Increasing the Cropping Intensity by Changing the Cropping Pattern in a Minor Tank

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ABSTRACT

Water scarcity is the main course for the poor cropping intensities and crop failures in most of the minor tanks located in dry zone. This situation can be addressed in several ways. This study focused on changing the cropping pattern to increase the cropping intensity because this method can be implemented immediately. A minor tank located in Anuradhapura district was selected for the study. Water resources in the catchment was analyzed using the method described in the irrigation department guide line. As the catchment is ungauged 75% probable rainfall of the zone in which the tank belongs was used in analyzing the water availability. Combinations of crop types were considered and paddy and soya bean were selected as the type of crops. Water requirement for both crops were calculated and a water balance study was done for three scenarios. An income comparison between three scenarios were done to find the most beneficial scenario out of the three. As the study was based on the parameters given in the irrigation guideline, present situation was analyzed for the variation of parameters within a range of 25%.

KEYWORDS: Cropping intensity, Irrigation and crop yield options

1. Introduction

Sri Lanka has a proud history of irrigation development with a hydraulic civilization dating back to over 2000 years. Primary purpose of irrigation development in Sri Lanka is for paddy cultivation as rice is the nation's staple food and farmers treat paddy as their life blood. In Sri Lanka there are over 30,000 small irrigation reservoirs (Data Base – Department of Agrarian Services).

Tank is categorized as a minor tank when its command area is less than 200 acres (ID 1984). Inflow of a minor tank is usually by the surface runoff from its own catchment and therefore depends on the rainfall and the characteristics of the catchment. In Sri Lanka there are two growing seasons namely North East Monsoon (NEM) called the Maha Season and the South West Monsoon (SWM) called the Yala season.

The dry zone experiences a low rainfall volume com-pared to the other areas of the country especially in the Yala season. Due to the variation of rainfall pat-tern and the low storage capacities in minor tanks, farmers are unable to cultivate their full extent of lands under minor irrigation schemes mainly in the Yala season thus leading to low cropping intensities. The ratio of effective crop area harvested during a given water year to the physical area is known as the cropping intensity. One option to ensure a higher cropping intensity is to grow low water consuming crops that enables a harvest with a higher monetary value. However, case studies with systematic application of engineering concepts are not available for practicing engineers to perform better by confirming or modifying the prevailing Irrigation Department Guidelines.

Therefore, the objective of this study was to demonstrate the potential of systematic analysis and critical evaluation of irrigation and irrigation water management to evaluate solutions for better food and water security in Sri Lanka.

2. Project Area and Data

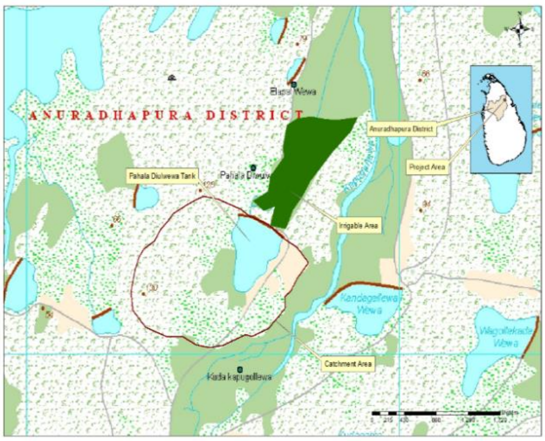

Figure 2.1 Location map of the project area

A minor tank named Pahala Diulwewa, located in Anuradhapura district and within Yan Oya river basin was selected for the case study. (207758mE, 386620mN). Tank has a catchment area of 5.12km2

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and command area of 73Ha. Capacity at full supply level is 83 Ha.m. Location map of the project area is in Figure 2.1.

1:50,000 Topographic map of the survey department enabled the preparation of maps. Irrigation Department Guideline (ID 1984) was the source for 75% probable rainfall, reference crop evapotranspiration, crop factors & growth stages, the Area Capacity curve of the tank was from the irrigation department regional office at Anuradhapura. Data used in the study are in Table 2.1.

Table 2.1 General data used

Description	Unit	Value
Catchment area	Sq.km	5.12
Command area	Ha	73
Yield - Maha	m	0.656
Yield - Yala	m	0.185
Minimum operation level	m MSL	28
Spill level	m MSL	30.8
Seepage factor		0.005
Capacity at FSL	Ha.m	83
Capacily at MOL	Ha.m	1.5

3. Methodology and Analysis

3.1. Water Resources Availability

Guideline ID (1984) procedure recommended for un-gauged catchments was used in this analysis. Inflow to the tank was considered as the surface runoff from the catchment. Since this tank is located in the agro ecological region DL1, 75% probability rainfall data corresponding to the above region was used. Monthly inflow to the tank was calculated by using the specific yield from the seasonal iso yield maps. Monthly inflow obtained are present in the table 3.1.

Table 3.1 Monthly inflow of the catchment

Month	Inflow/Ha.m
October	22.76
November	27.31
December	22.76
January	13.66
February	4.55
March	9.10
April	22.76
May	9.10
June	2.28
July	0.00
August	2.28
September	4.55

3.2. Irrigation Requirement

Irrigation requirement for paddy and other field crops were calculated as stated in the irrigation guide lines. It was assumed that the reference crop evapotranspiration at Maha Iluppallama was representative of the study area. A three stagger water issue method was used for both paddy and other field crops. . In the absence of project specific values, an application efficiency of 60% and a conveyance efficiency of 70% were used.

Paddy is selected as the main crop. Department of agriculture was consulted and based on the statistics on demand, marketing trend etc., recommendation for the other crop was Soya bean and Chilies. Out of the two. Soya bean was selected considering the post-harvest facilities such as marketing assistance and the pre cultivation support such as seeds.

Irrigation demand for paddy and soya bean was calculated based on three stagers. For this analysis, crop water requirement, field water requirement and irrigation demand were analyzed. Conveyance efficiency was taken as 70%. Table 3.2 presents the irrigation demand for paddy and soya bean.

Table 3.2 Irrigation demand for paddy and soya bean

Month	paddy/mm	Soya Bean/mm
October	231.13	106.47
November	303.87	103.73
December	302.58	164.94
January	358.32	145.19
February	388.18	0.00
March	189.49	0.00
April	0.00	95.75
May	305.50	290.63
June	515.78	383.38
July	534.89	313.02
August	496.08	0.00
September	199.29	0.00

3.3. Water Balance

Available water resources to meet the demand for cultivation of crops was studied using the water balance of the reservoir with the use of: inflow, demand, losses and spillage. Monthly water balance equation used is in equation 1.

Storage at the beginning of month +Inflow-Evaporation-Seepage-Demand-Spillage = Storage at the end of month -------------------------------------(1)

The monthly water balance enabled the evaluation of reservoir operation and the adequacy of the available water resources to meet the demand for the cultivation of crops. In this work reservoir operation study was carried out to determine the smallest capacity of the tank that would be required for the cultivation of the irrigable area for a desired cropping pattern and intensity following the ID (1984).

The operation study was commenced with the storage at the minimum operating level as the initial storage. This was for a period of one year and at a monthly temporal resolution.

3.4. Comparison of Scenario

Studied scenario were i) present condition: only paddy for both Maha and Yala seasons, ii) Future option I: paddy for Maha and OFC for Yala and iii) future option II, paddy for Maha and both crops for

Yala season. The largest possible irrigable area for combination of crops was determined through trial and error operation. Scenario evaluation was carried out with an income comparison. The market value of crops were taken and income was calculated for the land extents cultivated under each scenario. Cropping pattern which provided a higher income was selected for implementation. Statistics from Hector Kobbekaduwa agrarian research centre were used for this comparison (this analysis is presented in table 3.3).

Table 3.3 Statistics used in income comparison

Description	Unit	Value
Yield/paddy	Bushels/acre	90
Yield/soya bean	Kg/acre	445
Farm gate price/paddy	Rs/kg	30
Farm gate price/paddy	Rs/kg	95

4. Results

4.1. Water Balance

The water balance results of the scenario iii is in table 4.1.

Table 4.1 Water Balance results for option iii (all values are in Ha.m)

Month	Inflow	Losses	Demand	Spillage	End Storage
Oct	22.76	3.40	14.57	0.00	32.46
Nov	27.31	3.06	18.50	0.00	38.21
Dec	22.76	3.47	19.53	0.00	37.98
Jan	13.66	3.56	22.23	0.00	25.84
Feb	4.55	3.38	21.25	0.00	5.76
Mar	9.10	2.21	10.37	0.00	2.28
Apr	22.76	1.11	2.06	0.00	21.87
May	9.10	3.58	6.26	0.00	21.12
June	2.28	3.69	8.26	0.00	11.44
July	0.00	2.76	6.75	0.00	1.94
Aug	2.28	1.23	0.00	0.00	2.99
Sep	4.55	1.51	0.00	0.00	6.03

4.2. Cropping Pattern

The cropping pattern comparison obtained from the three crop type combinations is in Table 4.2.

Table 4.2 Comparison of Cropping patterns (Extents in Ha)

Scenario	Paddy	OFC	Total
Present	60.1	0.00	60.1
Future option I	47.9	22.5	70.4
Future option II	52.2	21.5	73.3

4.3. Income Comparison

Annual income comparison for the three scenario is in Table 4.3.

Table 4.3 Income comparison

Scenario	Annual Income/Rs (million)
Present	8.8
Future option I	9.4
Future option II	9.9

5. DISCUSSION

This study focused on changing the cropping pattern to increase the cropping intensity. This method does not include any time taking activities such as physical changes, rehabilitation to the existing tank or conveyance system, and need not any extra financial support. Therefore, this proposal can be implemented immediately.

Based on the income comparison, future option II is giving more income. Therefore, the cropping pattern in future option II is selected for implementation.

However, there are other options also to conserve water in the system and thereby increase the cropping intensity. Raising of tank spillway to increase the capacity and store more water, improve the efficiency of the system to minimize the losses and on farm water management like shallow water depth method and wet & dry method are some of the other methods that can be implemented to increase the crop-ping intensity. However, those are not verified in this study.

5.1. Issues and constraints

Most of the data were taken from the irrigation department guide line published in 1984. The rainfall was given for a region and evaporation was given based on the data at Mahailluppallama. Catchment yield was taken from the seasonal iso yield curves given in the guide line.

The analysis was based on the past records of data. But it was checked against the actual long term rainfall of Mahailuppallama.

Therefore, the option I (paddy only) was analyzed if those data change within a range of 25%. Parameters considered were, rainfall, losses and demand.

When the rainfall increases, cultivation area was also increased. Increase of evaporation and demand has resulted a decrease in area while the increase of seepage has no significant effect on the area cultivated.

With the 25% increase of parameters, the area that can be cultivated is in table 5.1.

Table 5.1 Cropping pattern with 25% increase of parameters (extents in Ha)

Parameter	Maha	Yala	Total
Rainfall	60.1	17.0	77.0
Evaporation	45.2	10.4	55.6
Seepage	47.9	12.2	60.1
Demand	39.1	9.4	48.5

The option i is analyzed for the 25% decrease of parameters too. When rainfall decreases, the cultivation area also decreases and for the decrease in evaporation and demand the cultivable area increased. In addition, the decrease of seepage has no significant change in cropping pattern.

With the 25% decrease of parameters, the area that can be cultivated is in table 5.2.

Table 5.2 Cropping pattern with 25% decrease of parameters (extents in Ha)

Parameter	Maha	Yala	Total
Rainfall	35.5	8.0	43.0
Evaporation	50.4	13.6	64.0
Seepage	47.9	12.2	60.1
Demand	62.4	16.9	79.3

The percentage variation of the cropping intensity due to the change of parameters also calculated and presented in table 5.3

Table 5.3 Variation of cropping intensity when parameters changed by ±25%

Parameter	Percentage variation in cultivation area	
	+25%	-25%
Rainfall	+28	-28
Evaporation	-7	+6
Seepage	0	0
Demand	-35	+32

6. CONCLUSION

Three scenarios were considered in the study including the present situation and it is revealed that the command area of the scheme can be increased by changing the cropping pattern.

This study based on the parameters given in the irrigation guideline. Variation of rainfall and demand showed a significant variation of the cropping pattern while losses indicated a less significant variation.

7. REFERENCES

Ponrajah A.J.P. Design of irrigation head works for small catchments (1984)