The Climate Smart Irrigated Agriculture Project

Water Management Plan for Palapathwala Cascade

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1 INTRODUCTION

1.1 Background and Context:

Water management is a critical aspect of sustainable development, particularly in regions where water resources are limited and subject to various pressures. In this context, the present report aims to select the most suitable cascade water management plan for the Palapathwala Cascade, located in the Ambanpola Agricultural Service Center (ASC) of the Kurunegala District in the North Western Province (NWP). This cascade lies within the Mi Oya river basin.

By carefully analyzing the data and assessing the specific needs of the region, we aim to recommend the most appropriate cascade water management plan that optimizes water use and minimizes potential risks and conflicts.

The findings and recommendations of this report are intended to guide members of cascade management committee, policymakers, water resource managers, and stakeholders in making informed decisions to secure a reliable and equitable water supply for the Palapathwala Cascade and the communities it serves.

1.2 Hydrology study of Mi oya River Basin

The Hydrology study of the Mi oya river basin was carried out by the TEAMS (Pvt) Limited, as per the request of the CSIAP. Rainfall data of 30 years for 13 rain gauge stations from 1990 to 2019 has been used for the study & rainfall runoff relationship has been computed for the 8 sub-basins indicated in figure below. Palapathwala cascade is located in sub-basin 3 of the Mioya river basin and it falls into the thissen polygon of the meteorological station Mediyawa. The hydrological data required for the development of WEAP model was taken from the study report submitted by the TEAMS (Pvt) Limited. The Palpathwala cascade falls into the thissen polygon of the Mediyawa meteorological station.

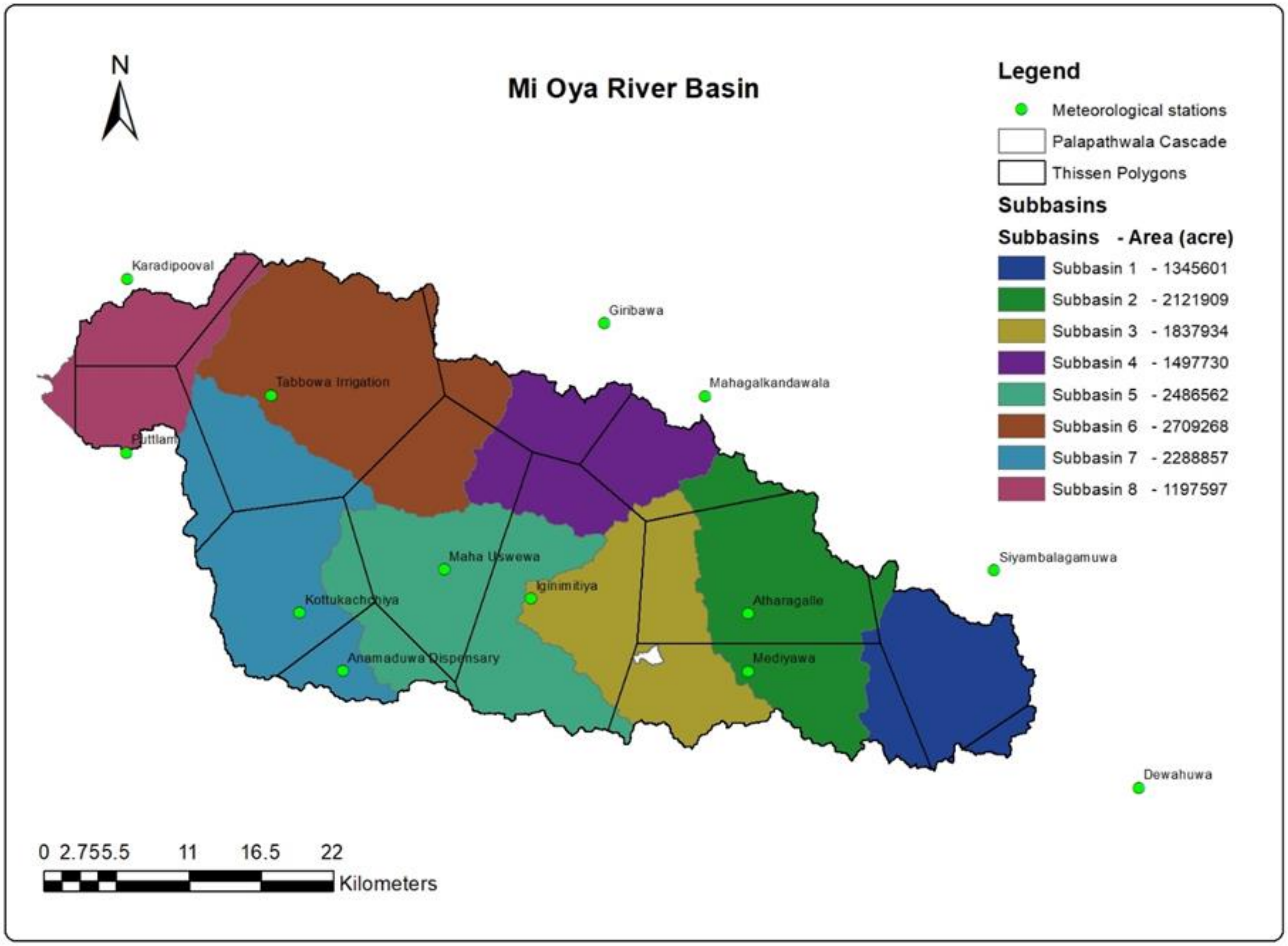

Figure 1.1 Mi Oya basin and Meteorological stations

1.3 Palapathwala Cascade Map

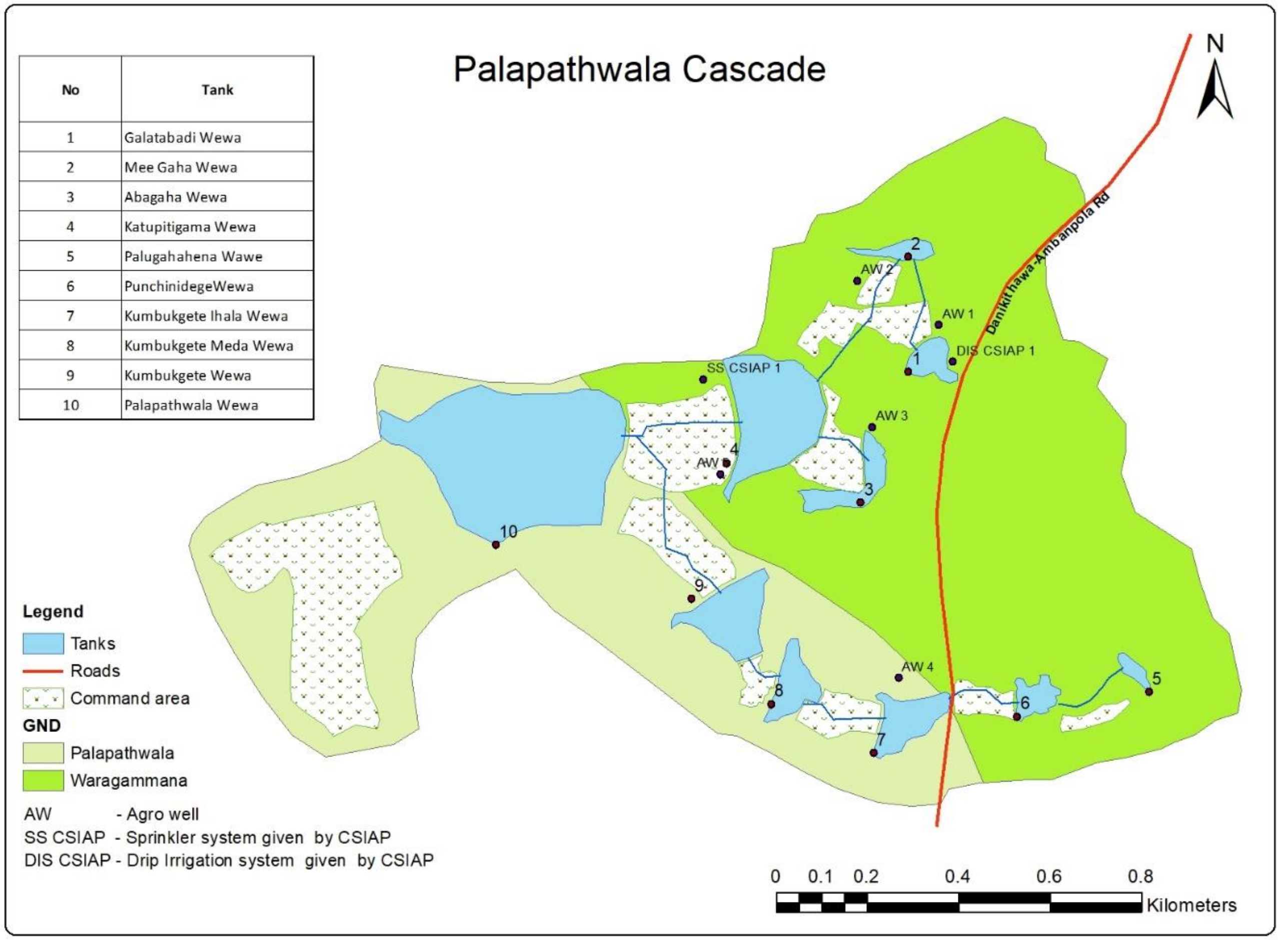

Figure 1.2 Palapathwala Cascade Map

1.4 Cascade Data

1.4.1 General

As indicated in the Figure above there are 10 tanks, five agro wells, one one drip irrigation system and one sprinkler Irrigation system located within the Palapathwala Cascade. The tank data can be summarized as follows.

Table 1.1 General Cascade Data

No	Tank	No of Farm Families	Command Area (ac)	FSL Capacity Before Rehabilitation (acft)	FSL Capacity Expected After Rehabilitation (acft)
1	Galatabadi Wewa	1	2.0	2.2	3.2
2	Mee Gaha Wewa	9	6.5	3.8	5.3
3	Abagaha Wewa	8	6.0	3.8	5.6
4	Katupitigama Wewa	3	12.0	34.5	37.9
5	Palugahahena Wawe	6	2.5	0.9	1.4
6	PunchinidegeWewa	5	2.2	6.4	7.6
7	Kumbukgete Ihala Wewa	4	4.0	11.4	13.2
8	Kumbukgete Meda Wewa	8	4.0	6.9	8.6
9	Kumbukgete Wewa	15	9.0	22.9	24.9
10	Palapathwala Wewa	65	53.0	154.8	158.7
	Total	124	101.2	247.5	266.3

1.4.2 Land use Pattern

The land use pattern within the Cascade System can be summarized as follows.

Table 1.2 The land use pattern of the Cascade System

No	Name of the Tank	Net Catchment (ac)	Jungle (ac)	Paddy (ac)	Water Bodies (ac)	Build up (ac)	Bare land (ac)
1	Galatabadi Wewa	28.4	6.2	0.0	1.7	7.3	13.2
2	Mee Gaha Wewa	17.6	5.6	0.0	1.2	6.0	4.9
3	Abagaha Wewa	40.5	10.1	1.1	2.7	12.2	14.4
4	Katupitigama Wewa	78.1	12.3	10.8	12.1	17.1	25.8
5	Palugahahena Wawe	25.2	12.1	0.0	0.6	0.0	12.5
6	Punchinidege Wewa	26.7	17.1	1.2	1.6	2.4	4.4
7	Kumbukgete Ihala Wewa	30.6	4.0	2.1	3.4	19.1	2.2
8	Kumbukgete Meda Wewa	23.2	4.8	3.3	2.7	3.7	8.7
9	Kumbukgete Wewa	21.4	9.8	1.4	5.3	0.0	5.0
10	Palapathwala Wewa	87.0	20.6	17.8	30.9	9.1	8.6
	Total	378.7	102.3	37.5	62.1	77.0	99.8

1.4.3 Rainfall Data

Variation of annual rainfall at the Mediyawa Tank Gauging Station during the period from 1990 to 2019 is shown in Figure 1.3. The average annual rainfall at this station over the period is about 1473 mm. The annual total rainfall at this station shows an increasing trend during the analysis period.

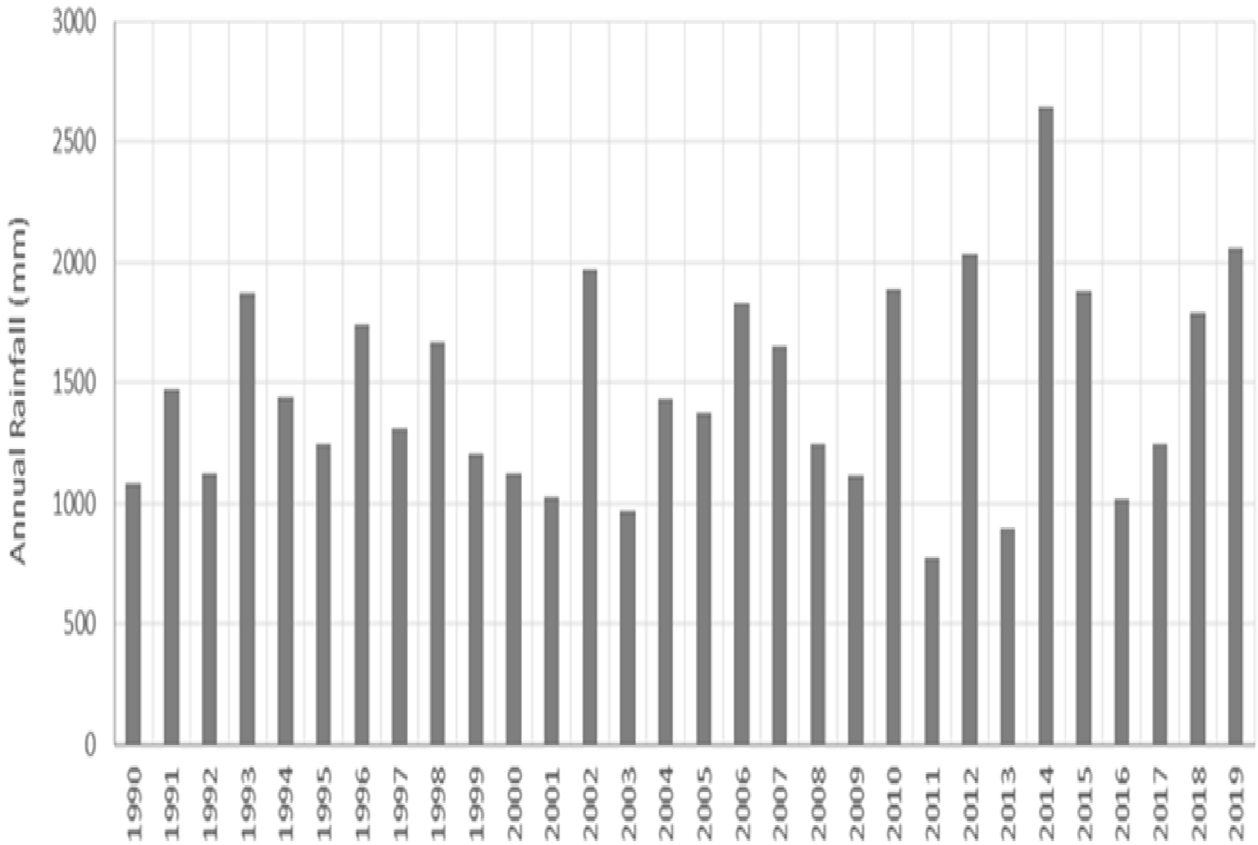

Figure 1.3 Variation of annual rainfall: Mediyawa Tank Gauging Station

The average monthly rainfall at the Mediyawa Tank rainfall gauging station is presented in Figure 1.4. The area seems to receive rainfall mainly during the inter monsoon periods and early part of north-east monsoon period.

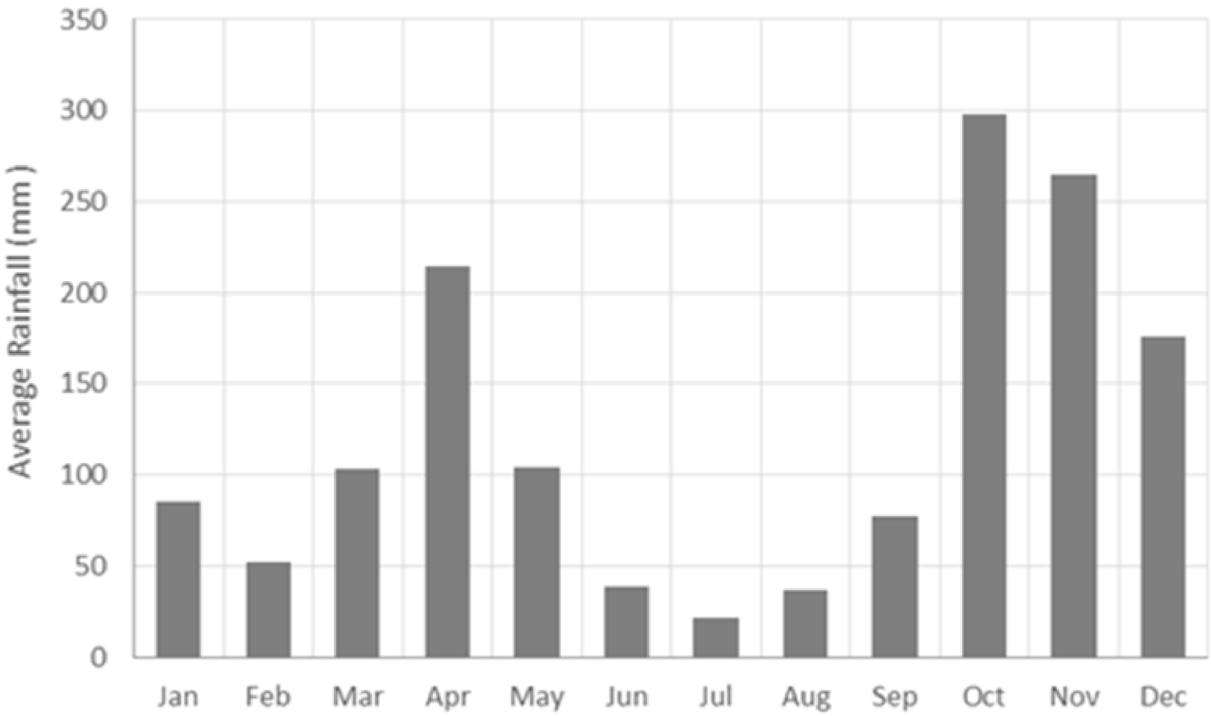

Figure 1.4 Variation of average monthly rainfall: Mediyawa Tank Gauging Station

1.4.4 Reference Crop Evapotranspiration (ETo) and Crop Water Requirement (ETc)

CROPWAT 8.0. was used for the calculation of the ETo and ETc.

The Food and Agriculture Organization (FAO) has published guidelines on the calculation of ETo using the Penman-Monteith method, making it a widely accepted and standardized approach and it was used for the calculations. Nearest weather station for this cascade is Galgamuwa near Mioya river & therefore, long term average ETo of the location was calculated using the meteorological parameters temperature, humidity, wind speed, and solar radiation obtained from the meteorological department of Sri Lanka and the calculated values are given in table 1.3.

In CROPWAT 8.0 the calculation of crop water requirements is carried out per decade. For the calculations of the Crop Water Requirements (CWR), the crop coefficient approach is used. The CWRs were calculated for three types of paddy and other field crops as indicated in the table 1.4 for the Maha Season and Yala Season separately.

Table 1.3 Reference crop Evapotranspiration

Month	**ETo (mm)**
Oct	121.1
Nov	123.7
Dec	149.7
Jan	140.3
Feb	136.5
Mar	122.3
Apr	130.7
May	134.8
Jun	127.7
Jul	119.2
Aug	99.9
Sep	100.6
Total	1506.5

Table 1.4 Crop Water Requirement

Season	Crop Type	Crop Water Requirement (mm/ Season)
Maha Season	Paddy (135 day)	756.7
	Paddy (105 day)	596.3
	Paddy (90 day)	525.1
Yala Season	Paddy (135 day)	810.7
	Paddy (105 day)	664.3
	Paddy (90 day)	593.9
	Greengram (75 day)	247.9
	Cowpea (90 day)	350.4
	Groundnuts (110 day)	385.5
	Finger Millet (90 day)	225.1

2 DEVELOPMENT OF WEAP MODEL AND RECOMMENDATIONS FROM THE ANALYSIS OF RESULTS

WEAP software was used for the water balance study of the cascade system and the details are attached as Annexure 1 along the economical analysis details. The detailed results are given in Annexure 2.

❖ Crop start dates for successful cultivation

Table 2.1 Crop Starting Dates

Season	Cultivation Start Date
Mid Season 1	31-Jan
Mid Season 2	01-Aug
Maha Season	16-Oct
Yala Season	01-May

*The dates are indicated excluding time for land preparation.

❖ Economical analysis for cropping patterns

The purpose of conducting an economic analysis for different scenarios is to assess and compare the financial feasibility and profitability of these scenarios. The profit per year per ac that can be obtained for each scenario was analyzed using the data from following data sources.

Data sources used:

- ❖ Provincial Department of Agriculture NWP
- ❖ Cost of cultivation of agricultural crops by Socio Economics and Planning Centre Department of Agriculture Peradeniya
- ❖ Paddy Statistics by Department of Census and Statistics

Table 2.2 Economical analysis for different Scenarios

Scenario	**Description**	**Profit (Rs/ac) / Year**	**Percentage Increase in Profit relative to Scenario A (Base Scenario) (%)**
A	Maha Season 100% Paddy; Yala Season 50% Paddy and 50% OFC	141,776.73	-
B	A, B Maha Season 100% Paddy; Yala Season 50% Paddy and 50% OFC with increased tank storage capacity.	141,776.73	-
C	Maha Season 100% Paddy; Yala Season 40% Paddy and 60% OFC with increased tank storage capacity.	146,912.48	4%
D	Maha Season 100% Paddy; Yala Season 40% Paddy and 60% OFC; Mid-Season 1 25% OFC with increased tank storage capacity.	185,895.09	31%
E	Maha Season 100% Paddy; Yala Season 40% Paddy and 60% OFC; Mid-Season 1 25% OFC; Mid-Season 2 25% OFC with increased tank storage capacity.	224,877.69	59%
F	Maha Season 100% Paddy; Yala Season 100% OFC with increased tank storage capacity.	143,584.91	1%

- From the economical analysis of the scenarios, it can be observed that with the introduction of OFC for 10% land area the profit has increased by 4% and with introducing OFC for Mid-Season 1 it has increased by 31% and by having two mid seasons it has increased by 59%.

- For ID_04, ID_07, ID_08, ID_09, and ID_10 as the results indicate that water supplies from tanks are reliable for all scenarios analyzed the focus should be on increasing the profit received by farmers by introducing more OFC during the Yala and the Mid Seasons.
- Based on the Demand Site Coverage results for the demand sites ID_01, ID_02, ID_03, ID_05 and ID_06 implementing a Mid-Season 2 is not recommended and it is recommended to use a drought-tolerant crop like Finger Millet for the Yala season.
- For ID_01 and ID_02 and ID_03 during the Yala Season water from existing agro wells AW 1, AW 2 and AW 3 respectively can be used to satisfy the water requirement.
- For ID_05 and ID_06 it is recommended if an alternative water source is found (constructing of an agro well) if people are willing to cultivate the full extent during the Yala season; if not to cultivate half of the command area.

3 SAMPLE CROPPING PATTERNS BASED ON THE RECOMMENDATIONS

Table 3.1 Proposed Cropping Pattern for Cascade

Tank	Command Area (ac)	Maha Season	Yala Season					Mid Season 1	Mid Season 2
		Paddy (105)	Paddy (90)	Ground Nuts (110)	Green Gram(75)	Cowpea (90)	Finger Millet (90)	Green Gram(75)	Green Gram(75)
Galatabadi Wewa	2	2					2*1	0.5	
Mee Gaha Wewa	6.5	6.5					6.5*1	1.5	
Abagaha Wewa	6	6					3*1		
Katupitigama Wewa	12	12	5	1	2.5	2.5	1	3	3
Palugahahena Wawe	2.5	2.5					1.5*2		
Punchinidege Wewa	2.25	2.25					2.25*2	0.5	
Kumbukgete Ihala Wewa	4	4	1	0.5	1	1	0.5	1	1
Kumbukgete Meda Wewa	4	4	1	0.5	1	1	0.5	1	1
Kumbukgete Wewa	9	9	3	1	2	2	1	2	2
Palapathwala Wewa	53	53	23	5	10	10	5	13	13

*1 For these tanks for Yala season water from existing agro wells can be used to satisfy the demand.

*2 For these tanks an agro well is proposed to be developed so during the Yala season it can be used to obtain water for the command area and during the Maha season it can be used with a drip/sprinkler system to deliver water for upland crops near the area.

Note : The agriculture specialist can change the cropping pattern based on the recommendations given above and the consultations by the water resource development specialist.

4 IRRIGATION SHEDULING

After computing the irrigation water requirements for the cultivated crops, Rotational water supply can be implemented. For identification of irrigation timing Alternate wetting and drying (AWD) method can be used. AWD is a water management technique, practiced cultivating irrigated lowland rice with much less water than the usual system of maintaining continuous standing water in the crop field. It is a method of controlled and intermittent irrigation. A periodic drying and re-flooding irrigation scheduling approach is followed in which the fields are allowed to dry for few days before re-irrigation, without stressing the plants. This method reduces water demand for irrigation and greenhouse gas emissions without reducing crop yields.

4.1.1 Implementation method

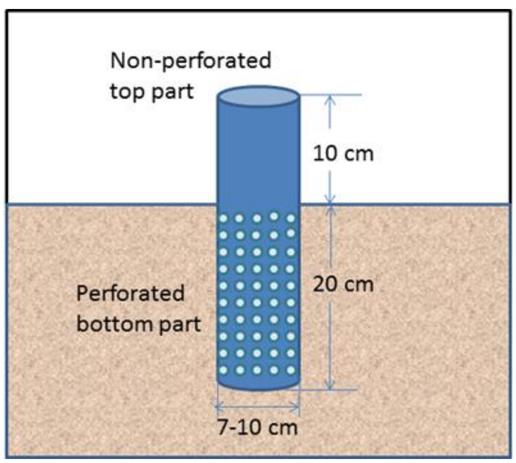

Figure 4.1 Illustration of alternate wetting and drying method

A water tube/pipe made of PVC is usually used to practice AWD method. The main purpose of the tube is to monitor the water depth. The tube allows measuring water availability in the field below the soil surface. The usual practice is to use a pipe of 7–10 cm diameter and 30 cm long, with perforations in bottom 20 cm. The pipe is installed in such a way that the bottom 20 cm of perforated portion remains below the soil surface and the non-perforated 10 cm above the surface. The perforations permit the water to come inside the tube from the soil, where a scale is used to measure water depth below the soil surface. However, there are variations in preparing the tube/pipe for the implementation of AWD. Some farmers use a bamboo pipe instead of PVC pipe. Some farmers use a 30 cm tube with 15 cm perforated at the bottom.

4.1.2 Operation technique

After the irrigation in the crop field, the water depth gradually decreases because of evapotranspiration, seepage, and percolation. Because of the installed tubes in the field, it is possible to monitor the water depth below the soil surface up to 15–20 cm. When the water level drops 15 cm below the soil surface, irrigation should be applied in the field to re-flood to a depth of 5 cm. During the flowering stage of the rice, the field should be kept flooded. After flowering, during the mid-season and late season (grain filling and ripening stages), the water level is allowed to drop below the soil surface to 15 cm before re-irrigation. To suppress the growth of weeds in the rice field, AWD method should be followed 1–2 weeks after the transplantation. In the case of many weeds in the field, AWD needs to be started after three weeks of transplantation. Usually, the fertilizer recommendations are as same as continuous flooding method. Application of nitrogen fertilizer is preferable on dry soil just before re-irrigation. To ensure a similar dry or wet condition throughout the crop field, which is essential to maintain good yield, it is important to level the rice field properly.

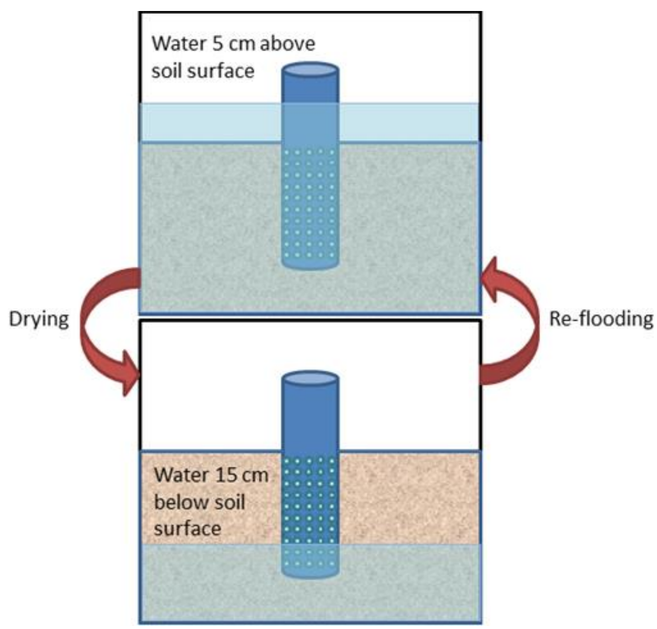

Figure 4.2 Illustration of AWD operation technique

Canal discharged needs marked in a gauge post using the calibrated cutthroat flume provided by the CSIAP.

Table 4.1 Calibration of canal for Katupitigama Tank

Canal Discharge (Cusec)	Gauge Reading
0.25	0.80
0.50	1.05
0.75	1.30
1.00	1.55

Table 4.2 Rotational irrigation schedule for AWD method

Canal	**Group Number**	**Command area under the group**	**Total irrigation time for the group**		**Mon**	**Tue**	**Wed**	**Thu**	**Fri**	**Sat**	**Sun**
			Hour	**Min**							
LB	1	2.75	11	5	6.30-17.35						
LB	2	1	3	55		6.30-10.25					
LB	3	2	7	50		10.25-18.15					
LB	4	2.25	8	50			6.30-15.20				
RB	1	3	11	45	6.30-18.15						

Table 4.3 Area Capacity Relationship of Katupitigama Tank

Elevation (m)	Area (ac)	Capacity (Ac.ft)	Remarks
87.85	0.00	0.00	
88.30	0.05	0.06	LSSL
88.50	0.36	0.95	
88.75	0.84	1.93	MOL
88.80	0.93	2.10	
89.10	1.47	3.50	
89.40	2.19	5.35	
89.70	3.04	7.96	FSL
90.00	4.26	11.60	
90.05	4.44	12.40	HFL
90.30	5.35	16.41	
90.60	6.35	22.26	BTL

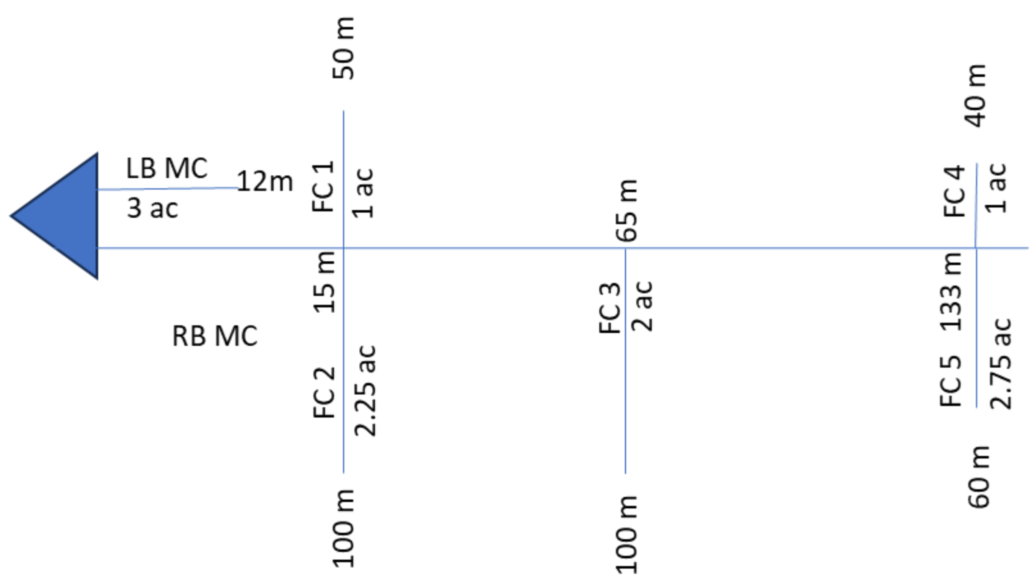

Figure 4.3 Issue tree of Katupitigama Tank

Note: For all the tanks in the cascade the irrigation schedule, area capacity table and issue tree need to be included.

5 MAINTAINANCE ACTIVITIES OF THE CASCADE

Table 5.1- Summary of the maintenance activities that needs to be carried out in the cascade.

Items	Tank bund (m)	Irrigation Canals (m)	Spillways and Spill Tain Canals (m)	Sluices
Quantity	1759	329	Crest wall - 8 Causeway - 1 CO - 1 Tail canal - 985	10 Head walls 1 Hume Pipe
Activities	a) Cleansing the jungle b) Removal of ant hills c) Restoring the eroded areas with soil d) Turfing	a) Cleansing the jungle hindering the spillway b) Removal of ant hills c) Removal of silt d) Restoring the eroded areas with soil e) Turfing	a) Cleansing the jungle hindering the spillway b) Removal of ant hills c) Restoring the eroded areas with soil d) Turfing	a) Apply Grease /Lubricant b) Apply paint coating c) Removal of silt
Time Period	a) When the jungle grows up to 6 inches b) As required c) As required d) As required	a) When the jungle grows up to 6 inches b) As required c) Twice a season d) As required e). As required	a) When the jungle grows up to 6 inches b) As required c) As required d) As required	a) Once every two weeks b) Once a year c) Once a season

Method	Divided share method according to share register	Divided share method according to share register	Selected small group	Selected small group
Responsibility	Relevant farmer	Relevant farmer	Members of the selected small group	Members of the selected small group
Supervision	Members of the FO Committee and the CMC	Members of the FO Committee and the CMC	Members of the FO Committee and the CMC	Members of the FO Committee and the CMC

6 GENERAL STANDARD OPERATING PROCEDURES FOR TANKS WITHIN THE CASCADE

6.1 Under Normal Conditions:

6.1.1 Technical staff:

- Water management: Prepare the irrigation schedule for each season. For paddy AWD method can be implemented as described in the chapter 4. Decide the acreage to be cultivated by the farmers according to the rainfall prediction and considering the available water capacity of the tank at the beginning of the season.
- Periodic Assessment: Conduct periodic structural assessments of the reservoir to ensure its integrity.
- Maintenance: Perform routine maintenance, including embankment repairs, intake structure cleaning, and control gate checks etc.
- Data Collection: Collect and analyze data on reservoir performance, water quality, and structural integrity.

6.1.2 Farmers:

- Water Management: Without using the tank water initiate dry land preparation using the rain water. Decide the irrigation timing with the usage of the AWD method and allocate the water according to the recommended irrigation schedule prepared by the engineer/technical officer. The FO is responsible for issuing the order for release of the water. The FO should observe the times that are taken actually in the field for the filling of water up to 5cm as in AWD method and should adjust the irrigation schedule accordingly. The paddy fields in which the water dries up first should be identified and water should be issued accordingly. The paddy fields should be leveled as to implement the AWD method.
- Routine Inspection: Regularly inspect the reservoir, embankment, and surrounding areas for signs of damage, leaks, or erosion.
- Vegetation Control: Ensure that the vegetation around the reservoir is well-maintained to prevent erosion and sedimentation.
- Water Quality: Monitor water quality and report any changes or pollution concerns to the technical officer.

6.2 Under Drought Conditions:

6.2.1 Technical staff:

- Drought Preparedness: Develop contingency plans for water conservation and drought management, including water allocation priorities.
- Emergency Planning: Establish protocols for emergency water release if necessary.
- Drought Monitoring: Continuously monitor water levels and drought conditions, providing guidance to farmers on adjusting their irrigation practices. The AGRO-MET ADVISORY can be used for this purpose.

  https://doa.gov.lk/agro-met-advisory/

6.2.2 Farmers:

- Water Conservation: Implement water-efficient irrigation methods and adhere to water rationing if required.
- Communication: Maintain communication with the technical officer and engineers regarding water availability and crop water needs.

6.3 Under Flood Conditions:

6.3.1 Technical staff:

- The spills of the tanks have been designed to with stand the flood of a 50-year return period and the used value for this cascade is 180 mm.
- The 9 Days Weather Forecast can be obtained from the meteorological department of Meteorology and if the values exceed 180mm the farmers should be warned about the chance of a flood event.

  9 Days Weather Forecast: http://222.165.186.51/public/emfc10d.html
- The designed afflux needs to be marked on the spill gauge in red colour. (High Flood Level) Designed afflux for tanks in the cascade are given in table 6.1.

Table 6.1 Designed afflux for tanks

Name of the Tank	Afflux (m)
Galatabadi Wewa	0.25
Mee Gaha Wewa	0.35
Abagaha Wewa	0.35
Katupitigama Wewa	0.70
Palugahahena Wawe	0.20
PunchinidegeWewa	0.40
Kumbukgete Ihala Wewa	0.56
Kumbukgete Meda Wewa	0.60
Kumbukgete Wewa	0.45
Palapathwala Wewa	0.71

- The emergency breach section for each tank should be identified, marked on the field as well as in the diagram in the O & M manual and the farmers need to be educated about it.
- Following factors should be considered when identifying a suitable emergency breach section.

  Impact on Downstream Area: The most critical factor is the impact on the downstream area. The emergency breach should be located in such a way as to minimize the risk to human life, property and infrastructure. Consider factors such as population density, critical infrastructure (eg schools, hospitals) and environmental sensitivity of the downstream area.

  Dam Structure: The structural integrity of the dam is very important. The breach should be at a point where there is minimal risk to the overall stability of the dam. Consider the dam's design, materials, and known weaknesses.

Elevation and Topography: Consider the elevation and topography of the area around the dam. The emergency breach should be located in such a way as to allow safe and controlled release of water.

Accessibility: Access to the breach site is critical for farmers and equipment. Ensure that the emergency services can reach there quickly.

Environmental Impact: Try to choose a location that has the least environmental impact downstream of the released water.

Public Awareness: Ensure that the people of the downstream area are aware of emergency procedures, escape routes and any warning systems in place.

- ❖ Damage Assessment: After the flood recedes, assess the damage to the reservoir and surrounding infrastructure and initiate rehabilitation.

6.3.2 Farmers:

- ❖ Safety First: Follow evacuation orders issued by local authorities and ensure the safety of family and livestock.
- ❖ The farmer should try to keep the water level below the red mark (HFL) by releasing the water through the available flood gates or removing the plank arrangements. Water should not be released through sluices so as the crops will get damaged.
- ❖ If the water level seems to be rising above the red mark of the spill gauge and the catchment is still receiving rainfall, the farmer should cut the embankment from the previously selected emergency breach section. The farmer organization should have the contacts of the persons and following goods should be available with FO
    - ❖ Persons
        - ❖ Engineer and technical officer, Machine operators for cutting the breach section, Labours etc.
    - ❖ Goods
        - ❖ Gunny bags, Mamoties, Sand, Gravel
- ❖ Crop Protection: Take necessary measures to protect crops from flood damage.

7 ANNEXURE 1

Development of the WEAP model

7.1 Schematics

Tanks were named Tank_No and the relevant drainage path as RIV_No. Agricultural lands (Command areas) were inserted as catchments using label ID_No to symbolize the Irrigation Demand. The tanks were joined with the relevant catchment using transmission links, and the Runoff/infiltration Links were connected from the catchment to the downstream of the river. The groundwater node was used to account for the loss to the groundwater.

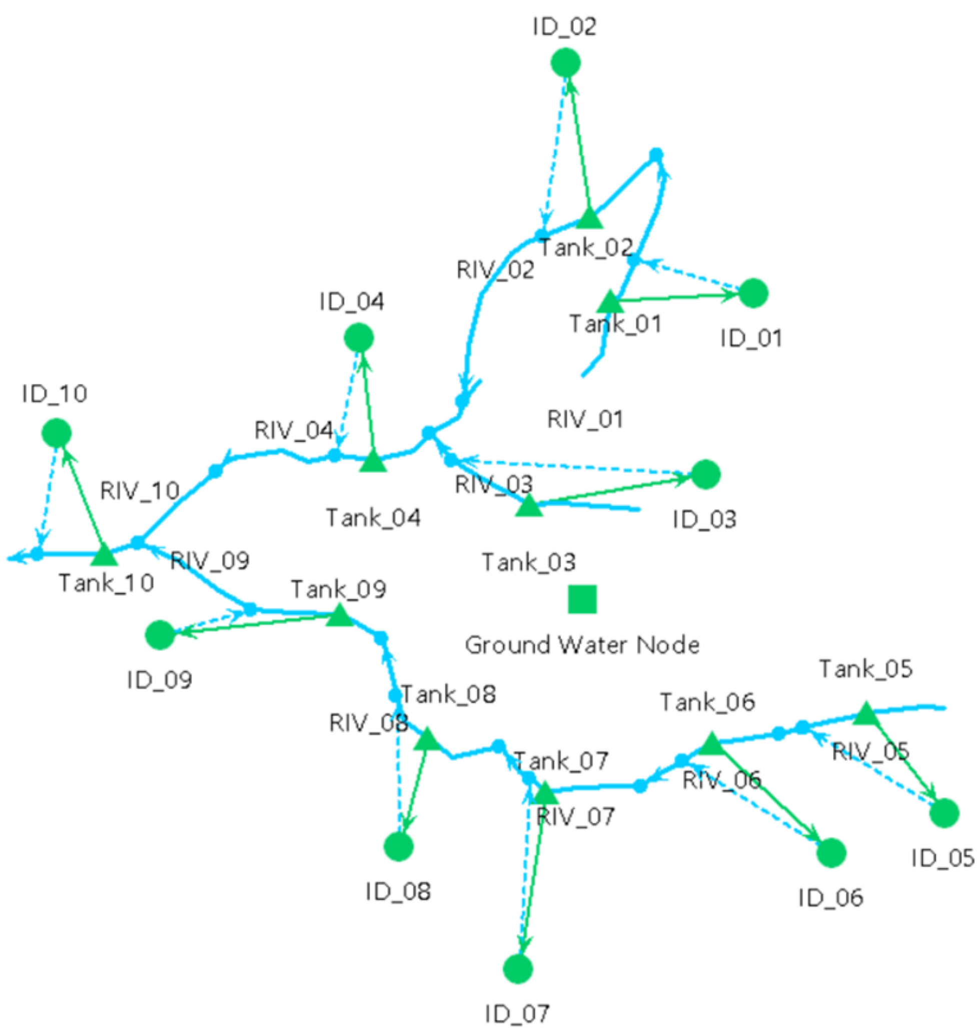

Figure 7.1 Schematics diagram of Palapathwala Cascade

7.2 Precipitation and Effective Precipitation for the model.

Effective Precipitation was calculated using the Dependable rainfall (FAO/AGLW formula).

Peff = 0.6 * P - 10 for Pmonth <= 70 mm

Peff = 0.8 * P - 24 for Pmonth > 70 mm

Peff – Effective Precipitation

P – Monthly precipitation

Table 7.1 Sample Precipitation Data for 1990

Month	Precipitation (mm)	Effective Precipitation (mm)	Effective Precipitation (%)
October	253.0	178.4	70.5
November	177.5	118.0	66.5
December	66.0	29.6	44.8
January	183.0	122.4	66.9
February	0.0	0.0	0.0
March	136.0	84.8	62.4
April	135.0	84.0	62.2
May	73.0	34.4	47.1
June	152.0	97.6	64.2
July	9.0	0.0	0.0
August	0.0	0.0	0.0
September	78.0	38.4	49.2

7.3 Headflows of tanks

During the hydrological assessment of Mi Oya, the location of the Palapathwala Cascade was determined to fall within subbasin 3. For finding the monthly flow of the sub basin power equations proposed in the hydrological study for sub basin 3 were used.

$$\boldsymbol{Y = cX^d}$$

Y- Monthly Discharge (MCM)

X- Monthly Rainfall (mm)

c- Coefficient

d- Power Coefficient

The next step was to compute the head flow for each tank. This involved utilizing the 'Total Flow of the sub basin' obtained from power equations and the obtained the Net Catchment Area proportion of each tank. To calculate the proportion of the net catchment area for each tank in relation to the total subbasin area, certain considerations were made. The net catchment areas were derived by deducting the area of the command area that lies within each net catchment. The Runoff was converted to mm using the area of the sub basin.

Table 7.2 Sample Runoff Calculations for 1990

Month	**Coefficient**	**Power Coefficient**	**Monthly Rainfall (mm)**	**Runoff For Sub Basin 3 (mm)**
October	0.000119	1.94615	253.0	30.8
November	0.001514	1.59701	177.5	32.2
December	0.001851	1.61199	66.0	8.6
January	0.040929	1.0145	183.0	43.9
February	0.000673	1.83459	0.0	0.0
March	0.000979	1.62614	136.0	15.7

April	0.000063	2.04592	135.0	7.8
May	0.000791	1.78188	73.0	9.0
June	0.00005915	1.892	152.0	4.3
July	0.000021	2.63245	9.0	0.0
August	0.014301	1.02246	0.0	0.0
September	0.00113	1.55602	78.0	5.4

Table 7.3 Monthly Average Headflows of Tanks

Headflows (acft)										
Tank No/ Month	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Oct	4.9	3.0	7.0	11.0	4.4	4.2	4.9	3.3	3.0	11.4
Nov	6.3	3.9	9.0	14.1	5.6	5.4	6.3	4.3	3.9	14.7
Dec	4.7	2.9	6.7	10.5	4.2	4.0	4.7	3.2	2.9	10.9
Jan	1.8	1.1	2.5	3.9	1.6	1.5	1.8	1.2	1.1	4.1
Feb	0.8	0.5	1.2	1.8	0.7	0.7	0.8	0.5	0.5	1.9
Mar	1.3	0.8	1.8	2.9	1.1	1.1	1.3	0.9	0.8	3.0
Apr	2.5	1.6	3.6	5.6	2.2	2.1	2.5	1.7	1.5	5.8
May	2.4	1.5	3.5	5.4	2.2	2.1	2.4	1.6	1.5	5.6
Jun	0.1	0.0	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.1
Jul	0.3	0.2	0.4	0.6	0.2	0.2	0.3	0.2	0.2	0.6
Aug	0.3	0.2	0.4	0.7	0.3	0.3	0.3	0.2	0.2	0.7
Sep	0.8	0.5	1.1	1.7	0.7	0.7	0.8	0.5	0.5	1.8
Total	26.1	16.2	37.3	58.5	23.2	22.2	26.1	17.7	16.0	60.7

7.4 Reservoir Data

Following data was input for the 10 tanks in the cascade under the reservoir data for the WEAP model.

- ❖ The Storage Capacity - Represents the total capacity of the reservoir (Enter the capacity of reservoir at High Flood Level in MCM)- FSL levels were obtained from the results of the spillway designs done for the cascade.
- ❖ Initial Storage - the amount of water initially stored there at the beginning of the first month of the Current Accounts year. WEAP maintains a mass balance of monthly inflows and outflows in order to track the monthly storage volume. (Minimum Operating Level Capacity in MCM was used)
- ❖ Reservoir Volume-Elevation Curve- In order to calculate the amount of evaporation and/or the amount of energy production from hydropower, WEAP must have a function to convert between volume and elevation. So, the are capacity diagrams by the tank survey was used.
- ❖ Top of Conservation - Full Supply Level Capacity in MCM
- ❖ Top of Buffer - Minimum Operating Level Capacity in MCM
- ❖ Top of Inactive - Sluice Sill Level Capacity in MCM
- ❖ Buffer Coefficient – a coefficient close to 1.0 will cause demands to be met more fully while rapidly emptying the buffer zone, while a coefficient close to 0 will leave demands unmet while preserving the storage in the buffer zone. 0.2 was used for this model as the buffer coefficient.

7.5 Calculation of the demand and scenarios used.

7.5.1 Method used

Rainfall Runoff Method (Simplified Coefficient Method) was used as the catchment simulation method. The Rainfall Runoff method also determines evapotranspiration for irrigated and rainfed crops using crop coefficients, the same as in the Irrigation Demands Only method. The remainder of rainfall not consumed by evapotranspiration is simulated as runoff to a river or can be proportioned among runoff to a river and flow to groundwater via runoff/infiltration links.

The cultivation dates for the demand calculations were used as given in table 2.1.

7.5.2 Kc values

Weighted Average method was used to calculate a weighted average Kc value based on the proportion of each crop's area within the total cultivated area. Multiply each crop's Kc value by its corresponding area, sum the results, and divide by the total cultivated area. This method considers the relative contribution of each crop to the overall water requirements.

The cultivation area proportions for different scenarios used for the WEAP model are given below.

For Maha season Paddy was proposed due to its climate resilience and as it was preferred by the people. For Yala Season combination of crops are used and, in these combinations, OFC are proposed as per the preference of the people and recommendations by the Agriculture Specialist. For Mid seasons green gram was proposed after consulting with the agriculture specialist due to its lesser cultivation time and higher commercial value.

Scenario A is used as the base case scenario to access the conditions before the rehabilitation and other scenarios are used to access the conditions after rehabilitation.

Table 7.4 Scenarios Analyzed

Cultivation Area (%)								
Scenario	**Maha Season**	**Yala Season**					**Mid Season 1**	**Mid Season 2**
	Paddy (105)	**Paddy (90)**	**Ground Nuts (110)**	**Green Gram (75)**	**Cowpea (90)**	**Finger Millet (85)**	**Green Gram (75)**	**Green Gram (75)**
A,B	100%	50%	10%	20%	10%	10%		
C	100%	40%	10%	20%	20%	10%		
D	100%	40%	10%	20%	20%	10%	25%	
E	100%	40%	10%	20%	20%	10%	25%	25%
F	100%					100%		

7.6 Losses from the system

The application efficiency of 60% and a conveyance efficiency of 80% was used for the calculation.

Loss to groundwater due to the seepage was considered as 0.5% of the initial volume of the particular month.

7.7 Economical Analysis of scenarios

The purpose of conducting an economic analysis for different scenarios is to assess and compare the financial feasibility and profitability of these scenarios. The profit per year per ac that can be obtained for each scenario was analyzed using the following data.

Data sources used:

- ❖ Provincial Department of Agriculture NWP
- ❖ Cost of cultivation of agricultural crops by Socio Economics and Planning Centre Department of Agriculture Peradeniya
- ❖ Paddy Statistics by Department of Census and Statistics

Table 7.5 Data for the Economical Analysis

Crop	Yeild(kg/ac)	Farm gate Price(Rs/Kg)	Total cost(Rs/ac)	Gross income (Rs/ac)	Profit*(Rs/ac)
Paddy Maha	1424.9	85	70,440	121113.0896	50,673
Paddy Yala	1650.0	125	145,816	206248.356	60,432
Ground Nuts	731.7	220	68653	160965.1033	92,312
Green Gram	468.4	420	40798	196728.4356	155,930
Cowpea	447.9	382	59,292	171081.8229	111,790
Finger Millet	324.0	435	48016	140927.8254	92,912

8 ANNEXURE 2

8.1 Results and discussion of THE SCENARIO analysis

The developed WEAP model was used to study the irrigation water supply to satisfy the demands by simulating the system operation during 30 years from 1990 to 2019.

8.2 Demand Site Coverage (% of requirement met) (Percent)

The percent of each demand site branch's requirement that is met, from 0% (no water delivered) to 100% (delivery of full requirement), according to each branch's optional distribution order. The coverage report gives a quick assessment of how well demands are being met. The tables below depict the demand site coverages for the scenarios analyzed.

8.2.1 Scenario A – Base Scenario Maha Season 100% Paddy; Yala Season 50% Paddy and 50% OFC

Table 8.1 Demand Site Coverage (%) for Scenario A

Demand Site	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
ID_01	99	100	100	97	100	100	100	100	70	10	50	100
ID_02	100	100	100	97	100	100	100	100	70	11	94	100
ID_03	98	100	88	73	100	100	100	75	7	8	41	100
ID_04	100	100	100	100	100	100	100	100	100	95	100	100
ID_05	98	100	98	89	100	100	100	92	24	11	64	100
ID_06	100	100	100	100	100	100	100	100	79	19	79	100
ID_07	100	100	100	100	100	100	100	100	100	97	100	100
ID_08	100	100	100	100	100	100	100	100	100	97	100	100
ID_09	100	100	100	100	100	100	100	100	100	100	100	100
ID_10	100	100	100	100	100	100	100	100	100	100	100	100

Demand sites ID_04, ID_07, ID_08, ID_09, and ID_10 consistently receive 100% coverage throughout the year, indicating a reliable water supply from the relevant tanks.

ID_01, ID_02, and ID_06 experience fluctuations in coverage, with lower percentages during certain months, particularly in months July and August in the Yala season. However, coverage generally exceeds 80% in other months.

ID_03 and ID_05 has significant coverage variations. While it enjoys good coverage during some months, it faces challenges particularly in the Yala season (June July and August) with a very poor Demand Site Coverage for these months.

8.2.2 Scenario B –Maha Season 100% Paddy; Yala Season 50% Paddy and 50% OFC with Increase in Storage Capacity of the 10 tanks after rehabilitation.

Table 8.2 Demand Site Coverage (%) for Scenario B

Demand Site	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
ID_01	98	100	100	99	100	100	100	100	85	15	49	100
ID_02	100	100	100	99	100	100	100	100	85	16	96	100
ID_03	98	100	97	83	100	100	100	95	28	9	45	100
ID_04	100	100	100	100	100	100	100	100	100	100	100	100
ID_05	99	100	100	99	100	100	100	100	61	12	59	100
ID_06	100	100	100	100	100	100	100	100	92	36	78	100
ID_07	100	100	100	100	100	100	100	100	100	100	100	100
ID_08	100	100	100	100	100	100	100	100	100	100	100	100
ID_09	100	100	100	100	100	100	100	100	100	100	100	100
ID_10	100	100	100	100	100	100	100	100	100	100	100	100

Here we can see though the Demand Site Coverage has increased in the demand sites ID_01, ID_02, ID_03, ID_05 and ID_06 with the increase in storage capacity, still during the Yala season the water supply system is unable to satisfy the water demand for these sites.

8.2.3 Scenario C –Maha Season 100% Paddy; Yala Season 40% Paddy and 60% OFC with Increase in Storage Capacity of the 10 tanks after rehabilitation.

In this scenario the Demand Site Coverage has increased slightly in the demand sites ID_01, ID_02, ID_03, ID_05 and ID_06 with the more crop diversification but still during the Yala season the water supply system is unable to satisfy the water demand for these sites.

Table 8.3 Demand Site Coverage (%) for Scenario C

Demand Site	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
ID_01	98	100	100	99	100	100	100	100	86	16	49	100
ID_02	100	100	100	99	100	100	100	100	86	16	96	100
ID_03	98	100	97	83	100	100	100	95	29	9	45	100
ID_04	100	100	100	100	100	100	100	100	100	100	100	100
ID_05	99	100	100	99	100	100	100	100	63	12	59	100
ID_06	100	100	100	100	100	100	100	100	93	37	78	100
ID_07	100	100	100	100	100	100	100	100	100	100	100	100
ID_08	100	100	100	100	100	100	100	100	100	100	100	100
ID_09	100	100	100	100	100	100	100	100	100	100	100	100
ID_10	100	100	100	100	100	100	100	100	100	100	100	100

8.2.4 Scenario D –Maha Season 100% Paddy; Yala Season 40% Paddy and 50% OFC; Mid-Season 1 25% OFC with Increase in Storage Capacity of the 10 tanks after rehabilitation.

Table 8.4 Demand Site Coverage (%) for Scenario D

Demand Site	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
ID_01	98	100	100	99	97	100	100	100	86	15	50	100
ID_02	100	100	100	99	98	100	100	100	86	16	96	100
ID_03	98	100	97	83	82	92	100	95	29	9	45	100
ID_04	100	100	100	100	100	100	100	100	100	100	100	100
ID_05	99	100	100	99	94	97	100	100	63	12	59	100

ID_06	100	100	100	100	100	100	100	100	93	36	78	100
ID_07	100	100	100	100	100	100	100	100	100	100	100	100
ID_08	100	100	100	100	100	100	100	100	100	100	100	100
ID_09	100	100	100	100	100	100	100	100	100	100	100	100
ID_10	100	100	100	100	100	100	100	100	100	100	100	100

Same as in Scenario C for demand sites ID_01, ID_02, ID_03, ID_05 and ID_06 during the Yala season the water supply system is unable to satisfy the water demand for these sites. As the Mid-season 1 was planned to start on 31-Jan-23 immediately after the Maha Season the demand site coverage during the Mid-Season 1 for all the demand sites exceed 85% except for ID 03.

8.2.5 Scenario E –Maha Season 100% Paddy; Yala Season 40% Paddy and 50% OFC; Mid-Season 1 25% OFC; Mid-Season 2 25% OFC with Increase in Storage Capacity of the 10 tanks after rehabilitation.

Mid-season 2 was planned to start on 01-Aug and with that we can see in demand sites ID_01, ID_02, ID_03, ID_05 and ID_06 the demand site coverage has further reduced during the month of august.

Table 8.5 Demand Site Coverage (%) for Scenario E

Demand Site	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
ID_01	98	100	100	98	97	100	100	100	86	15	41	64
ID_02	100	100	100	98	98	100	100	100	86	16	56	85
ID_03	98	100	97	83	82	92	100	95	29	9	39	63
ID_04	100	100	100	100	100	100	100	100	100	100	99	100
ID_05	99	100	100	99	94	97	100	100	63	12	45	63
ID_06	100	100	100	100	100	100	100	100	93	36	51	77
ID_07	100	100	100	100	100	100	100	100	100	100	100	100
ID_08	100	100	100	100	100	100	100	100	100	100	100	100
ID_09	100	100	100	100	100	100	100	100	100	100	100	100
ID_10	100	100	100	100	100	100	100	100	100	100	100	100

8.2.6 Scenario F –Maha Season 100% Paddy; Yala Season 100% OFC with Increase in Storage Capacity of the 10 tanks after rehabilitation.

In this scenario the Demand Site Coverage of the demand sites ID_01, ID_02, and ID_06 has increased significantly compared with the other scenarios but the demand sites ID_03 and ID_05 still has a lower Demand Site Coverage during the month of July.

Table 8.6 Demand Site Coverage (%) for Scenario F

Demand Site	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
ID_01	99	100	100	100	100	100	100	100	98	45	97	100
ID_02	100	100	100	100	100	100	100	100	98	45	99	100
ID_03	98	100	98	84	100	100	100	100	52	9	97	100
ID_04	100	100	100	100	100	100	100	100	100	100	100	100
ID_05	99	100	100	100	100	100	100	100	88	20	97	100
ID_06	100	100	100	100	100	100	100	100	100	76	98	100
ID_07	100	100	100	100	100	100	100	100	100	100	100	100
ID_08	100	100	100	100	100	100	100	100	100	100	100	100
ID_09	100	100	100	100	100	100	100	100	100	100	100	100
ID_10	100	100	100	100	100	100	100	100	100	100	100	100

8.3 Demand Site Reliability (for each Demand Site)

The percent of the timesteps in which a demand site's demand was fully satisfied. For example, if a demand site has unmet demands in 6 months out of a 10-year scenario, the reliability would be (10 * 12 - 6) / (10 * 12) = 95%.

Table 8.7 Demand Site Reliability

Demand Site	**Scenario A**	**Scenario B**	**Scenario C**	**Scenario D**	**Scenario E**	**Scenario F**
ID_01	81	82	82	82	78	91
ID_02	82	84	85	84	78	91
ID_03	67	72	72	69	65	78
ID_04	97	100	100	100	99	100
ID_05	75	80	80	79	75	88
ID_06	83	85	85	85	80	93
ID_07	98	100	100	100	100	100
ID_08	98	100	100	100	100	100
ID_09	99	100	100	100	100	100
ID_10	100	100	100	100	100	100

Demand sites ID_04, ID_07, ID_08, ID_09, and ID_10 have a reliability of nearly 100% for all scenarios except for the base case scenario indicating a reliable water supply from the relevant tanks. Demand sites ID_03 and ID_05 have the lowest reliabilities compared to other demand sites. From analyzing Scenario A and Scenario B it was observed that only by increasing storage capacity without changing the cropping patterns the reliability has increases by a slight amount. By comparing Scenario B and Scenario C it was observed that with the reduction of paddy area by 10% and cultivating OFC within that area the reliability has slightly increased only in ID_02. But if Scenario F is used, which proposes 100% Finger millet cultivation for Yala season we can see that the reliability has considerably increased.