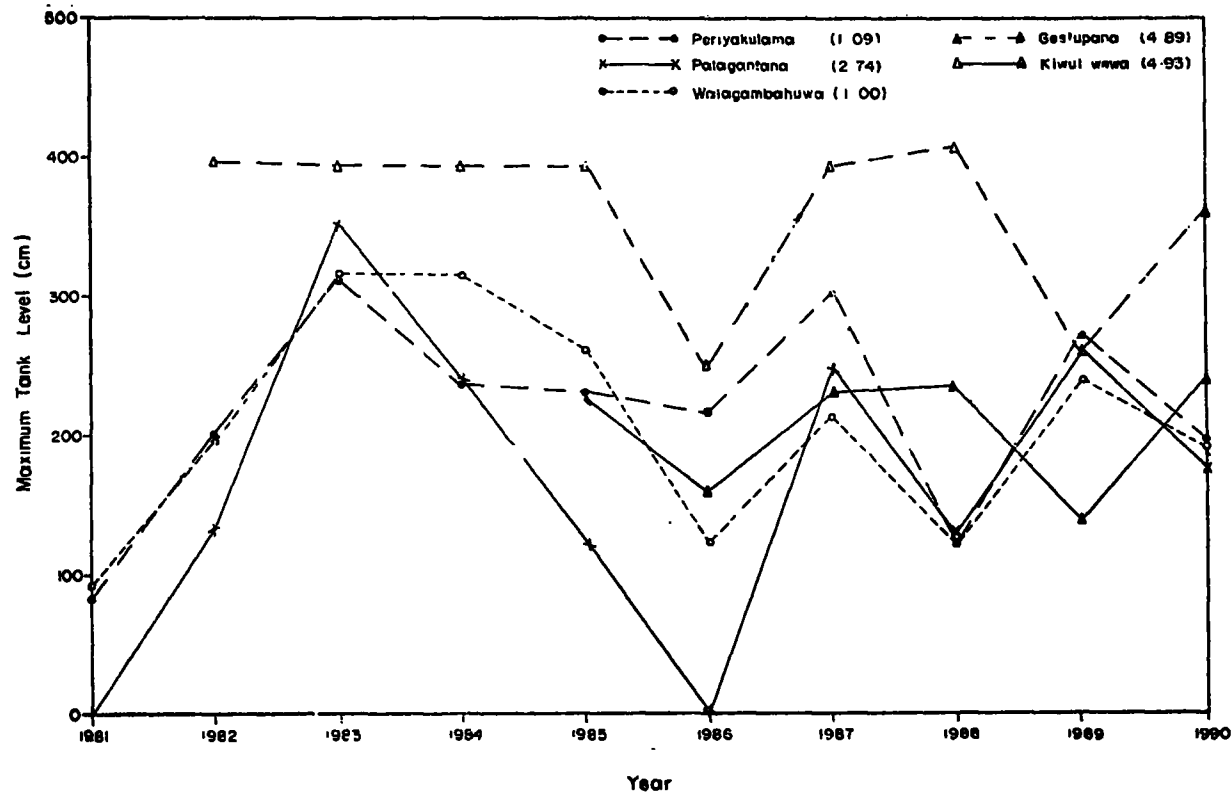


Fig. 2. Variation of maximum water level in some minor irrigation tanks of the dry zone during 1981 — 1990. Figure within bracket indicates the catchment tank capacity ratio

Table 2. Catchment size and tank water supply relationships

Tank*	Catchment / capacity ratio	Av. Rain in maha (mm)	No. of observations (maha seasons)	Frequency of attaining	
				FSL	75% of FSL
Periyakulam	3.58	—	10	20	40
Puwarasan kulam	8.10	746	11	9	9
Maha Palaganthana	8.99	808	11	Nil	9
Walagambahuwa	3.28	857	11	10	20
Kalpe	11.65	858	10	50	50
Nabodawewa	10.50	—	10	40	50
Ellebodagama	18.31	675	9	45	55
Kivulwewa	16.17	771	9	67	77
Telulla	5.77	—	7	28	57

*Locations of tanks are shown in Fig. 1; FSL = Full supply level

Tank density and irrigation potential

In a situation, where a minor tank system is installed in first, second and third order stream valleys to catch all the runoff that occurs during rainy season, the tank density is an important factor that merits careful attention. This has great relevance in particular to the northern dry zone of Sri Lanka.

It can be argued that at low tank densities, sites of tanks are such that each tank includes a large catchment area making the water supply more stable. Therefore, at low tank densities irrigated agriculture becomes stable and it could be made economically attractive. However, with the increase of population, instead of attempting to increase the food production per unit of irrigated land, more and more small settlements are established by building more minor tanks in the same drainage basin on one hand and on the other, command areas of minor tanks are extended without increasing the water supply (Examples of this kind of development are common in Sri Lanka). With the increase in tank density, the water supply becomes unstable due to limitations in the catchment size. Then, irrigated agriculture becomes unreliable, risky and economically non-viable. It is observed that under a large number of minor tanks, the command areas remain fallow when the tanks fail to reach full supply level; this is common in areas of high tank densities. The marked difference in cropping intensity between the districts (Fig. 1) of Anuradhapura and Hambantota (Tables 3, 4 and 5) can be at least

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Table 3. Area cropped as percentage of the asweddumized area under minor tanks in selected districts during maha seasons (1980—1989)

<i>District</i>	<i>Year</i>										<i>Average</i>	<i>Std. dev.</i>
	80	81	82	83	84	85	86	87	88	89		
Anuradhapura	82	40	42	74	53	53	31	54	05*	39	52.0	16.7
Vavuniya	89	86	88	87	71	56	31	44	23	20	59.5	28.3
Hambantota	72	54	71	72	57	67	48	64	57	41	60.3	10.7
Moneragala	93	81	94	87	92	92	68	80	70	63	82.0	11.5
Kurunegala	96	73	69	80	91	93	57	80	68	77	78.4	12.3

* Value omitted when calculating the average and std. deviation

Source: Department of Census and Statistics, Sri Lanka.

Table 4. Area cropped as a percentage of the asweddumized area under minor tanks in selected districts during year seasons (1968—1979)

<i>District</i>	<i>Year</i>										<i>Average</i>	<i>Std. dev.</i>
	68	70	71	72	73	74	76	77	78	79		
Anuradhapura	68	58	61	58	65	15	56	87	87	85	64.0	21.0
Vavuniya	73	75	75	73	75	58	89	97	70	66	75.1	10.3
Hambantota	45	54	48	64	73	64	67	69	74	72	64.0	10.2
Moneragala	73	77	78	68	79	96	91	69	90	93	81.4	10.4
Kurunegala	78	60	63	67	69	45	82	88	91	93	73.6	12.8

Source: Department of census and Statistics, Sri Lanka.

Table 5. Area cropped as a percentage of the asweddumized area under minor tanks in selected districts during yala seasons (1980—1989)

<i>District</i>	<i>Year</i>										<i>Average</i>	<i>Std. dev.</i>
	80	81	82	83	84	85	86	87	88	89		
Anuradhapura	2.0	1.5	1.5	1.4	28	5.8	9.3	1.2	6.4	0.4	6.1	8.0
Vavuniya	0.6	0.7	0.7	0.4	21	0.4	5.7	0.3	1.7	—	3.5	6.8
Hambantota	32	36	41	23	50	32	40	19	23	21	31.7	6.7
Moneragala	09	10	12	08	20	15	18	03	30	09	13.9	6.7
Kurunegala	37	34	42	26	83	44	54	27	57	17	41.3	18.2

Source: Department of Census and Statistics, Sri Lanka.

partly attributed to the differences in the tank densities. This view is further supported by the observed high values of standard deviation in the proportion of the area cultivated in Anuradhapura compared to that of Hambantota. In Hambantota, there are only few working tanks and therefore, they have large catchment areas. However, the size of command area under minor tanks in Hambantota may also be small in which case the tank storage per unit of the command area is high and this facilitates a higher cropping intensity. Table 2 shows that tanks having more than 9.8 ha of catchment per one ha m. of capacity, attain full supply level in 40–67% of maha seasons (probability of 40–67 years in 100 years) and at least 75% of the tank capacity is reached in 50–77% of maha seasons. Thus, irrigation potential of minor tanks would be reasonably high with a peak supply of more than 75% of the designed storage at least in 5 out of 10 maha seasons, if the tank density is such that catchment area per one ha m. of capacity is more than 9 ha.

Where the tank densities are high, as in some parts of Anuradhapura district, there are several tanks in a first order valley or in a second order valley, closely spaced. Each tank has a low catchment area per unit of tank storage capacity. None of the tanks receive adequate runoff regularly and hence, water availability is highly variable from season to season. Furthermore, the water supply to major tanks in the downstream is drastically reduced. The instability resulting from high tank densities has been further aggravated by the land tenure, different land uses and management practices in catchments in the tank-village settlements. While minor tank catchment sizes remain constant, the command areas have been expanded through village expansion schemes (Akkarawela²) and encroachments in tail-end areas. The small size of holdings further complicates the issues in land and tank water use. Consequently, even when there is some water in the tanks, very low priority is given to cropping in the command area. In a study of tank density in India (von Oppen.

²Akkarawela is an asweddumized area that is irrigated from a high level sluice when the tank level reaches FSL. It is the newly alienated area usually at the rate of 0.4 ha per family, under village expansion programmes.

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and Subba Rao, 1980, Unpubl.) it was concluded that when the tank density passes a threshold value, minor tank irrigation becomes an inefficient system for irrigated agriculture.

Stability of irrigated agriculture under minor irrigation

It had been clearly recognized even at the time of early settlement of dry lowlands in Sri Lanka (during the early historic period) that supplementary irrigation was an important factor that governs, at least some measure of stability in agricultural production. It is also a historical fact that the region was subjected to depopulation after the 12th century. The most likely reason for the depopulation may be the deterioration of irrigation works and the consequent de-stabilization of agricultural production process. Foreign invasions or diseases may have caused the destruction of irrigation systems due to disrepair and lack of maintenance. Therefore, a breakdown in food production would have resulted in food shortages and the inability to support a larger population.

A highly erratic and seasonal rainfall where the maha season is lasting for about 100 days with mid-season droughts and a very short yala season, which is less than 60 days are not the conditions ideal for stable crop production. The recent studies have confirmed that to ensure food supply of settlers in the dry zone outside major irrigation systems, minor tanks should form an essential and an integral part of the settled land use pattern in the region (Abeyratne, 1956; 1957).

The data from five districts namely, Anuradhapura, Vavuniya, Hambantota, Moneragala and Kurunegala (Fig. 1), where minor tanks constitute the dominant minor irrigation works, show that the total area developed for irrigation is 101,220 ha. The percentage of the area cultivated in the maha season in the past twenty years is shown in Tables 3 and 4. These percentages vary from year to year. In any maha season, the cropped extent in each drier district, Anuradhapura, Vavuniya and Hambantota is lower than the percentage of the area cultivated in less dry districts of Kurunegala and Moneragala. The means of areas cultivated in terms of percentages of the total available command areas in each district are 52.0, 59.5, 60.3, 78.4 and 82.0 for

Anuradhapura, Vavuniya, Hambantota, Moneragala and Kurunegala, respectively. The coefficients of variation of these percentages are 32, 48, 18, 14 and 16 respectively for the above five districts. The larger coefficients of variation indicate higher degrees of instability or unreliability of irrigated agriculture under minor irrigation systems than when the coefficients are smaller. There is also a very high percentage of area left uncultivated in any maha season due to the shortage of water.

The unreliability of irrigated agriculture under minor irrigation in the yala season is more than that of the maha season. Table 5 shows the percentage of the area cultivated in each yala in the 5 districts during the period 1980 to 1989. The means of the percentages of area cultivated in Anuradhapura and Vavuniya are less than 10. In these two districts, the coefficient of variation of area cultivated is greater than 100% (when the data for 1984 is taken into account). In Kurunegala and Hambantota proportions of the area cultivated are comparatively high and have lower coefficient of variation. In Moneragala, the area cultivated in yala remains quite low (about 14%). In the latter three districts, the coefficient of variation is between 31 and 54%. However, if the data for yala 1984 is not taken into account as it appears to be abnormal, the averages will be further reduced without much improvement in the coefficient of variation. Thus, the yala cultivation under minor irrigation is most unstable.

In all five districts, the cropping intensities have been very low. Although the normal way of assessing the cropping intensities assumes a possible maximum of 200%, in this environment the maximum cropping intensity possible can be fixed at 100% for maha season and 50% for yala season to give an annual maximum of 150%. On this basis the actual cropping intensities realized are: 64% in Anuradhapura, 66% in Vavuniya, 124% in Hambantota, 110% in Moneragala and 161% in Kurunegala, out of a possible maximum value of 150% (Note: in Kurunegala more than 50% of the area is cropped during yala).

However, under the particular rainfall regime experienced in the dry zone, the minor tank systems are most likely not designed for double cropping, but only to provide supplementary irrigation for a

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rice crop in maha. Therefore, it would be more reasonable to assess the cropping intensities on the basis of one crop per year, in which case cropping intensities are much higher (Tables 3 and 4).

Some of the reasons for such low cropping intensities and the variability of area cultivated from season to season are, too larger command area per unit of water stored in a tank, low irrigation potential of the tanks and inadequate catchment area to provide adequate runoff. Either due to a decline in rainfall or due to high density of tanks or both, the water availability has become very unreliable in the recent past. Thus for more than one reason, the irrigated agriculture under minor irrigation is unstable. Therefore, it is extremely important to stabilize the farmer incomes through off-farm employment, high income generating crop cultivation and increasing cropping intensities through improved water management.

CONCLUSIONS

Minor tank system is an important infrastructure facility which has a major influence on the social, economic, cultural and religious lives of the people in the dry zone. It is probably the most important source of water that recharges the shallow groundwater aquifer in the hard rock area which provides the essential supply of potable water. The climate, physiography, geological formation and hydrology provide the necessary conditions for the establishment of minor tank systems, while the life styles of the people in the region have made it imperative that such a system is developed.

The stability of tank water supply is determined by the local rainfall, catchment size as well as other characteristics of the catchment area. Next to rainfall, the catchment area available per unit of storage capacity is the most important determinant for the stability of water supply. Thus, the tank density in a region will strongly influence the irrigation potential of minor tanks in the area. There exists a large number of minor tanks with a highly fluctuating annual storage, a condition which renders the utilization of this water resource ineffective unless some appropriate strategies are adopted to use such extremely variable water supplies.

To obtain more regular and adequate supply of water for irrigated agriculture, it is very necessary to have tanks with large catchment areas. The tanks with less than 9 ha per ha m. of storage capacity are found to have very low irrigation potentials in the dry zone of Sri Lanka. Such tanks receive adequate runoff to bring the tank to full supply stage only once in about 10 years, whereas, tanks that have more than 9 ha per ha m. of storage capacity attain full supply level in about 50% of the years.

The agriculture in the command areas of minor tanks is quite unstable. This instability is more in areas of high tank densities than in areas of low tank densities. The year to year fluctuations in the extent of area cultivated is very high in the Anuradhapura district whereas, fluctuations in other districts are less—tank densities in Anuradhapura are much higher than that of other districts.

The cropping intensities under minor tank systems are very low; intensities in maha season range from about 31 to about 96% whereas, yala cropping intensities are negligible and range from 0 to 54%. In the northern dry zone districts the yala cropping intensities rarely reach 10%, while in the south of the country it varies from 20 to 50%. In districts of the intermediate zone the yala cropping intensities range from 8 to 83%. Under some tanks, in some years the irrigation potential is low and cropping is not possible.

The land and water resources within the minor tank system are grossly underutilized. Due to the presence of too large a command area which is beyond the irrigation potential of the tank, both land and water remain normally unutilized, unless the tank attains full capacity.

There is an urgent need to improve the management of tank water supplies. Steps are necessary to improve catchment runoff yields. In areas of high tank densities, people who are now entirely dependent on the minor tank system for their sustenance must have some alternatives to ensure a regular income. It can be high value crop production with improved resources management and alternative employment to supplement agricultural incomes, without which they will remain below poverty level.

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In the development, rehabilitation or reconstruction of minor irrigation systems, it would be very necessary to consider the probability of success of irrigated agriculture. What is the level of risk of crop failure that farmers in minor systems can absorb? It is not more than one in four. Therefore, any tank should have the ability to provide adequate irrigation under proper management at least in three out of 4 years. This requires new strategies in tank design, determination of the command area size and assessment of catchment area required to ensure command area water requirement. Unless the command area size matches with catchment area size, tank capacity, the rainfall and runoff conditions, the minor tanks would fail to meet the desired objectives of having such a system in the development of agriculture.

ACKNOWLEDGEMENTS

I wish to thank the staff of the Land and Water Management Research Centre, Department of Agriculture, Peradeniya for all the assistance given in carrying out this study. Author is very grateful for the encouragement and support given by Dr. C. R. Panabokke (former Director of Agriculture) at the commencement of this study. I am also thankful to the Project Director, Village Irrigation Rehabilitation Project and the World Bank for providing the funds, without which this study could not have been possible.

TROPICAL AGRICULTURIST, VOL. 147, 1991

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