Attempting to improve seasonal performance of Land and water productivity through systematic analysis: Case study of Dahanaka Minor Irrigation Tank in Anuradhapura District of Sri Lanka

P.R. Gamage and N.T.S. Wijesekera

ABSTRACT

Water conservation in small and medium tanks for agriculture in dry, semi dry and intermediate zones of Sri Lanka are considered as the reason for successful rice cultivation during the period of our ancestors. However, it is often mentioned that the available statistics during last few decades also point to the lower productivity of agriculture under minor irrigation tank systems. The aim is to apply the present guideline recommendations to evaluate a typical dry zone irrigation reservoir system and to make recommendations for farmer livelihood enhancement considering seasonal performance, crop water requirements for paddy and other Food Crops (OFC) and possibilities of suitable crop diversification. System water balance is used to obtain the results in each case and financial analysis used to calculate the income of the farmers. Also it is important to maintain a database for each minor tank because more than 192,000 ha of lands are cultivated under these tanks by contributing considerably to the Sri Lanka economy. Therefore, it is important to find, what are the suitable methods that can be applied to improve the land and water productivity.

KEYWORDS: Irrigation Demand, Water balance study model, Cropping Intensity

1. Introduction

1.1. General

Total number of minor tanks in use and abandoned condition are about 30,000. (Medagama, 1982; FFHC 1979). According to Department of Agrarian Services, small tanks or the village tanks are those tanks, which command area not more than 80 ha. There are about 8500 operational minor tanks in the dry zone alone (Dayarathna, 1990). There are about 192,085 ha are under minor Irrigation system (S. Somasiri), 1987). If better water management techniques can be identified then these agricultural lands are capable of contributing to the Gross National Product (GNP) while achieving national food security. Since a very large section of the rural population of Sri Lanka depends on minor irrigation tanks for their livelihood, it is very important to make every attempt to increase land and water productivity in these systems. Reported cropping intensities are as low as 1.25 in minor tanks, while production is most unstable even in areas where there are tanks at a high density. It has been noted that year after year, a high proportion of irrigation lands remain unutilized reportedly due to lack of water. Hence, there is an urgent need to improve the management of water availability in irrigation tanks of Sri Lanka to reach higher cropping intensities. Water balance models are versatile tools for water and land management ensuring better levels of productivity. Though application of water balance models and their importance are highlighted in guidelines, there is a void in critical applications. Therefore, the present case study is intended to contribute towards the industry requirement to achieve better land and water productivity.

Dahanaka tank is situated in Anuradhapura District which is the case study reservoir receives water only from its own catchment and there are no other inputs from diversions and this is an ungauged reservoir.

2. Objective

The objective of the study is to systematically apply the ID (1984) guideline recommendations to evaluate a typical dry zone irrigation reservoir system and to make recommendations for farmer livelihood enhancement considering seasonal performance, crop water requirements for paddy and other Food Crops (OFC) and possibilities of suitable crop diversification. Accordingly, the specific objectives were as follows.

a) To find the crop water requirement for paddy and OFC.
b) To carry out an operation study to evaluate alternatives for land and water productivity.

P.R. Gamage, *IESL (Sri Lanka), AMIE (Sri Lanka), Irrigation Department, Sri Lanka*

N.T.S. Wijesekera, *B.Sc.Eng. Hons (Sri Lanka), PG. Dip (Moratuwa), M.Eng. (Tokyo), Ph.D (Tokyo), C.Eng., MICE(UK), FIE(SL), Senior Professor, Department of Civil Engineering, University of Moratuwa, Sri Lanka.*

c) To evaluate a cropping pattern to increase the cropping intensity, increase farmer income and uplift the living standard of the farmers in the area using water balance study.

2.1. Project Area

The project area is located at Kahatagasdigiliya Divisional Secretary's Divisions (DSD) in Anuradhapura District. Co-ordinate of the tank is according to Irrigation Department Guideline (ID 1984) is F/5(12.6 *1.0). Conventional coordinates are 8021'58" N, 80042'06"E. (figure 1). The tank is operated and maintained by the Koon wewa office of the Department of Agrarian Development. Aththikka-Gaha is the name of the associated farmer organization and it is reported that 130 Acres of land is cultivated under this tank.

Table 1: Basic Data of Dahanaka Tank

Data Type	Description
Catchment Area	2.1 sq. miles
Location	Lat. 8 21'58" Lon. 80^0 42'06"
Capacity at FSL	391 Ac.ft.
Length of the Bund	945 m
B.T.L,	107 m M.S.L.
F.S.L.	106.42 m M.S.L.
H.F.L.	106.8 m M.S.L.
B.T.L,	107 m M.S.L.
Side Slope	1:2

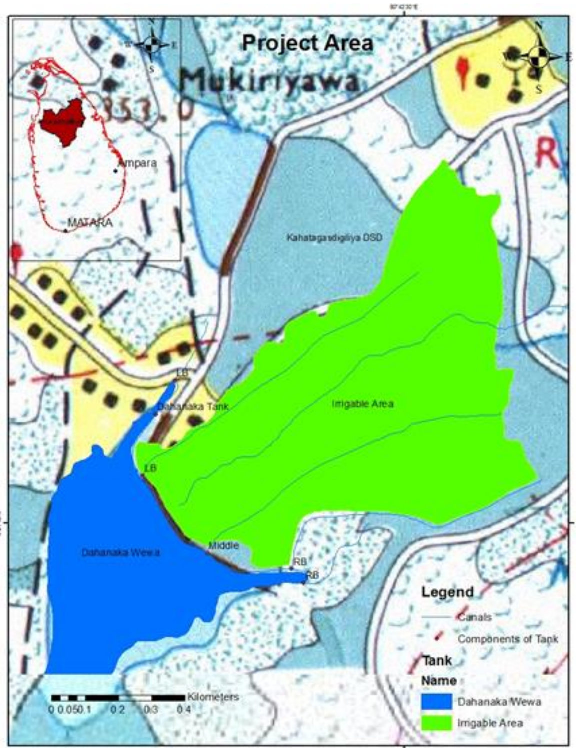

Figure 1: Study area showing Dahanaka Tank

3. Design

Reservoir area capacity curves, field observations on number of times the reservoir would reach minimum and maximum water levels in a given year, farmer crop preferences, approximate extents cultivated in each season from 2007 Yala to 2014 were available for the analysis. An Irrigation water requirement study and a reservoir operation were carried out while considering the influence of associated parameters and a variety of trial cultivation options. System water balance computation was assumed the guideline (ID 1984) recommended coefficients for seepage, effective rainfall, yield thresholds, canal efficiency and evaporation.
The schematic diagram of the water balance model, which is applied to the system shown in Figure 2.

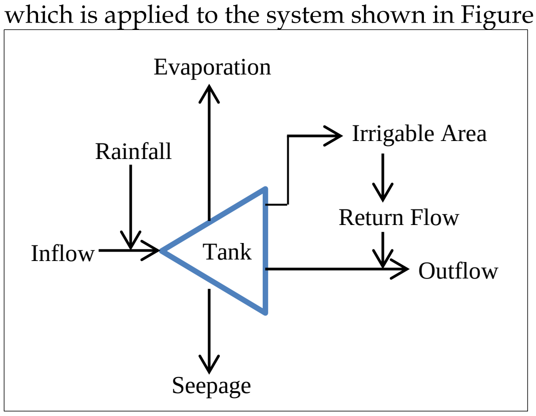

Figure2: Schematic Diagram of the water Balance Model

Table 2: 75% probability rainfall

Month	75% probability rainfall(mm)	Month	75% probability rainfall(mm)
October	127	April	127
November	152	May	51
December	127	June	13
January	76	July	0
February	25	August	13
March	51	September	25

Table 3: Data used for the Study

Data	Source
1:50 1:50,000 topo maps	Department of Survey
Monthly 75% probability rainfall	Irrigation Department Guidelines
Crop factors & growth stages	Irrigation Department Guidelines
Reservoir Bed Survey	DI's office Anuradhapura
Monthly Evaporation Data	Irrigation Department Guidelines
Monthly rainfall	Hydrological Annual, Irrigation Department
Cultivation performance previous years	Department of Agrarian Development
Economic data	CIC Institute of Agro business, November 2010

Water balance for the system was carried out in order of magnitude evaluation of the system components. Water balance was done for both seasons in a typical water year.

The reservoir water balance was done, considering Inflow, Irrigation Demand, Seepage, Evaporation and Farm Losses. The water balance was computed using equation (1).

Storage at the beginning of the month +Inflow to the Reservoir - Evaporation - Seepage - Irrigation Demand- = Storage of the Reservoir --------------- (1)

$$Si + I - EP - SP - D = Se$$

Table 5: References and Assumptions used for the system water Balance

	Description	Purpose for Water Balance	Reference/Assumption
1	75% Probability rainfall	Inflow to Reservoir and calculate Field Irrigation Requirement.	ID(1984)
2	Runoff Coefficient as 0.3	Calculate monthly yield	ID(1984)
3	Evaporation (Pan Evaporation)	Reservoir Evaporation	ID(1984)
4	Water Release for Land Preparation	Field Irrigation Requirement	ID(1984)
5	Farm Losses	Field Irrigation Requirement	ID(1984)
6	Conveyance efficiency as 60%	Water Demand from Reservoir	ID(1984)
7	Effective Rainfall	Inflow calculation and Irrigation Requirement	ID(1984)
8	Seasonal Yield from Iso Yield Curves	To calculate monthly yield	ID (1984)
9	Yield Thresholds as 35% and 7.5%	To adjust the specific yield	ID (1984)
10	Initial storage as MOL	To take the storage at	ID (1984)
11	Seepage Losses - 0.5% of Storage	Calculate the seepage volume from the reservoir	ID (1984)
12	Crop factors for Paddy and Other Food Crops	Calculate Irrigation Demand	ID (1984)
13	Depth Area –Capacity curve	To calculate the seepage, evaporation	

3.1. Assumption Made during the Study

Lack of adequate measured data required the present study to make assumptions to evaluate the system. Therefore, recommendations made by the ID (1984) and other appropriate for the situation were used for the system evaluation. Assumptions made during the study are as follows. Details are given in table no 5.

1. 75% Probability rainfall values are from the ID (1984)
2. Runoff Coefficient for calculation of inflow to the tank is assumed as 0.3.
3. Evaporation Data based on the values in ID (1984).
4. Water Requirement for land preparation is assumed as 172mm for 15 days.
5. Farm losses are assumed as 152 mm.
6. Conveyance efficiency is assumed as 60%
7. Seepage Losses - 0.5% of Storage
8. Crop Factors for Paddy and Other Food Crops
9. Effective Rainfall
10. Initial storage is at Minimum Operation Level (MOL)

4. Result and Discussion

Reservoir water balance was done for different cropping pattern and did economic evaluation to find the best option.

Table 4: Option privatization for the water balance model

Option Number	Crop Type	Irrigable Area (Ha.)	Income (Rs.Mn)
1	105 Days Paddy	16.47	3.4
2	90 Days Paddy	19.59	3.6
3	Soya Beans	20.0	4.5
4	Cowpea	23.15	2.8
5	90 days Paddy and Soya beans	19.59	4.1
6	90 days Paddy and Cowpea	20.03	3.3
7	105 days Paddy and Soya	18.70	4.0
8	105 days Paddy and Cowpea	17.81	3.2

4.1. General: Command area

1) Soya Beans and Cowpea were the OFC crops preferred by the farmers while the 90 days paddy and 105 days paddy were the varieties cultivated in Yala and 135 days paddy for Maha seasons.

2) For the existing situation, Reservoir operation study was carried out for paddy both Yala and Maha seasons.

3) Cultivation Extent for Maha season is 44.52 ha and the Irrigation water requirement is 1790 mm. For Yala season, average cultivation extent is 19.15 ha and the Irrigation Water Requirement is 1658 mm. Peak months for water requirements in Yala season are June and July while October and January are for Maha season. Peak requirements for Yala and Maha seasons, when cultivating paddy for both seasons 526 mm and 490 mm.

4) Difficulties in the assumptions

Canal efficiency based on field inspections and the guidelines given in the Guidelines ID -1984, effective rainfall and 75% probability rainfall are based on Guidelines ID -1984. Farm losses are also based on Guidelines in ID -1984. After applying, the all values, results should be checked and verified using the actual cultivation data from the office and by Google maps.

4.2. General - Reservoir

1) Average Seasonal inflow in Yala Season 43.09 hectare meter and Maha Season 104.99 hectare meter Dead Storage is 0.52 ha.m, Minimum Operating Level is 105.3 m MSL
2) Reservoir filling once in two years and reservoir empting is twice in one year according to the data collected from the Koon Weva office of the Department of Agrarian Development.
3) Spilling months are November and December.
4) Minimum inflow months are March, April, June, July and August.

4.3. Cultivation Extents

1) We can cultivate both seasons with paddy to a cropping intensity (CI) of 1.32
2) Water utilization for paddy both seasons 1.92m/season/ha for Yala and 1.79 m season/ha Maha from reservoir when effective rainfall is taken into consideration.
3) Max cropping intensity can be achieved is 1.5 with cowpea for Yala season and paddy for the Maha season. Water utilization during max cropping intensity is 1.39m/season/ha Yala and 1.79 m/season /ha for Maha from reservoir when effective rainfall is taken into consideration.
4) Comparison of farmer financial status was carried out for the all options by doing income expenditure analysis, to select suitable options. Cultivation of paddy only for both seasons income is nearly 3.5 million rupees for Yala season only. Maximum income is generated from Yala season is 4.51 million rupees with soya beans.
5) Comparison of food security, maximum yield received for the Yala season is 105 days paddy for Yala season.

4.4. Options Prioritization

1) Considering Income only, it is most suitable to cultivate Soya Beans for Yala season cultivation. It can be cultivated 21.3 Ha of Soya Beans.
2) Considering Income and cultivation extent in Yala season, it is most suitable combination of Soya Beans and 105 days paddy. 19.59 Ha can be cultivated it is the 2nd highest extent can be cultivated.
3) Cultivation extent is highest for only Cowpea is cultivated in Yala season. but income is less.

5. Conclusion and Recommendations

There should be a good database for each minor tank to evaluate alternatives, which are helps to increase the land and water productivity. Considering the climate change in Sri Lanka water scarcity will be the major problem and it will cause arise the problems in food security also. According to the recent data, more than 5000 Acres of lands have been fully destroyed in Ampara District, 1000 acres in Anuradhapura District and large amount in other Districts due to prevailing drought. Storage of considerable number of major and medium tanks become 26% of capacity at Full Supply Level in mid of January 2017. The condition of minor tanks are worst compare to major and medium tanks in Sri Lanka.

This is the time we have to introduce Other Food Crops to farmers with low Irrigation Requirement.

Depth Area capacity curve to be developed for each minor tanks to do a better study and also the actual quantity of lands cultivated under these minor tanks separately.

5.1. Recommendations

1) Farmers should be trained and aware on OFC cultivation. Training should be carried out to change their habits.
2) Land preparation and land soaking should be done rainwater if possible.
3) For selling agricultural products there should be suitable convenience method.
4) Database for each minor tanks should be maintained to achieve better land and water productivity.

6. Acknowledgement

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7. References

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Small tank system in Sri Lanka: Issues and consideration by C.R. Panabokke, M.U.A. Tennakoon and R.de. S. Ariyabandu

Physical and Hydrological Aspects

Different scholars have made different estimates of the number of small tanks in Sri Lanka.