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Verification of Design Parameters for Operational Studies of Minor Tanks in the Dryzone

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ABSTRACT. *About 2280 minor tanks with irrigation potential of 40,000 ha are located in the Anuradapura District. Most of these tanks rehabilitated under various projects are reported to have never been filled to the designed capacity in order to cultivate the targeted area. The factors attributed to this were suspected to be the inaccurate assessment of water inflow (rainfall and water yield) to the tank and the water outflow from the tank (tank water losses, irrigation issues). A research study was conducted to verify the validity of design parameters given by Ponrajah (1984) for the minor tanks.*

Rainfall data at 12 meterological stations were collected to assess the spatial variations of rainfall within the district. To study the water balance components rainfall, tank water height, evaporation and irrigation issues were measured in two minor tanks on daily basis for the study period of 3 years. The results showed that the 75% probability rainfall does not uniformly represent the DL-1 agro-ecological region mainly due to the spatial variation of rainfall, which increases from west to east. Existing procedure given by Ponrajah (1984) tends to overestimate the water available for irrigation due to the underestimation of seepage and percolation losses. An allocation of a higher seepage and percolation value, in the range of 25-35% of the storage volume, instead of the recommended 0.5% would provide a more reasonable estimate for the amount of water available for irrigation.

INTRODUCTION

The term village based minor tank (*wewa*) has been used to refer to an artificial lake or pond for storing water on the surface of the ground which has been constructed by local people with their indigenous skills from ancient times. There are about 9500 such minor tanks scattered throughout the country with an irrigation potential of over 161000 ha. About 65% of these tanks are

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in the dry zone and the balance are in the intermediate and wet zones (Navaratne, 1998). Most of these tanks are shallow mini reservoirs with an average depth of 2.5 to 3.5 m with micro-catchments of less than 6.5 sq.km. The streams are non perennial and water flow is available for relatively short periods following monsoon rains. These tanks provide supplementary irrigation in the *Maha* (wet) season for the rain-fed crop and any residual storage for the *Yala* (dry) crop which is grown on a restricted extent.

Rehabilitation of small scale irrigation schemes is the foremost amongst the development activities launched by the government from the recent past. The national government and international agencies have been paying increasing attention to minor irrigation development since the cost of rehabilitating minor schemes is relatively less compared to major schemes and the benefits are accrued much faster. These are not only used for irrigation, but also as water resource for domestic needs, water for cattle and source of food supply such as tank fish. These rehabilitation activities also provide an opportunity for farmers to gain additional income by participating on construction activities during the dry season.

The cropping intensity in minor irrigation schemes are low, limited to 40 to 80 percent with only a few exceeding 100 percent with respect to the target of 120 percent (WBSAR, 1981). The major constraints are said to be inadequate catchment area and limited rainfall. Many of the dry zone tanks had been built in cascades along the valley during ancient times as an attempt to maximize the use of available water resources (Madduma Bandara, 1985). However, at present tanks in a cascade functions independently having its own command area regardless of the size of its net catchment area. This was due to rehabilitation works carried out over the years considering tanks as independent units. The procedure suggested by Shakthivadiwel *et al.* (1996) to consider a tank as a unit in a cascade has never been considered in the past during rehabilitation.

The absence of adequate and reliable data pertaining to design and operation of minor tanks is a major drawback in understanding the poor performance of in terms of anticipated cropping intensity. Most of the data provided in the design manual by Ponrajah (1984) were computed by observing major catchments and reservoirs. It is reasonable to expect differences in hydrological behaviour between minor and major schemes. For example, wetted area to volume ratio is much more for minor tanks compared to major tanks due to the shallowness of the former. This might lead to more losses as a percentage of available capacity in minor tanks compared to major tanks. As a result of the inaccuracy of design and operational guidelines, the rehabilitation proposals made are bound to be inconsistent with the actual field conditions and consequently additional expenditure is incurred on unwanted structures and inappropriate agricultural and water management practices.

Therefore, a research study was conducted to assess the validity of the parameters given by Ponrajah (1984) for the design and operation of minor tanks so that the inconsistencies, if there is any, could be identified. This would help to determine the available water for irrigation under minor tanks more accurately. Irrigation and agricultural planners could then design a suitable cropping system with an associated water management technology to obtain a higher cropping intensity in a more realistic manner rather than plan for a higher quantity of water, which is not to be found in practice.

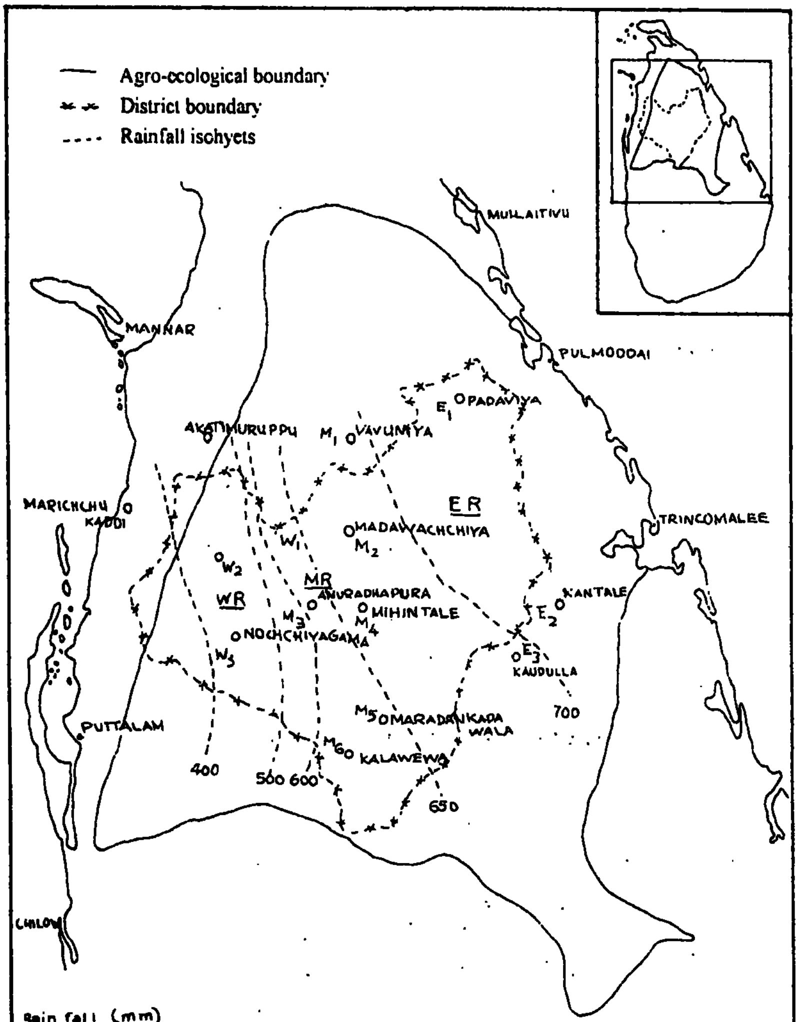
MATERIALS AND METHODS

Location

This study was carried out in Anuradapura District, located in the dry zone low country (DL-1) agro-ecological region (Figure 1), which has about 2450 minor tanks providing irrigation facilities to nearly 50,000 ha. Two of such minor tanks, namely Ulankulama tank and Meegassagama tank, located in Tirappane Divisional Secretariat Division was selected for the study. Both these tanks are situated adjacent to the Anuradapura -. Maradankadawala - Kekirawa road. Field investigations were carried out in the two tanks from 1989/91 to 1992/93.

The total average annual rainfall in the area is about 1445 mm with annual rainfall ranging from 875 - 1875 mm. It is characterized with well defined bimodal rainfall pattern with the main rainy seasons, *Maha* (October to January) and *Yala* (mid March to mid May). The *Maha* rains are followed and ended up with a short dry period in February and March. The *Yala* rains are followed by a spell of dry weather with dry winds and intensive heat and end up with next *Maha* rains in late September.

The topography is generally undulating with a slope of 2 to 4 percent. The major soil group is reddish brown earth comprising sandy-loam to sandy clay loam. The soil becomes sticky when wet and very hard when dry. During the *Maha* season, farmers cultivate paddy in the entire command area depending on the availability of rainfall. Other field crops such as maize, chillies, and vegetables are cultivated in the uplands. During *Yala* season, the cultivated area reduces sharply due to shortage of water and, therefore, farmers resort to cultivate lesser extent with other field crops. Consequently, the ratio



Rain fall (mm)

station	W_1	W_2	W_3	M_1	M_2	M_3	M_4	M_5	M_6	E_1	E_2	E_3
75% Pro Rainfall	738	500	430	709	637	659	632	698	728	726	733	670
Annual Rain fall	1148	1171	1026	1400	1262	1291	1332	1379	1322	1508	1508	1479

Figure 1. **Locations and computed 75% probability rainfall (mm) at the selected rainfall stations within DL-1 agro-ecological region.**

of other field crops to rice increases relatively during *Yala*. The total irrigated area under respective tanks are planned at the beginning of the season through a consultation process between farmers and village level officers. Decisions are made with regard to the date of land preparation, seed varieties, water issues, and specially the dates for maintenance work in the tank bund and channels. Each tank based farmer organization conducts its own meetings separately.

Characteristics of experimental tanks

The catchment areas of tanks were measured with the aid of 1982 aerial photographs obtained from the Survey Department. The tank bed surveys were carried out for both tanks in 1989 and elevation-area and elevation-capacity curves were prepared (Navaratne, 1998). Surveys on the irrigable (command) area were also carried out in 1989. The seasonal irrigated area varies every year mainly due to rainfall. The summary of the physical parameters of the two experimental tanks are given in Table 1.

Table 1. Details of experimental tanks.

Characteristics	Ulankulama tank	Meegassagama tank
Catchment area - Gross	1523 ha	484 ha
- Net	409 ha	356 ha
Tank capacity	460,000 m^3	360, 000 m^3
Height (sluice to spill)	2.97 m	3.04 m
Water spread area at spill	44.7 ha	30 ha
Irrigable area (command)	40.5 ha	26 ha

Water delivery system

The two tanks under the study, Ulankulama and Meegassagama were rehabilitated at a cost of Rs. 750,000 and Rs 475,000 respectively in 1987/88 under the Village Irrigation Rehabilitation Project. Tank bunds were repaired, new sluices (water intakes) were constructed and the channel systems were improved. Each command area was divided into a number of blocks depending on the location and cultivation practices and necessary water control structures - regulators, pipe outlets, drop structures *etc.* were provided for proper water management practices. Water flows from the tank through the outlet to the main channel and then to branch channels. The prevailing pattern of field to field irrigation was the main reason for wastage of water and some time also leads to disputes among farmers. Water intake for each block was, therefore, provided and a field ditch (secondary channel) was constructed from the intake to the last plot in the block. As a result any farmer in the block could take water without disturbing the others and damaging the main bund.

Rainfall data for spatial analysis

In order to analyse the spatial pattern of rainfall in the Anuradapura District, rainfall data from 12 stations, as shown in Figure 1, were collected from the Meteorological Department. Two stations in the west (*i.e.*, Marichchukaddi and Akatimuruppu) lies outside the district boundary. In order to represent the western part, three new stations, such as W1, W2 and W3 were created by interpolation using a *Thiessen* triangular method and the details are given by Navaratne (1998). Due to close proximity, Kantalai and Kaudulla were considered to represent eastern part of the district, with Padawiya, though the former two lies out side the district boundary.

Tank water balance

Daily rainfall in the tank areas were measured with non recording type rain gauges with an accuracy of + or - 0.25 mm. Evaporation was measured by using class 'A' evaporation pan located close to the tank bund of Meegassagama tank. The water depth was measured by a hook gauge fitted with a micrometer. Daily records were taken at 7.30 am during the research period. Open water evaporation was computed by multiplying the observed value by 0.8 (Pan coefficient). Sum of weekly evaporation was multiplied by the average water surface area of the tank during the week to estimate the weekly evaporation.

Since Seepage and Percolation (S and P) from the tanks could not be measured directly, indirect estimates were made based on measured components of rest of the tank water balance equation. When there was no inflow to the tank, seepage and percolation could be estimated by the following equation.

$$S\ and\ P = (FS - IS) - (E + Sp + Ir) \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

Where,

$S\ and\ P$ = Weekly seepage and percolation
FS = Water storage of the tank at the beginning of the week
IS = Water storage of the tank at the end of the week
E = Weekly evaporation
Sp = Weekly spillage
Ir = Weekly irrigation issues

This computation was done in weekly basis and the rate of S and P losses at different water heights were assessed. This relation was used in the subsequent water balance calculations for operational studies.

The water discharge over spills was computed by using equations given by Ponrajah (1984). Ulankulama tank has two spills, left bank one is 30 metres long natural spill and the right bank one is 21 m long clear overfall spill. There is a natural spill of 25 m length in the Meegassagama tank. The discharge measurements over spills have less accuracy mainly due to; a) blockages and hence the water levels were not uniform throughout the spill, b) the water height variation being gradual and slow and exact measurements were not possible, and c) practical difficulties confronted with water level measurements during night and the times of heavy rains.

Irrigation issues were measured by using Cut-Throat and Parshall flumes installed in main irrigation channels at sluice outlet points. A rotational water distribution system with a seven day irrigation frequency was practised in both schemes. Water heights in the flumes and time duration were recorded during the study period. The rotational time table was adjusted on rainy days to satisfy the field irrigation requirement with the objective of fully utilizing the rainfall.

During a particular week, the total yield to the tank is computed by substituting values for all the variables to equation 2 given below.

$$I = (IS - FS) + (E + S\ and\ P + Ir) - Drf \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

Where,

I	=	Water yield (Inflow to the tank)
Drf	=	Direct rainfall contribution to tank

Tank storage is determined from the elevation of the water surface, by making use of the elevation capacity relationship. Direct contribution was computed by multiplying the average surface area of tank water during that week with measured rainfall. The area-capacity curve is used to compute the surface area at a given water height. The design water yield is determined from 75% probability rainfall values for DL-1 region and Iso-Yield curves given by Ponrajah (1984) using the standard procedure. Since all the maps, standard limits and specifications available were in F.P.S system, the water yield calculation was done in the same units and finally converted to SI units.

Operational study

The design operational study for *Maha* and *Yala* seasons for both experimental tanks were carried out using the procedure given by Ponrajah (1984), while a computer model with measured/estimated water balance components were used for the actual operation study. This provides the information of water allocated (or used) from the total quantity of water available to satisfy different components of the water balance equation, such as for evaporation, seepage and percolation, irrigation issues *etc.* The comparison of design and measured would provide an indication as to how valid the design parameters in practice under field conditions.

RESULTS AND DISCUSSION

Spatial variation

The preliminary analysis showed that rainfall increases from west to east in the Anuradapura district. Therefore, the district was divided in to three regions, namely western, middle and eastern for the analysis of rainfall data. The average annual rainfall of 12 rainfall stations, computed from 32 to 40 years of data from 1955 to 1995, depending on the maximum available records, is given in Table 2.

Despite the small area of the district (7350 sq. km) the rainfall varies to a remarkable extent over the area. Baghirathan and Shaw (1978) also bisected the Anuradapura district, along the north-south direction, into two climatic regions based on rainfall. The annual averages in western, middle and eastern regions are 1115, 1322 and 1498 mm respectively. Mean annual average rainfall for all 3 stations in the western region was less than the Over All Average Rainfall (OAAR) of the district whilst all 3 stations in the eastern regions showed rainfall values above the OAAR.

Table 2. Rainfall stations, annual averages and number of years the annual averages were less than the over all annual average rainfall.

Code	Station	Average annual rainfall (mm)	Years less than OAAR	No. of years considered
W-1	Station 1	1171	31 (76%)	40
W-2	Station 2	1089	34 (83%)	40
W-3	Station 3	1148	25 (71%)	35
Average rainfall for western region = 1136 mm				
M-1	Vavunia	1401	16 (44%)	36
M-2	Medawachchiya	1262	19 (57 %)	33
M-3	Mihintale	1332	17 (47%)	36
M-4	Anuradhapura	1292	25 (61%)	40
M-5	Maradankadawela	1379	20 (50%)	40
M-6	Kalawewa	1322	22 (58%)	38
Average rainfall for middle region = 1131 mm				
E-1	Padawiya	1508	9 (28%)	32
E-2	Kantalai	1507	13 (32%)	40
E-3	Kaudulla	1479	15 (36%)	40
Average rainfall for eastern region = 1498 mm				
Over All Average Rainfall (OAAR) for the district = 1322 mm				

W-1, W-2 and W-3 are the 3 new stations where the rainfall was computed by *Thiessen* Triangular Method.

Comparison with the design rainfall

Water yield is estimated for the design of irrigation works based on 75% probability rainfall values on monthly basis for the respective agro-ecological regions. The Department of Agriculture has divided the country in to Agro-Ecological regions and computed the 75% probability rainfall for each region. These values were taken for the determination of water yield for irrigation work by Ponrajah (1984). In this study, rainfall probability analysis was calculated according to the two methods described by Doorenbos and Pruitt (1977). The first method computes the number of years in which the monthly rainfall received was less than the 75% probability values and thereby represent as a percentage from the total years considered. The second method compute 75% probability rainfall values in each month from the total years considered. The averages of these values were computed in regional basis and are given in Table 3. The annual values for the district is shown in Figure 1.

Table 3. Comparison of design rainfall values (mm) with the computed 75% probability rainfall in the west, middle and eastern rainfall regions in the Anuradapura district.

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Design values	76	25	51	127	51	13	0	13	25	127	152	127	787
Station W3 Western Region	22	10	30	92	37	0	1	2	19	148	160	95	616
Anuradhapura Middle Region	30	7	32	114	34	1	2	3	20	176	166	102	680
Kantalai Eastern Region	80	16	11	46	25	0	0	16	49	126	218	187	736

The information given in Figure 1 and Table 4 indicate that the 75% probability design rainfall value lies between the values computed for the western and eastern stations. Within the same region, the computed 75% probability rainfall values varies according to the number of years and the period considered for the calculation. It is apparent for all three stations that the rainfall values are higher during the 3 decades from 1930-1960. This trend had been observed during the same period throughout the country by Chandrapala (1997). The computed 75% probability rainfalls during this

Table 4. Comparison of 75% probability rainfall during different rainfall periods for three rainfall stations selected to represent west, middle and eastern regions.

Rainfall stations and the period during which the analysis was done		75% probability annual rainfall (mm)
Design rainfall		787
W-3 Rainfall station (Western region)		
73 years	(1923 - 1995)	616
First 36 years	(1924 - 1959)	652
Second 36 years	(1960 - 1995)	590
Anuradhapura rainfall station (Middle region)		
100 years	(1896 - 1995)	680
First 50 years	(1896 - 1945)	713
Second 50 years	(1946 - 1995)	644
First 35 years	(1891 - 1925)	732
Second 35 years	(1926 - 1960)	753
Third 35 years	(1961 - 1995)	686
Kantalai rainfall station (Eastern region)		
98 years	(1898 - 1996)	736
First 49 years	(1898 - 1946)	792
Second 49 years	(1947 - 1996)	750
First 32 years	(1899 - 1930)	746
Second 32 years	(1931 - 1962)	936
Third 32 years	(1963 - 1994)	738

period were 652, 753 and 936 mm for western, middle and eastern region respectively. The following period from 1960-1990s showed a lower value for all three regions compared to the design 75% probability rainfall. The 75% design rainfall values computed by the Department of Agriculture and published in 1975 was thus heavily influenced by the high rainfall period observed during 1930-60. The 75% design rainfall values will be lower if the Department of Agriculture updates the Agro-ecological map using data up to 1990's.

Tank water yield

The comparison of design rainfall and water yield values for both experimental tanks are given in Table 5. It is difficult to compare the 75% probability design and measured rainfall values since both have different meanings. The 75% probability rainfall is used to incorporate the risk factor of not getting the designed rainfall and its impact on agricultural enterprise into the small tank design. Therefore, the observed annual rainfall totals cannot be compared with the design 75% probability values for the sake of comparison. The comparison of the OAAR for the district (1331 mm) with the observed rainfall for the two tanks indicated that the experimental period can be considered as 'dry', since measured rainfall values from 1989/90 to 1992/93 are less than OAAR.

The estimated water yield for both tanks during the experimental periods compare well with the design values. The monthly variations as well as seasonal variations could be attributed to climatic, tank and catchment characteristics. It was observed that rainfall intensity plays a major role in determining the tank inflow compared to the total rainfall. For example, the total rainfall in December at Meegassagama tank was recorded as a continuous rain within 4 days. This has resulted a more than two fold increase in water yield (84 mm) compared to the design value of 34 mm. Estimated *Maha* season water yield in Ulankulama tank was more in both years compared to the design values. In contrast, estimated *Maha* seasons water yield for Meegassagama was less during both years compared to the design values. This may be, perhaps, due to the steeper slope (6%) of the Ulankulama tank catchment, which may increase the inflow, compared to the lesser slope of the Meegassagama tank catchment (3%). Many such factors might have been responsible for the variations observed between the estimated and designed water yields.

In theoretical water yield computations the direct rainfall contribution is not considered separately. It was found from the study that there was a substantial input in to the tank from the direct rainfall. That was because the tank surface area in each tank was nearly 10% of its catchment area and hence the influence of direct rainfall on water yield is high. In the study it was observed that *Maha* season's direct contribution was 40% of the total water yield. During *Yala* season this contribution was more than the run off (54% of the total water yield). The reason was that it was assumed that the direct contribution add to the tank storage without any loss. Hence in one way, when the water spread area is large the direct water contribution to the tank is high, but at the same time losses due to evaporation is also higher due to large surface area.

Table 5. Comparison of design and measured rainfall and water yield values (mm) for the two experimental tanks.

	Maha season							*Yala* season						
	Oct	Nov	Dec	Jan	Feb	Mar	Total	Apr	May	Jun	Jul	Aug	Sep	Total
Design rainfall														
	127	152	127	76	25	51	558	127	51	13	0	13	25	229
Measured rainfall for Ulankulama tank														
1989/90	350	475	95	192	22	125	1259	180	343	0	127	65	171	715
1990/91	396	183	307	165	41	70	1162							
Measured rainfall for Meegassagama tank														
1991/92	214	461	366	18	0	0	1059	244	133	3	45	12	18	455
1992/93	170	393	245	11	0	154	973	151	68	0	69	14	12	314
Design water yield for Ulankulama tank														
1989/90	14	89	20	42	77	13	255	13	28	0.5	2	5	25	49
1990/91	83	40	47	28	14	26	238							
Design water yield for Meegassagama tank														
	35	41	34	21	7	14	152	10	4	1	0	1	2	18
Estimated water yield for Meegassagama tank														
1991/92	11	34	80	14	7	0	146	26	10	1	3	2	3	45
1992/93	3	44	35	6	18	0	106	6	2	1	1	0	2	13

Tank water losses

The design and measured evaporation losses for both tanks are given in Table 6. Evaporation is one of the parameters, among the other components of the water balance equation, that agrees well with the measured values. This is to be expected since evaporation losses from the open water surfaces can be estimated fairly accurately with the measured values from Evaporation Pan. The percentage variation in *Maha* and *Yala* seasons are within the measurement accuracy.

Theoretically the seepage and percolation losses are computed by taking 0.5% of the capacity available during a particular month. But it can be observed from Table 6, that this value is very low compared to the actual. The seepage and percolation values were computed in mm by dividing the volume by surface area. The actual values are very much higher than the design values and are not shown since they are more than 10 times (>1000%) higher.

Table 6. Comparison of design and measured water losses (mm) for the two experimental tanks.

	Maha season							*Yala* season						
	Oct	Nov	Dec	Jan	Feb	Mar	Total	Apr	May	Jun	Jul	Aug	Sep	Total
Design evaporation														
	121	101	96	98	104	131	651	123	137	145	152	155	158	712
Measured evaporation for Ulankulama tank														
1989/90	83	72	72	80	135	170	612	140	113	141	130	159	147	674
1990/91	107	116	95	112	116	126	672							
Measured evaporation for Meegassagama tank														
1991/92	67	65	70	83	126	175	586	138	117	137	155	154	161	862
1992/93	130	140	97	115	136	168	786	141	118	153	171	201	158	942
Design seepage and percolation loss														
	1	1	2	2	2	2	10	2	2	1	1	0.5	0.5	7
Estimated seepage and percolation loss for Ulankulama tank														
1989/90	12	46	49	72	77	42	298	28	123	154	187	25	232	747
1990/91	32	27	29	18	16	26	148							
Estimated seepage and percolation loss for Meegassagama tank														
1991/92	160	150	157	155	141	154	917	150	155	150	154	152	146	907
1992/93	154	150	156	154	142	155	912	150	155	150	154	155	145	908

Irrigation issues

Theoretical requirement of irrigation for 135 days paddy in *Maha* and 105 days paddy in *Yala* according to Ponrajah (1984) is given in Table 7 with measured values. Since the irrigation requirement is independent of physical parameters of the tank and only depends on agro-climatic features of the area, the cultivation pattern and the calender, these values could be used for any of the minor tanks in the DL-1 region. Irrespective of higher water yield (Table 5), the measured irrigation issues were less than the designed in all the seasons for both tanks. These variations are higher for *Yala* season compared to *Maha*. The main reason for the above observations is due to the higher water losses from the tanks.

Table 7. Comparison of design and measured irrigation issues (mm) for the two experimental tanks.

	Maha season							*Yala* season						
	Oct	Nov	Dec	Jan	Feb	Mar	Total	Apr	May	Jun	Jul	Aug	Sep	Total
Design irrigation issues														
	84	140	187	256	121	-	788	137	335	427	407	-	-	1306
Measured irrigation issues for Ulankulama tank														
1989/90	0	0	76	190	314	129	709	100	20	100	60	76	43	356
1990/91	5	12	38	76	105	277								
Measured irrigation issues for Meegassagama tank														
1991/92	0	18	102	138	179	154	591	128	136	194	226	254	136	1074
1992/93	0	10	59	148	252	102	572	123	91	77	9	0	0	299

This is clearly indicated in Table 8 which shows the design and measured values of different components of water balance based on the operational study for both tanks. Design and measured evaporation values compared well for both tanks as discussed earlier. The measured component of irrigation is always less than the designed figures. This reduction is represented in the increased seepage and percolation losses. Error component of the water balance calculation for the Meegassagama tank, possibly due to spillage in 1991/92 as mentioned in methodology, and some unknown error in 1992/93 have introduced some 'noise' in to the average values estimated in the last column. However, this does not distort the general picture emanated from the study.

Table 8. Design and measured values (percentages) of different components of water balance based on the operation study for the two experimental tanks.

	Ulankulama tank		Meegassagama tank			Average	
Maha season	Design	Measured	Design	Measured 91/92	Measured 92/93	Design	Measured
Evaporation	38.7	30.7	23.3	22.9	18.3	31.0	24.0
Seep and Perc	1.8	21.2	0.8	34.2	21.8	1.3	25.7
Irrigation	45.5	28.4	55.0	40.8	38.7	50.1	34.0
Spillage	0.0	0.76	0	58.6	0.0	0.0	19.8
Error in water balance	14.0	18.9	20.9	-56.5	21.2	17.5	-5.5
Yala season							
Evaporation	60.7	46.1	44.7	28.8	73.8	52.7	49.6
Seep and Perc	2.0	50.5	1.3	27.8	71.4	1.7	49.9
Irrigation	41.0	8.4	44.7	26.0	40.5	42.9	25.0
Spillage	0	0	0	0.0	0.0	0.0	0.0
Error in water balance	-3.7	-5.0	9.2	17.4	-85.7	2.8	-24.4

The error in underestimating the seepage and percolation may be due to the unavailability of adequate information as quoted by Ponrajah (1984) in the design manual which reads; *"However, in the absence of such measurements (i.e. seepage and percolation) the monthly seepage loss may be assumed to be 0.5% of the volume of water stored in the reservoir"*.

This 0.5% value was found to be accurate for the major tanks such as Lunugamvehera[1]. However, it is reasonable to expect a much higher seepage and percolation loss for minor tanks, mainly due to the increased wetted surface to storage volume compared to a major tank. A very high seepage and percolation losses were also reported by Somasiri (1979) and Dharmasena

1 Personal communication, Dr. N.T.S. Wijesekere, University of Moratuwa, Moratuwa.

(1989) for Walagambahuwa and Pandikulama tanks respectively. A recent study has shown that the seepage and percolation loss from Puwakpitiya tank within the same DL-1 region ranges from 14% to 60% throughout a year with a weighted average of 32% (Gunawardena, 1998). The evidence from four independent studies is adequate to convince the planners to introduce reasonable seepage and percolation values for the minor tanks. However, there may be a reluctance on the part of those who are responsible to do the necessary modifications in the light of difficulties in justifying the rehabilitation programmes for the minor tanks. A higher seepage and percolation figure would reduce the available water for irrigation, which in turns reduces the cost/benefit ratio according to the standard cost benefit analysis. However, this could be circumvented by adopting the extended cost benefit analysis for the irrigation sector projects.

CONCLUSIONS

The results indicated that the 75% probability design rainfall does not uniformly represent the DL-1 agro-ecological region mainly due to the spatial variation of rainfall from west to east. It is always advisable to use 75% probability rainfall values computed for a given locality if the long term records are available. If the local rainfall information are not available, existing values and the procedure still could provide the initial information to derive the reliable water yield data for the minor tanks.

Existing procedure given by Ponrajah (1984) tends to overestimate the water available for irrigation from minor tanks. The reason for this is assigning lower seepage in percolation rates applicable under major tanks to minor irrigation tanks which have a higher S and P ratio as shown by the study. An allocation of a higher seepage and percolation value, in the range of 25-35% of the storage volume, instead of the recommended 0.5% would provide a much more reasonable estimate for the amount of water available for irrigation from the minor tanks.

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