IDENTIFICATION OF WATER MANAGEMENT CONCERNS IN IRRIGATION - STUDY OF WATER ISSUE PRACTICE AT RAJANGANA RESERVOIR, SRI LANKA

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Degree of Master of Engineering in
Water Resources Engineering and Management

Department of Civil Engineering

University of Moratuwa
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Thesis Submitted in Partial Fulfillment of the Requirements for the
Degree of Master of Engineering in Water Resources Engineering and Management

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Water Resources Engineering and Management

Supervised by
Professor N.T.S.Wijesekera

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August 2014

DECLARATION

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ABSTRACT

Sri Lankan paddy production satisfies only 90% of total demand and 10% is being imported from other countries. On one hand, the cultivable land is narrowing day by day because of the urbanization. On the other hand, Climate change factors, food requirements for increased population and present level of yields demonstrate the need to significantly increase the production in support of future food requirements. Average rice yield of Sri Lanka is 4.5 MT/Ha but the potential is between 7 to 12 MT/Ha. In most parts of Sri Lanka, water is the critical factor for cultivation. Using the appropriate amount saves water for more land to be cultivated. Hence efficient water management is very important to increase food production. Irrigation water distribution is usually carried out with the help of Guidelines. Therefore in a operational scheme, it is possible to compare a canal water issues and planned water issues to capture the status of water management for necessary improvements

The present work is a study of irrigation water issue practice in Rajangana Irrigation Scheme at Anuradhapura which is located in the North Central Province of Sri Lanka Technical Guideline of Irrigation Department is the document used for irrigation system management in Sri Lanka. Using water issues and other data for the period of 2008-2013 the present work compared weekly water requirements with actual water issues. Initially using field data computed the water requirements as recommended by the Guideline was computed using field data and 75% probability rainfall. Then the quantities were calculated to identify the modifications to the plan with the availability of actual rainfall data during operations. These two data sets was named "Recommended Irrigation Plan" and "Anticipated water use" respectively. They were compared with each other and also with irrigation plans that had been prepared by Rajangana Irrigation Scheme, and with the water issues at the sluice gate. The study compared the case of Left Bank gravity fed irrigation area which covers an approximate 2500 Ha area with 39 Km tertiary canal network. The Rajangana project area is cultivated mainly with paddy during the two main rainy seasons namely "Maha" and "Yala". Water issue model for the study comparisons was developed using a weekly time resolution.

Comparison of actual water use with the quantities which were computed by following Irrigation Department Guidelines, disclosed a significant over issue in Maha and Yala seasons amounting to 63% and 52% respectively. In the case of making the adjustments to the plan with the receipt of actual rainfall, then a further reduction of water issue by 35% and 8% in Maha and Yala respectively could have been possible. It was revealed that though computations were based on the same Irrigation Department Guideline recommendation, average Maha and Yala water requirements land increased by 25% and 75% respectively in the Rajangana Irrigation Division plan when compared with the plan developed by the study. Average actual water use during the initial crop growth stage was 4 times higher than the guideline recommended plan and taking account of rainfall received at Rajangana Scheme. In case of other growth stages too, the average increase of usage between 1.5 to 2.4 times reflected a poor rainfall accounting in practice. Evaluation revealed the need of gauge network, a spatially distributed performance monitoring system and a critical evaluation of the present Guideline in order to suitably manage the water utilization in the Rajangana Left bank irrigation scheme. It has been pointed out that better use of water in the scheme would enable better chances of serving other water deprived areas.

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1 INTRODUCTION

In Sri Lanka, farmers prefer to grow paddy because it is the staple food of a majority of Sri Lankans. Sri Lanka has an average production of paddy reaching 3,876,000 MT per annum (Department of Census and Statistics Sri Lanka [DCS], 2008). Food Production has reached more than 90% of the National demand through it was only 40% in 1950 (Water Resource Management Sri Lanka [WRMS], 2010). According to Census 2012, total population of Sri Lanka is approximately 20 million growing at an approximate rate of 0.7% per annum (Demographic of Sri Lanka [DSL], 2014). Annual rice consumption rate is 100 Kg in Sri Lanka (Department of Agriculture Government of Sri Lanka [DAG], 2014b) and it is showing that the rice consumption is increasing by about 1.4 MT per year. The growth of rice demand at a rate of 1.1% per year, points out that the chances of facing a critical food supply situation in the future would be high. To meet this increasing demand, rice production should grow at the rate of 2.9% per year (DAG, 2014b). De Oliveira et al., (2009) had reviewed irrigation water management practices in Latin America where it was quoting Jensen, (2007) and pointing out that in 2003, 850 million people in the world are food insecure and in which 60% of them would be living in South Asia and Sub-Saharan Africa. This shows that food security situation is critical in South Asia.

Sri Lanka has three major climatic zones namely Wet, Dry and the Intermediate. The range of annual rainfall in the wet zone is 2500 mm and intermediate zone has the record of rainfall within the range of 1750mm-2500mm. The dry zone with an annual rainfall of less than 1750 mm is considered as a region with limited rain (DAG, 2014a). A case study of Walawe basin (2009) which had quoted both ID (2003) and Sekler (1998) indicated that the annual surface water availability is approximately 43,000MCM, and that the rainfall in wet zone and dry zone are 2900mm and 1500 mm respectively. According to the above author, irrigation sector had used only 28% while 65% of water is accounted as either flowing to sea, percolates to the ground or evaporates. Only 7% was the use for domestic and industrial purposes. This indicates that there is a possibility of using more water for irrigation through loss minimization and other ways. On the other hand, climate

change is excepted to cause a rise in temperature, and make changes to rainfall. This is said to cause a decrease of average runoff by approximately 7% when compared with the present condition (Wijesekera, 2011), creating a significant challenge for the design, construction and operation of irrigation systems. A rise in temperature would increase the evapotranspiration thereby causing a stress in irrigation management.

Average rice yield of Sri Lanka is 4.5 MT/Ha but the potential is between 7 to 12 MT/Ha (WRMS, 2010, p.50). Case study in Walawe basin (2009) quote the DCS (2007) where it is mentioned that the average paddy yields were 4.2 MT/Ha and 4.0MT/Ha in Yala and Maha respectively for 2004/05. Climate change factors, food requirements for increased population and present level of yields show the requirement to significantly increase production to support future food requirements.

In this context water management plays an important role because a better use of water not only supports more area to be reliably cultivated but also keeps the farmers secure. Presently average duty of water use in Sri Lanka is approximately 1300 mm in the Maha season and 1770 mm in the Yala season (Imbulana & Merrey, 1995). This document indicates that the area irrigated per unit volume of irrigation water has decreased by 19%, irrigation duty has increased by 22% during Maha season and by 29% in Yala season and irrigation water productivity has decreased by 20 percent over the 9 year period between 1984 and 1993. This hints that in order to achieve food security an urgent need could be better irrigation water management and efficient scheduling of water issues.

In Sri Lanka water schedule preparation and planning is done by using the guidelines of the Department of Irrigation (Ponrajah, 1988). Prior to the commencement of each cultivation season, water schedules are prepared and discussed with farmers in schemes in order to arrive at a consensus. At each major and medium irrigation reservoir managed by the Irrigation Department of Sri Lanka, water issues are carried out in consultation with farmer leaders. Water issues vary from the plan with actual rains and other unexpected variations in the field requirements such as crop types, starting point of cultivation, time for crops to reach maturity, and uncertain parameters such as efficiency of canals and application. Therefore it is very

important to compare the planned and the actual issues in order to manage water suitably and its application.

Though it has been recognised that water management especially in relation to irrigation in Sri Lanka is very important for food security and sustenance of the dry zone farmers, it can be noted that very limited research had been done in relation to the country on methods and practices. Wijesekera (2010), in a review of water research publications studied many publications in water and climate fields, and identified 16 related to irrigation reservoirs, 3 on water use and 12 regarding climate change effects on irrigation sector. De Alwis and Wijesekera (2011) carrying out a review of performance assessment indicators for the evaluation of irrigation schemes in Sri Lanka had discussed the availability of indicators to asscess irrigation duty and water duty, but argued that it is important to incorporate indicators that could capture total water use by plants.

Wickramaarachchi, Wijesekera and Gamage (2000) analysing the water management issues of a distributory canal in block 406 of Mahaweli system had mentioned that a lack of concern about the sensitivity of paddy to water stress is a major concern with regards to water scheduleing and that it results in low yields. Shantha, Ali and Bandara (2012) carrying out a study of four minor tanks in Trincomalee mentioned that a majority of dry zone paddy farmers are poor and that they require improvement in the efficiency of using the water resource.

De Costa (2010), in an evaluation of the policy framework for agricultural crop production in relation with climate change adaptation had highlighted the need of a good policy framework, and a committment for research in the area of water and farming communities to build a critical mass of human resource pool.

Irrigation methods, water and scheduling is a widely researched area. Hadad and Bakr (2013) who carried out a study on the effect of irrigation scheduling on irrigation requirement at four zones of Iraq, had stated that rainfall, irrigation scheduling methods, climatic factors, soil factors and plant type are those which affect the irrigation water issues. Hamlyin (2004) in a review work on Irrigation scheduling also supported these conclusions. Several studies on irrigation water

management (Faulkner et al. (2008); Bauman and Tuong (2001); De Olivera et al. (2009); Wriedt at al. (2009) mention the need of evaluating seasonal variations of precipitation and soil water content in order to study the requirements related to effective management of irrigation water thereby enabling better options for the selection of suitable agricultural patterns, technology and crop varieties.

Bauman and Tuong (2001), in the study of data from India and Philippines found that a reduction of ponded depth for paddy cultivation could save water up to 23% while restricting the yield reduction to approximately 6% thus indicating that water taxes based on volume would produce better results than conventional extent based taxes. Studies on environmental friendly methods such as aerobic rice production (Parthasarathi et al., 2012) demonstrates options for significant reduction of water use as much as 50% and better crop yields reaching 4-6 MT/Ha. De Oliveira et al., (2009) has reviewed the studies of Latin America where some research results had confirmed that Deficit Irrigation is successful in increasing water productivity for various crops without causing severe yield reductions. Rama Rao (2011), in a research work on estimation of efficiency, sustainability and constraints in a system of rice intensification at Andhra Pradesh, had stated that rice intensification practices increased paddy yield by 20.15% when compared with the traditional practices while inputs could be reduced by a 10.85% of coverage compared to traditional practices.

Though the irrigation water issues in Sri Lankan reservoirs are planned and implemented according to the techincal guidelines of the Irrigation Department (Ponrajah, 1988). However, it appears that there is the necessity to carryout comparative studies in order to evaluate the degree of adequacy with respect to guideline recommendations in order to achieve the much desired efficiency in water usage.

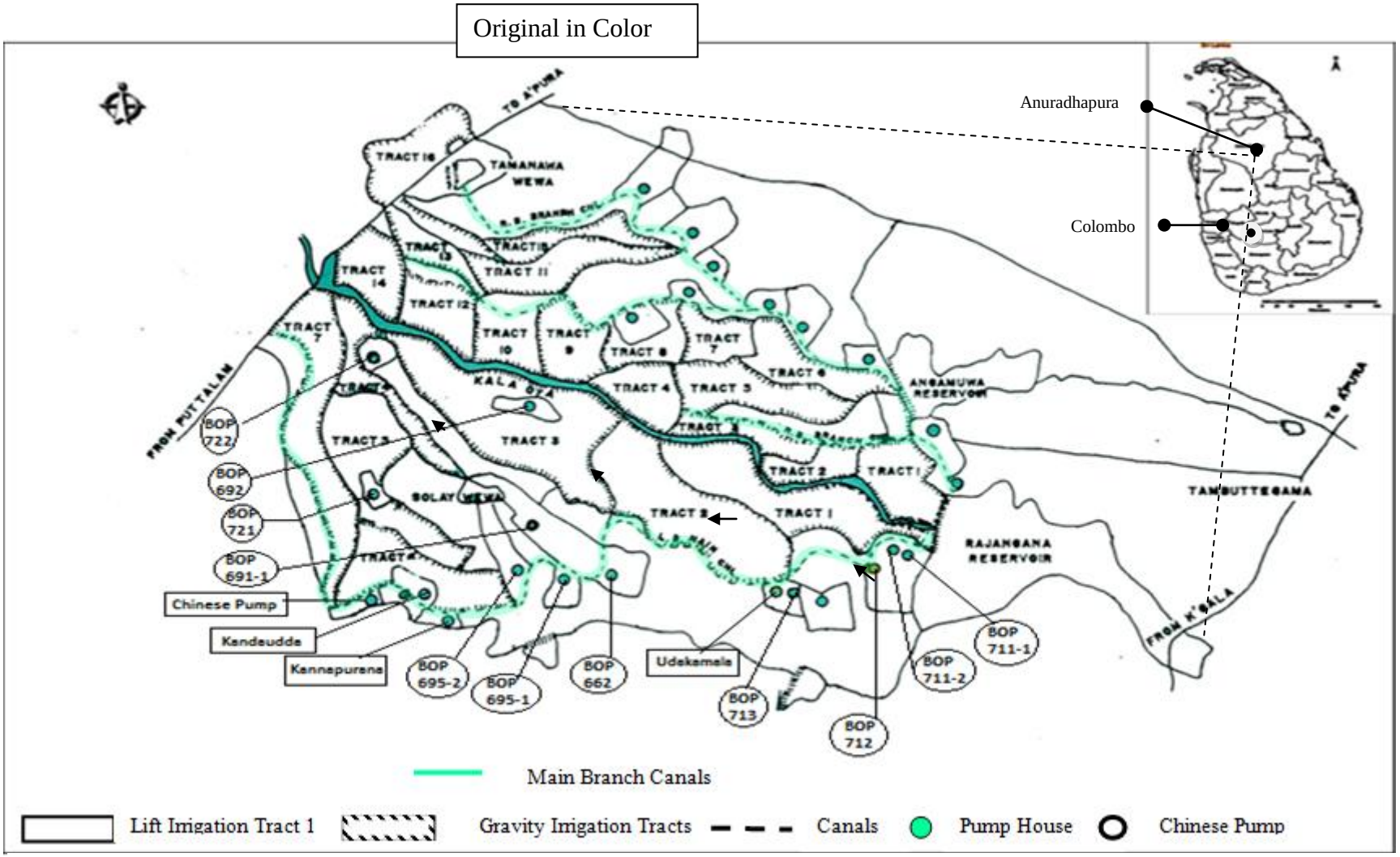


Figure 1.1-1 Location of Rajangana Irrigation System

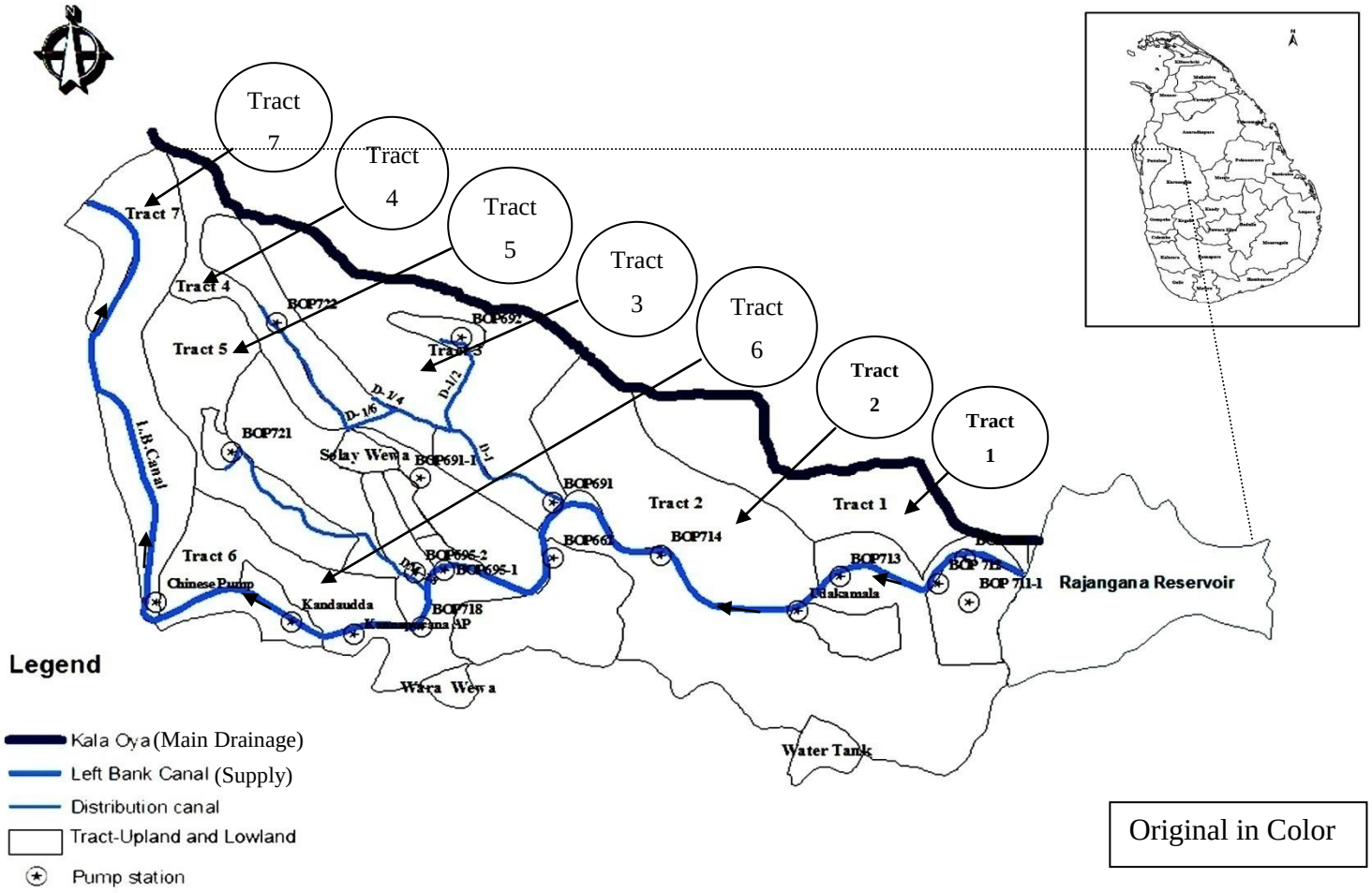


Figure 1.2: Study Area –Left Bank (L.B.) Canal System of Rajangana Irrigation Scheme

Rajangana reservoir in the North Central Province of Sri Lanka (Figure 1-1) has a capacity of 100.66 MCM and it is considered as a water abundant reservoir. A water management synthesis study of the Rajangana irrigation scheme [WMS] (1982) states that at the initial period of Rajangana Reservoir renovation in 1968, there was no necessity to manage water because of the high availability of water during both Maha and Yala seasons. In the early 1970's, the Department of Irrigation had implemented a program of water management at the Rajangana irrigation scheme to reduce the high consumption of water by the farmers. This study, WMS (1982), shows that at the Rajangana irrigation scheme, water scheduling practice was managed and maintained poorly. Agronomic reconnaissance surveys done for the study had suggested that low level of production were associated with inequitable distribution of water, over irrigation of upland crops, low input levels, poor land preparation and weed control and development of salinity problems in the lower reaches of turnouts. De Alwis (2008) in the work for evaluation of operational performance had mentioned that, though Rajangana is a water abundant scheme, the productivity in the context of water and land management was not good as expected. In the Rajangana irrigation scheme, a single canal system is used for both gravity and lift irrigation. Available records do not reveal a comparative evaluation of irrigation water issues and releases for gravity fed agriculture. Considering the importance of water management in irrigation reservoirs and also the scale of Rajangana reservoir, the present research carried out a comparative evaluation of planned and actual water releases in the gravity fed areas of the left bank irrigation canal network.

1.1 Objective

The Overall objective of this study was to carry out a comparative evaluation of the Irrigation demand and the actual water issued for gravity fed irrigation in the left bank canal system in order to identify suitable management options for the preparation of water issue plans, crop types, scheduling and implementation. This research is to target the best use of water received at the Rajangana irrigation scheme of Sri Lanka.

1.2 Specific Objectives

The specific objectives of the present research are as follows.

1. Evaluation of the existing methods of cultivation, water scheduling, water issues and other water management at the Left Bank (L.B.) canal in Rajangana irrigation scheme.
2. Computation and analysis of the planned water requirement with the guideline recommendations.
3. Computation and analysis of the water consumption by the gravity fed irrigation area of the L.B. canal system.
4. Comparative evaluation of the planned and actual water use in the gravity fed irrigation area of the L.B. canal system.
5. Make recommendations for efficient and effective water management at the Rajangana irrigation system and especially with respect to the gravity fed irrigation area of the L.B. canal system.

2 LITERATURE REVIEW

2.1 Irrigation Scheduling

Wickramaarachchi, Wijesekera and Gamage (2000) studied water scheduling in paddy cultivation at Mahaweli System H of Sri Lanka, using irrigation department guidelines (Ponrajah, 1988) and field observations. In this work, authors had noted that paddy yield in the study area was 180 Bushel/Ha while the regional average was 242 Bushel/Ha. Field work revealed that water issue canals were overloaded and farmers modified rotation intervals during cultivations. Considering the varities of paddy and their sensitivity to water shortage at different plant growth stages, a modified schedule had been proposed by authors to overcome various farmer practices that had resulted in significant deviations from the recommended scheduling. Authors concluded that 2% of total supply increase through the proposed scheduling could result a yield increase of about 25%.

Paul et al. (1998) studied the effect of irrigation depth on yield in the semi-arid region of Indian Punjab, used a stochastic dynamic programming model to vary the water availability from zero to the minimum depth in order to capture the maximum potential relative yield. In this study, authors identified that gram and wheat required 115 mm and 109 mm respectively as the minimum depths of water.

It is important to carryout water scheduling with suitable monitoring of soil moisture in the cultivating area. Incrocci et al., (2014) studied scheduling for growing nursery crops in Pistoia, Italy for the period 2007 to 2010 where four ornamental shrubs when subjected to a change in irrigation frequency based on soil moisture level reflected a substantial reduction of water use from 21% to 40% without any effect on plant growth and quality. Haddad and Bakr (2013) carried out a study of the possibility of using a practical and applicable irrigation scheduling program for four climatic zone of Iraq and for different soil types incorporating water budgeting. Field trials on an area of NahrSa'd Irrigation Project revealing a water saving of 36 and 56 MCM for two different seasons under the assumption minimum drainage water from the system, reported that water scheduling could be a water saving tool if cropping pattern is chosen carefully. Literature on water scheduling reflects that

suitable field monitoring of soil moisture and other components corresponding to water budget leads to substantial water savings.

2.2 Crop Water Requirement (CWR)

Research of Irrigation Water Demand Forecasting Study by Khan, Islam and Hafeez (2011) had quoted FAO (1994) and the work of Smith (2000) to indicate that on average only 45% of water is used by crop, 15% is lost during conveyance, 15% is lost in supply channel within the farms and the remaining 25% is lost due to inefficient water management practices. Coding of a program by Ali (2013) to determine crop water requirement using local meteorological and research data of Sudan, reflects the use of same values quoted by Khan, Islam & Hafeez (2011). Field based evaluations by Wickramaarachchi et al. (2000) mentioned that the initial phase and flowering stage of the crop are highly sensitive and hence a defficiency in the water requirement during this period would result in decreased crop yield.

Pakhale et al., (2010) had studied about the irrigation water requirement of wheat crop in Karnal District, Haryana state of India. This study that used LANDSAT remote sensing data showed that the water requirement for wheat is higher in the development and mid season stage and varied from 78.63mm/month to 201.14mm/month increasing the passage of time and less crop water requirement in maturity stage when as compared with initial stage. Abideen (2014) had studied about crop water requirement of four hybrid varieties of maize irrigated on clay loam at the research farm of University of Agriculture Peshawar, Pakistan during July-October 2012 and reported that hybrid varieties demonstrate 24% to 34% higher actual evapotranspiration than the local varieties.

Crop water requirement is highly dependent on the temperature, and water availability. Chowdhury et al., (2013) in a research done in an arid agricultural region of Saudi Arabia comparing four scenarios for the period from 2011 to 2050 and using CROPWAT model had identified a 5.3% - 9.6% increase of crop water requirement for an overall increase of 6% in the ET_0. This work indicated that a temperature increase by one degree centigrade would increase the Crop Water Requirement by 2.9%.

2.3 Land Preparation

Cabangonand Tong (2000) had studied about the effect of surface tillage and straw mulching in fallow period and the water flow component during the land preparation in four sites during the wet and dry season in the Philippines. This study found out that shallow surface tillage can reduce about 31-34% of the water input for land preparation, equivalent to a saving of 108-117mm of water depth and shortened time required for land preparation. This type of water saving during land preparation increases the service area of an irrigation system. In rain fed areas, shallow surface tillage may also lead to earlier crop establishment thus reducing the risk of late season drought.

Loeve et al. (2003) had studied about the reduction of land preparation delays in North Central Province of Sri Lanka where Tract 1, 5 & 7 of LB canal of Rajangana system was sampled from the starting time of land preparation to the collection of yield. Majority of farmers had taken the 11-25 days for the land preparation work in Rajangana. Approximately 72% of farmers had completed their land preparation in less than 21 days. Reason of the delay in land preparation was attributed to mismanagement of water and socio political factors. Farmers whose land preparation was delayed had a 8% decrease in paddy yield when compared with those who completed in time.

According to Irrigation Guideline (Ponrajah, 1988), clayey soil or heavy soils in low land, generally requires two water applications for paddy cultivation. One is a 4 inch water requirement in 5 days for land soaking and a 3 inch water requirement in 10 days for land tillage. In total, Irrigation Department recommendation is 15 days with 7 inches of total water depth for land preparation. In the case of transplanting, the tillage water requirement is to be divided in to two applications where water depths are 1.75 inches for tillage and 1.25 inches prior to transplanting.

In the Irrigation Guideline, information with respect to On Farm Crops (OFC) is lesser when compared with paddy. OFC cultivation in upland area is recommended with 1.5 inches of water depth for a pre-determined and preparation time of 15 days.

In case of maize cultivation in Sri Lanka, it has been reported that the land preparation time generally varies between 4-7 days (DAG, 2014a).

2.4 Irrigation Water Requirement (IWR)

Wriedt et al. (2009) studying irrigation requirement for the cereal crops and fruits using the EPIC model (Erosion Productivity Impact Calculator) in 22 European countries identified that inefficient conveyance and improper irrigation management increased the irrigation water delivery by 1.3 to 2.5 times when compared with the field requirement.

Raju et al., (2008) evaluated the progression of rice crop acreage in Orissa state of India using remote sensing data and identified that the water supply adequacy was only about 88%. An oversupply of approximately 45 MCM which was nearly 15% of total during the initial part of the season and a deficit of approximately 20% in the peak development stage which had shown that proper water scheduling could have facilitated a high crop productivity.

Pakhale et al. (2010) carrying out a study at Haryana state of India computing Wheat crop IWR in Rabi season having assumed the conveyance and field losses as 35%, had recognized that the effective rainfall and crop water requirement as main factors affecting the computed IWR values.

2.5 Farm Losses

Naderi et al., (2013) studied the irrigation application efficiency of 12 wheat farms of Semnan province in Iran and found out that the average deep percolation was 54.9%, runoff was 7% and the average application efficiency was 30.6%. Field experiments performed at the HsuehChia Experimental Station in Taiwan from 1993 to 2001 revealed that deep percolation for the first rice crop and second rice crop were 295 mm and 296 mm respectively. Percentage of percolation in the single rice cropping fields is around 30.7% compared to 26% in the double rice cropping area (Kuo, Ho & Liu, 2005).

2.6 Effective Rainfall

Due to the scarcity of water in many parts of the world, it has become increasingly important for the design and operation of irrigation systems to account for the rainfall received at the fields. Since rainfall received in a particular area can significantly contribute to consumptive use of requirements of crops, effective rainfall has to be carefully incorporated when calculating the irrigation water requirements. According to the definition of effective rainfall in agriculture is the contributing component of rainfall for cultivation or crop growth. The same in hydrology is the contributing component of rain for the generation of surface runoff. This difference has also been highlighted by Patwardhan, Neiberand and Johns (1990) in a test of effective rainfall accuracy which was estimated by a soil water balance model using United State Department of Agriculture Soil Conservation Service (USDA-SCS) and Hershfield effective rainfall estimation method applied at 22 locations in the United States. This study concluded that USDA-SCS method and Soil Water Balance Model (SWBM) are fairly good to apply for well-drained soil conditions but USDA-SCS method overpredicts effective rainfall in the case of poorly drained soils when compared with the SWBM method.

During the planning of irrigation water schedules it is important to identify the rainfall values that are used to compute the effective rainfall. FAO Report No 24 (Doorenbos and Pruitt, 1977) recommends the use of 75% for probable rainfall for the effective rainfall calculation. Irrigation Department Guidelines of Sri Lanka (Ponrajah, 1988) also recommends the use of 75% probability rainfall and contains two equations for the computation of effective rainfall for lowland and upland cultivations.

Tsai, Chen and Wang, (2005) in a study of irrigation management system in Taiyuan main canal of Taiwan had identified that the 75% probability of occurrence as a suitable value for the computation of effective rainfall.

Variation of effective rainfall had been found seasonal. Demonstrating the importance of correctly identified effective rainfall for crop water computation, Rahaman, Islam and Hasanuzzaman (2008) in a study of different climatic zones in

the southern part of Bangladesh concluded that effective rainfall in Kharif season varies widely from 13.94% to 100% while in Rabi season almost 100% of rainfall is contributing to effective rainfall. This study concluded that effective rainfall is directly proportional to the consumptive use and inversely proportional to the amount and intensity of rainfall.

Adnan and Khan (2011) studying effective rainfall with 58 meteorological station data of different climatic zones and irrigated plains in Pakistan concluded that effective rainfall for Rabi season varies widely from 13.03% at northeastern Punjab to 100% at several stations throughout Pakistan. During Kharif season, effective rainfall percentage varies widely from 21.31% at northeastern Punjab to 100% at most station in this country.

2.7 Water Issue Practices

Appropriate water use practices enable assuring satisfaction among farmers and managers. Farmers would identify the adequacy of water availability to their farms while the irrigation managers would be able to control the parameters such as efficiency, equity and wastage (Mattamana, Varghese & Paul, 2013).

Water distribution in small irrigation systems is mostly controlled by farmers. In Sri Lanka water schedule preparation and reservoir water releases are assisted by the irrigation managers while the farmers take a lead role in the water distribution. It is mentioned that in most cases farmers use inefficient irrigation practices either by applying too much water or by irrigating sooner than required. Gersfelt (2007) studying the practices in Egypt quotes that the major drawbacks of the rotational system are in the determination of irrigation frequency for shallow rooted crops, insufficient water received at the tail end of the canals, and farmer manipulations of the system to receive enhanced water quantities.

Work of Wickramaarachchi, Wijesekera and Gamage (2000) reported earlier, also identified a water scarcity in 7 to 10 day rotation practices during field investigations. This work reports the desire of farmers to limit the rotation interval to 7 days.

Farmers use increased water quantities for the purpose of leaching. According to Hvidt (1998), farmers applied 50 percent to 250 percent more water than required by the crops to achieve leaching requirements.

Ajmera and Shrivastava (2013) in their study of conventional distribution system at Warabandi canal in the Choral river of India reports a water scheduling system modified according to site conditions. In this distribution system, distributory canals are managed by the state while farmers manage the field canals. Recognizing the difficulties in receiving water at the tail end of canals, a modification considering the seepage losses along the channel had provided water as required even to the tail end farmers. Huppert (2000) who has also studied the Warabandi system of India recommends appropriate policy frameworks and smaller groups for the effective application of fixed rotation water issues. De Oliveira et al., (2009) reviewed the key aspects of irrigation management in Latin America and concluded that a large amount of water is inefficiently supplied to the farmers because of the lack of appropriate tools for effective water scheduling and delivery.

3 METHODOLOGY

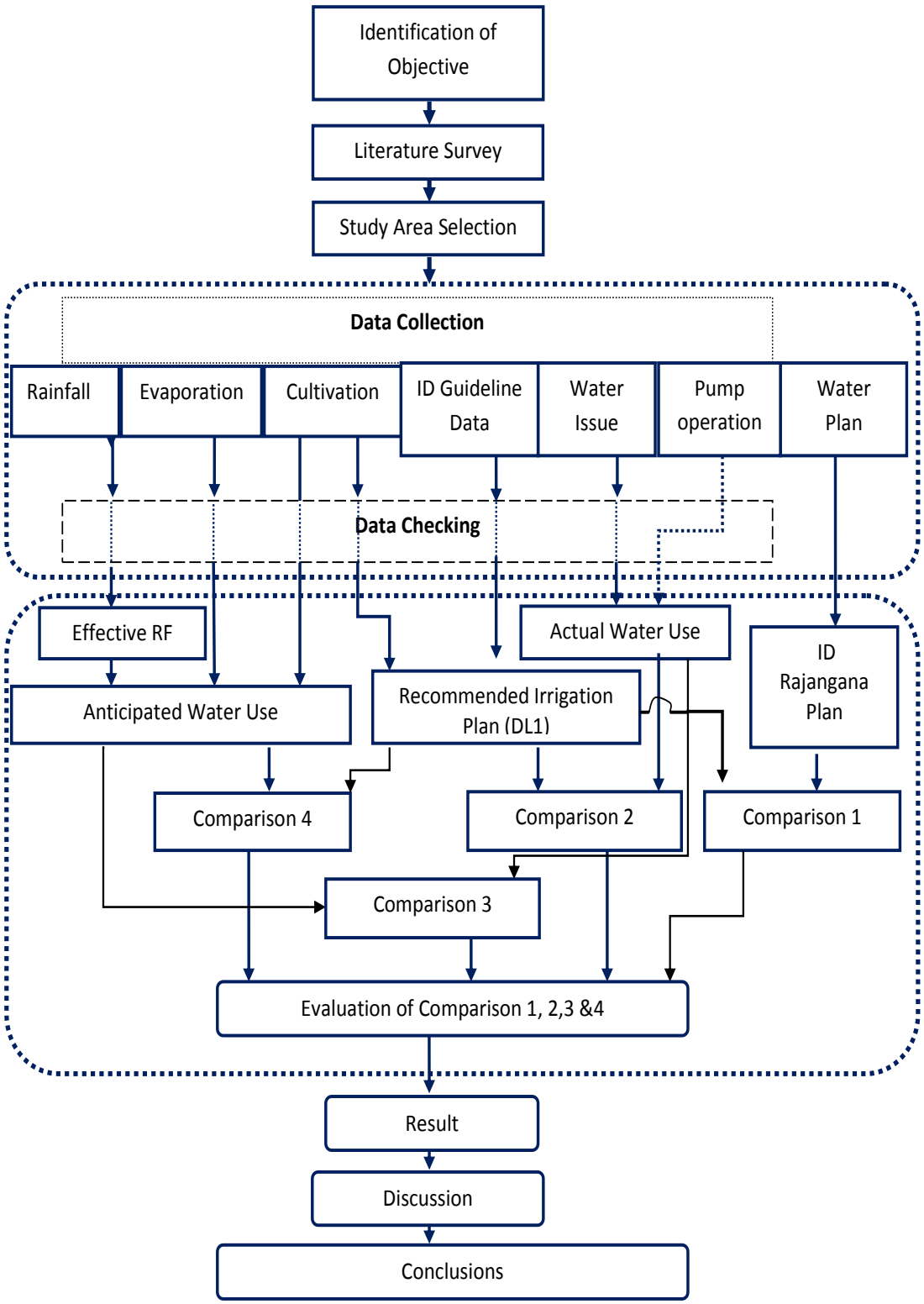


Figure 3.1: Methodology Flow Chart

Methodology adopted for the study is shown by the flow chart in Figure 3.1.

The present work commenced with a study of prevailing water resources situation especially in Sri Lanka and then with the identification of the research problem and objectives. Rajangana irrigation system was selected as the study area. Institutional visits and field visits were undertaken to the project area for data collection followed by data checking and incorporating suitable assumptions for computations. In the Rajangana irrigation scheme both the gravity and lift irrigations systems are fed by the same canal system. This research work contains the study of the gravity irrigation system. The water requirements for the project area computed as per Irrigation Department guidelines were compared with the actual planned quantities and issues. Prior to the computations a detailed literature review was carried out to understand the available guidelines, practices and related research in Sri Lanka, Rajangana scheme and elsewhere. Detailed field surveys were undertaken for both data collection and gap filling of institutional data. A critical evaluation of the results were then discussed and concluded by marking water management recommendations.

4 STUDY AREA

Left bank canal of the Rajangana reservoir was selected for the comparative study (Figure 1.2). In this canal, there are seven tracts and there are 37 turn outs in the gravity fed system (Table 4.1). Total low land area is 2559.44 Ha in the Left Bank Canal system. For upland cultivation, 18 established pumping stations are located along the canal (Figure 1.1 and Figure 1.2). Most pumping stations have old Lister Pitterpumps which consist of two types and their pumping capacities are 90 and 120 cum/hr. Stakeholder based information revealed that these pumps were those established in the rehabilitation year which was in early 1968. Some early pumps had been replaced with support from Government of Japan and those are pumps with brand name Kubota having a 90cum/hr pumping capacity. Presently at these pumping stations, 11 new electric pumps with the capacity from 12.5 Hp to 60 Hp are in existence. Water management synthesis study (1982) had mentioned that there were 10 pumping stations and 44 diesel pumps. At that stage cultivation area had been 858 Ha. Presently the pumping stations are providing water to 334 Ha of upland area. Compared to the inception of the project, the upland cultivation extent at present has decreased by 61 percent. In low land area, paddy is the main crop for the cultivation and in Yala season, some OFC farming is also taking place at a small extent of low land. In upland area, cultivation taking place is predominantly OFC. There are fruits and vegetables also cultivated in the upland area.

Table 4-1: Tract area Details of Left Bank Canal System

Tract No.	Name of Canal	Command Area (Ha)	Canal length Km
Tract 1	FC1	6.47	0.21
	FC2	23.96	0.20
	D1	124.64	1.10
	D2	140.02	2.40
	Sub total	*295.10*	*3.91*
Tract 2	FC1	32.54	0.20
	D1	98.74	1.73
	D5	52.61	0.65
	D2	153.78	0.52
	Sub total	*337.67*	*3.10*
Tract 3	D1	575.46	2.31
	D2	124.64	2.65
	Sub total	*700.11*	*4.96*
Tract 4	Sole Wewa	275.19	3.91
	Sub total	*275.19*	*3.91*
Tract 5	FC1	21.04	0.22
	D1	503.39	7.60
	Sub total	*524.43*	*7.82*
Tract 6	Fc1	22.66	0.44
	FC3	14.57	0.27
	FC5	28.33	0.46
	D5	47.75	0.74
	FC18	40.47	4.93
	FC26	20.23	0.28
	Sub total	*174.02*	*7.12*
Tract 7	FC1	2.21	0.02
	FC2	24.00	0.80
	FC9	15.11	0.73
	FC14	33.00	0.58
	FC19	27.30	0.83
	FC28	7.91	0.37
	FC29	7.11	0.56
	FC30	5.51	0.27
	FC31	3.81	0.00
	FC33	5.51	0.26
	FC34	7.11	0.26
	FC35	6.31	0.45
	FC36	7.91	0.17
	FC38	24.90	0.77
	FC42	16.71	0.55
	FC48	14.31	0.81
	FC49	7.11	0.39
	FC54	37.10	0.49
	Sub total	*252.93*	*8.31*
Total of Left Bank Canal		**2,559.44**	**39.12**

5 DATA COLLECTION AND CHECKING

5.1 Collection of Data and Information

At the onset of the study, the data collection methods and temporal resolutions suitable for the study were evaluated. Considering the availability of data and resource availability, the present study selected a "week" as the time resolution for computations. Water year from October of a given year to September of forthcoming year was taken as the "data-year" for comparisons.

A five water-year study period from 2008/09-2012/13 was selected by evaluating spatial and temporal data of the Rajangana Irrigation System and in its left bank canal, various techniques were used for the collection of data. Associated data categorized as institutional and farmer based, physical and operational etc., were collected from study area.

5.1.1 Data of irrigation department and farmer organization

Government organization responsible for the Rajangana reservoir system is the Department of Irrigation (ID). Overall management and administration is with the Head Office of Irrigation Department at Colombo (ID Colombo), Regional jurisdiction is with the Director of Irrigation Anuradhapura (ID Anuradhapura) and the project area has a separate institutional arrangement called Rajangana Irrigation Engineer Division (ID Rajangana). The Blocking out Plans (BOP), Issue Tree schematic diagram of the irrigation system, rainfall, evaporation, water issue plans etc., are the institutional data collected from the Irrigation Department (Table 5-1). In cases where data gaps and ambiguities were identified, field surveys were carried out to supplement and complement such information. Rajangana farmers of LB canal are represented by Farmer Organizations (FOs) responsible for distributories and field canals. The Lift irrigation systems have 18 different farmer organizations. Left and Right Bank cultivation area details of the Rajangana Irrigation Scheme are shown in the

Table 5-2.

Table 5-1: Details of Rajangana Irrigation Scheme

Data	Station	Data source	Data Period/Scale
Detail of area	Rajangana	ID.Rajangana	
Pan Evaporation (Monthly)	Maha-Illupallama	Secondary data from ID Colombo	2005-2013
Daily rainfall data	Rajangana	ID.Rajangana& ID Colombo	1991-2013
Cultivation area data	Spreadsheet Records	ID.Rajangana	2008/09-2012/13
Blocking Out Plans	Rajangana Irrigation Scheme	ID-Anuradhapura	1Inch: 12 Chain
Issue Trees	Rajangana Irrigation Scheme	ID Rajangana	Not to Scale
Planning data(Whole System)	Updated records	ID. Colombo	2008/09-2012/13
Command area data	Spread sheet and Record	ID.Rajangana	2008-2013

Entire command area included in BOP, issue tree map and several spreadsheet based records were collected (

Table 5-2 and Table 5-8). Every season, Rajangana Irrigation System makes plans for water management in the entire cultivation area under the Rajangana reservoir. These data are managed by ID-Colombo. An evaporation measurement gauge is not available within the Rajangana Scheme area. Evaporation data of close proximity are at Maha-Illupallama which is a meteorological data station approximately 20 Km from Rajangana reservoir. These data were also collected from ID-Colombo (Table 5-3). The irrigation department maintains a rain gauge in the project area. Daily rainfall data of that station were received in the format shown in Table 5-4.

Table 5-2: Information of Cultivation Area

Canal Type	**Cultivation Area**			
Water Distribution Canal	Gravity Fed (Acres)	Upland (Acres)	Total (Acres)	%
Right Bank canal(RB)	7,315.50	2189.6	9505.1	51.49%
Left Bank canal (LB)	6,324.50	2631	8955.5	48.51%
Total LB and RB	13,640.00	4,820.60	18460.6	100%

Table 5-3: Pan Evaporation data of Maha-Illupallama Station (mm)

Year	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
2008	66	77	70	84	123	116	120	123	133	73	66	73
2009	62	73	93	99	115	112	147	125	126	96	48	46
2010	70	84	120	86	100	115	118	119	92	93	57	47
2011	45	75	94	97	124	129	143	143	140	108	69	63
2012	82	70	109	93	142	140	152	166	154	81	58	44
2013	62	64	94	106	118	122	134	131	113	119	71	52
Average	64	74	97	94	120	122	135	134	126	95	61	54
ID Guideline	96	104	129	121	135	143	149	153	156	119	100	95

Note: Monthly pan evaporation value at Kalawewa station is the available data in ID Technical Guideline

Table 5-4: Daily Rainfall Data Format of Rajangana Station

Year	2008																						
Month	January	Month	February	Month	March	Month	April	Month	May	Month	June	Month	July	Month	August	Month	September	Month	Octomber	Month	November	Month	December
Date	Rainfall	Date	Rainfall	Date	Rainfall	Date	Rainfall	Date	Rainfall	Date	Rainfall	Date	Rainfall	Date	Rainfall	Date	Rainfall	Date	Rainfall	Date	Rainfall	Date	Rainfall
1		1		1		1		1		1		1		1		1	17.0	1		1		1	
2		2		2		2	4.5	2		2		2		2		2		2		2		2	
3		3		3		3	12.6	3		3		3		3		3		3		3		3	
4		4		4		4		4		4		4		4		4		4		4		4	
5		5		5		5		5		5		5		5		5	6.2	5		5		5	
6		6	5.0	6	13.5	6		6		6		6		6		6		6		6		6	12.5
7		7		7		7	8.3	7		7		7		7		7		7		7		7	24.8
8		8		8		8	13.0	8		8		8		8		8		8		8		8	
9		9	32.0	9	65.0	9	2.0	9		9		9		9		9		9		9		9	16.5
10		10	4.5	10	57.0	10	5.5	10		10		10		10		10		10		10		10	
11		11		11		11	21.0	11		11		11		11		11		11		11	10.0	11	
12		12		12	45.5	12	8.0	12		12		12		12		12		12	11.0	12		12	
13		13		13	19.0	13	4.2	13		13		13		13		13		13	21.5	13	7.5	13	
14		14		14	11.5	14		14		14		14		14		14		14	11.3	14	3.0	14	
15		15		15	27.7	15		15		15		15	11.5	15		15		15		15		15	7.2
16		16		16		16		16		16		16		16		16		16	5.0	16		16	6.0
17		17		17	16.7	17		17		17		17		17		17		17		17		17	48.5
18		18		18	27.7	18		18		18		18	30.7	18		18		18	9.2	18		18	37.0
19		19		19	32.3	19		19		19		19		19		19		19		19		19	
20		20		20	6.5	20		20		20		20		20		20		20	5.4	20	7.3	20	
21		21		21		21		21		21		21		21		21		21	65.0	21	37.0	21	
22		22		22	4.7	22		22		22		22		22		22		22	12.0	22		22	
23		23		23		23		23		23		23		23		23		23	12.2	23	19.0	23	3.5
24		24		24		24		24		24		24		24		24		24	22.0	24	56.7	24	
25		25		25		25	16.0	25		25		25		25	35.0	25		25	13.5	25	23.5	25	
26		26		26		26	78.0	26		26		26		26	10.0	26		26		26	25.0	26	
27		27	19.0	27		27		27		27		27	7.5	27		27		27		27	1.8	27	
28		28		28		28		28		28		28		28		28		28		28		28	
29		29	4.7	29		29		29		29		29	4.8	29		29		29		29		29	
30				30		30		30		30		30		30	62.0	30		30		30		30	
31				31				31				31		31	17.0			31				31	
	0		65.2		327.1		173.1		0		0		54.5		124		23.2		188.1		190.8		156

5.1.1.1 Cultivation area data

There are 7 Tracts in the left bank canal system. Its entire command area is cultivated in the Maha season (October -March). In Yala season (April -September), a very small extent of about 3 percent is covered by OFC while the balance 97 percent is covered by paddy (Table 5-5 and Table 5-13). Upland area cultivation of OFC crops consist of Chilly, Green gram, Groundnut, Cowpea, Pulse, Maize and some Citrus.

Table 5-5: Cultivation Area detail of Left Bank Canal from 2008/09 to 2012/2013

OFC in Yala season	**Cultivation Area (Ha)**				
	2009	2010	2011	2012	2013
Maize (Iringu)	18	59.5			10
Cow pea	8	39	3		
Green gram	4	6.2	19	5	15
Pulse(Undu)	2	10	9	40	3
Ground nut	2	30	7		13
Soybean		19			7

5.1.1.2 Blocking out plans (BOP)

Blocking out plans were available for all seven tracts. BoP gives the detail of lowland paddy allotments and canal network layout. These plans had been drawn to a scale of 1 inch to 12 chains which is approximately equivalent to 1: 9504. Each paddy allotment is approximately 2.5 Acres in extent. Canal naming details such as, Main canal, Branch Canal, Distributory canal and Field Canal are also included in the BoP. Figure 5.1 shows the scanned copy of BOP for the Tract 6 of LB main canal.

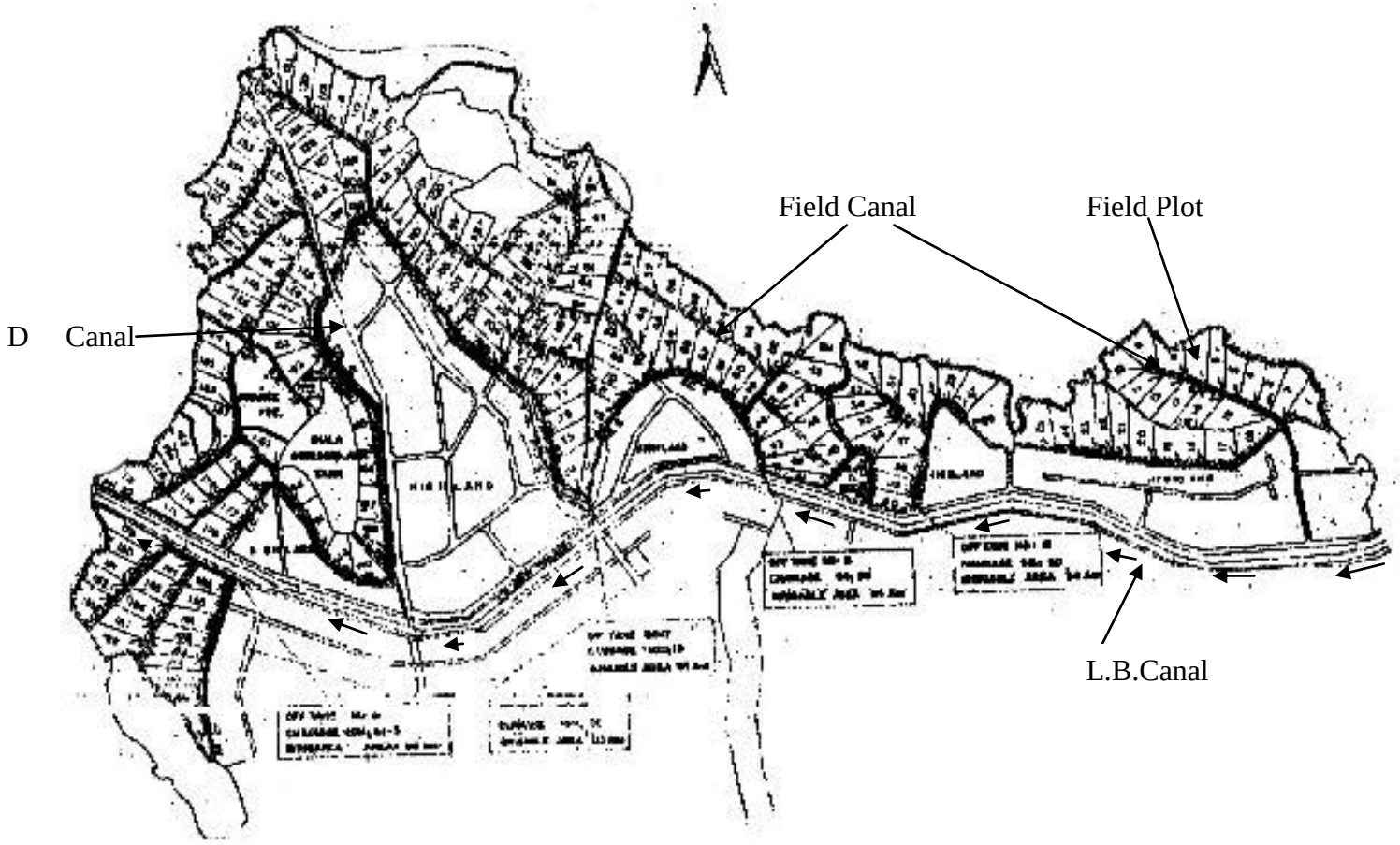


Figure 5.1: BOP of Tract 6 (Not to Scale)

5.1.1.3 Issue Tree

The issue tree of the Rajangana irrigation scheme (Tract 1) is shown in the Figure 5.2. Details such as tracts, canal lengths, canal type and command area under turnouts are included. Each tract of the Rajangana scheme has a similar issue tree. These data were collected from the Irrigations Engineer's office at Rajangana.

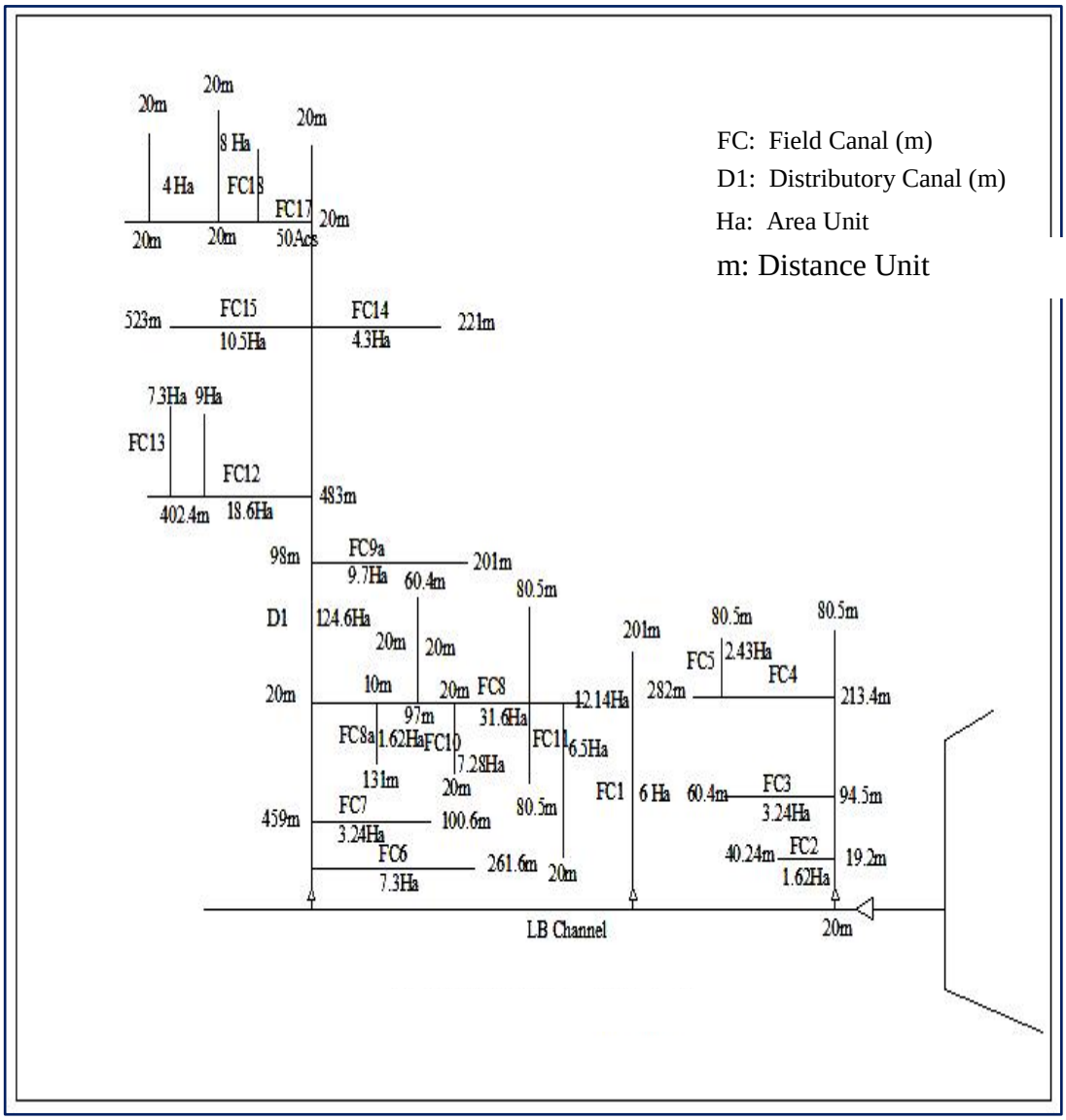


Figure 5.2: Issue Tree of Tract 1 (Not to Scale)

5.1.1.4 Planned Water Issue Data

Rajangana Irrigation Division prepares water issue plans for each season of the year. The available plans provide monthly totals for each year under study and they are for the entire irrigation scheme. Total monthly volumes in the plan were divided proportionately between the LB and RB canals in order to identify the quantities estimated for Rajangana LB canal study plans. Table 5-6 and Table 5-7 show the planned water issue amounts in MCM.

Table 5-6: Water Issue Plan for LB Canal of Rajangana Irrigation System during Maha Season (MCM)

Water Year	Oct	Nov	Dec	Jan	Feb	March
2008/2009	13.44	8.59	7.91	11.25	6.60	3.59
2009/2010	0.00	5.97	10.28	11.06	10.67	7.76
2010/2011	0.00	10.19	9.41	11.45	7.52	5.77
2011/2012	0.34	8.97	8.78	12.90	12.03	4.90
2012/2013	0.97	11.30	8.10	11.01	11.64	2.18

Table 5-7: Water Issue Plan for LB Canal of Rajangana Irrigation System during Yala Season (MCM)

Water Year	April	May	June	July	Aug	Sept
2008/2009	9.07	6.65	10.87	10.96	4.07	4.22
2009/2010	7.62	8.68	8.49	9.31	2.38	0.15
2010/2011	9.31	15.96	10.38	15.38	7.86	1.31
2011/2012	9.27	16.83	11.74	11.45	8.59	1.12
2012/2013	17.46	13.53	15.72	15.38	6.60	3.83

5.1.1.5 Command area data

Upland and Low land command area details were collected from the Irrigation Department Rajangana office. The base data in typical data forms as shown in Figure 5.3, were in handwritten format. Data extracted from these forms are shown in the Table 5-8.

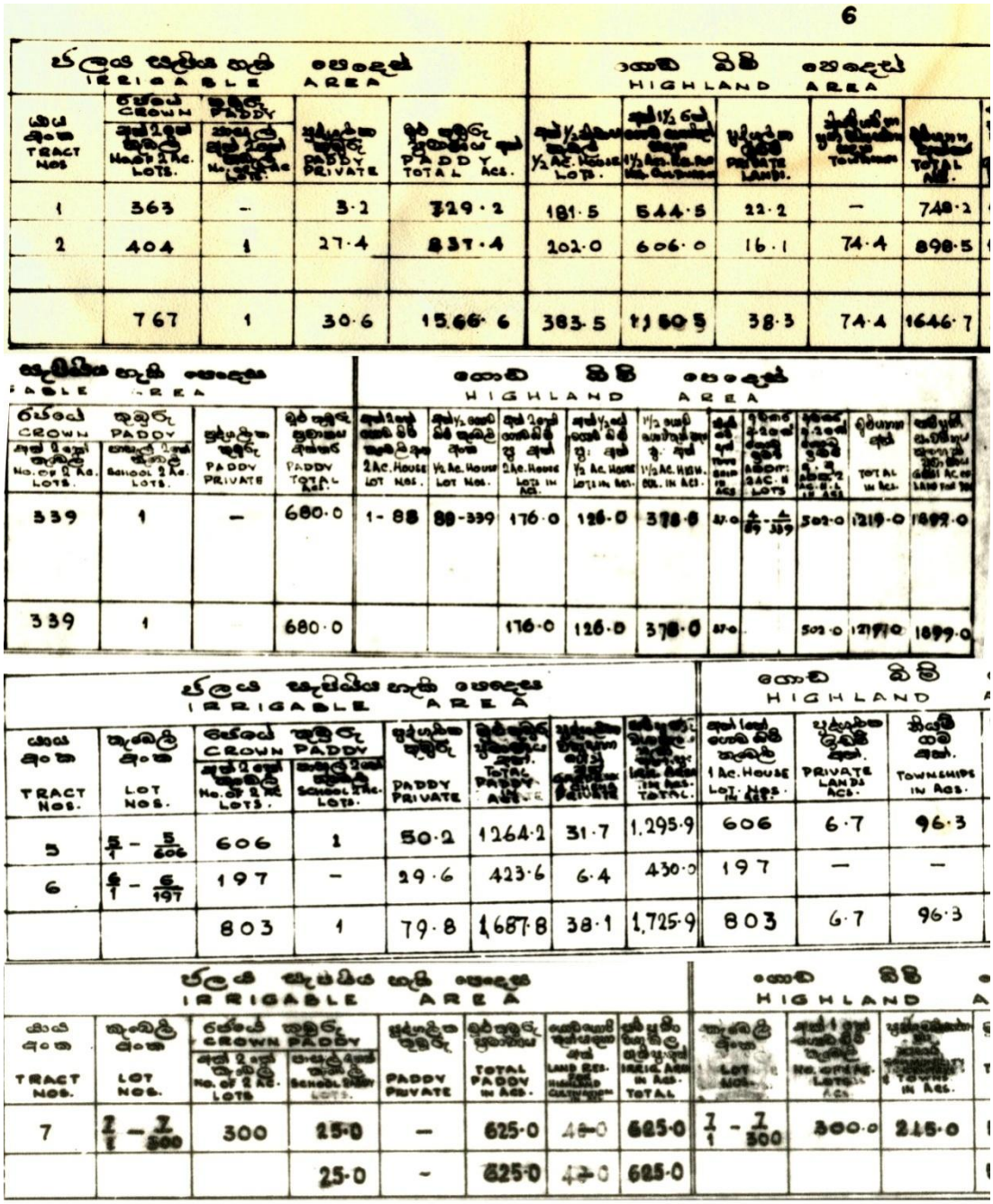


Figure 5.3: Typical Irrigation Department Data Forms

Table 5-8: Details of Upland and Lowland Command Area

Lowland Command Area						Upland command area								Gross Developed Land. (Acre)
Tract No	Paddy land		Paddy Private(Acre)	Private cropped area (Acre)	Total paddy Land (Acre)	1 Ac. House lots.	2 Ac. House lots.	1/2 Ac. House lots.	1 1/2 Ac High land cultivation (Acre)	Private land (Acre)	Township Area(Acre)	Other Area (Acre)	Total highland Area (Acre)	
	2 Ac. Farmer Lots	2 Ac. School Lot												
1.	363.00	-	3.20	-	729.20	-	-	181.50	544.50	22.20	-	-	748.20	1,477.40
2.	404.00	1.00	27.40	-	834.40	-	-	202.00	606.00	16.10	74.40	-	898.50	1,732.90
3.	865.00	-	-	-	1,730.00	379.00	-	-	-	-	-	-	-	-
4.	339.00	1.00	-	-	680.00	-	88.00	250.00	378.00	-	37.00	502.00	1,219.00	1,899.00
5.	606.00	1.00	50.20	31.70	1,295.90	606.00	-	-	-	6.70	96.30	-	709.00	2,004.90
6.	197.00	-	29.60	6.40	430.00	197.00	-	-	-	-	-	-	197.00	627.00
7.	300.00	25.00	-	-	625.00	300.00	-	-	-	-	215.00	-	515.00	1,140.00
Total	3074.00	28.00	110.40	38.10	6,324.50	1482.00	88.00	633.50	1,528.50	45.00	422.70	502.00	4,286.70	8,881.20

5.1.2 Operation data

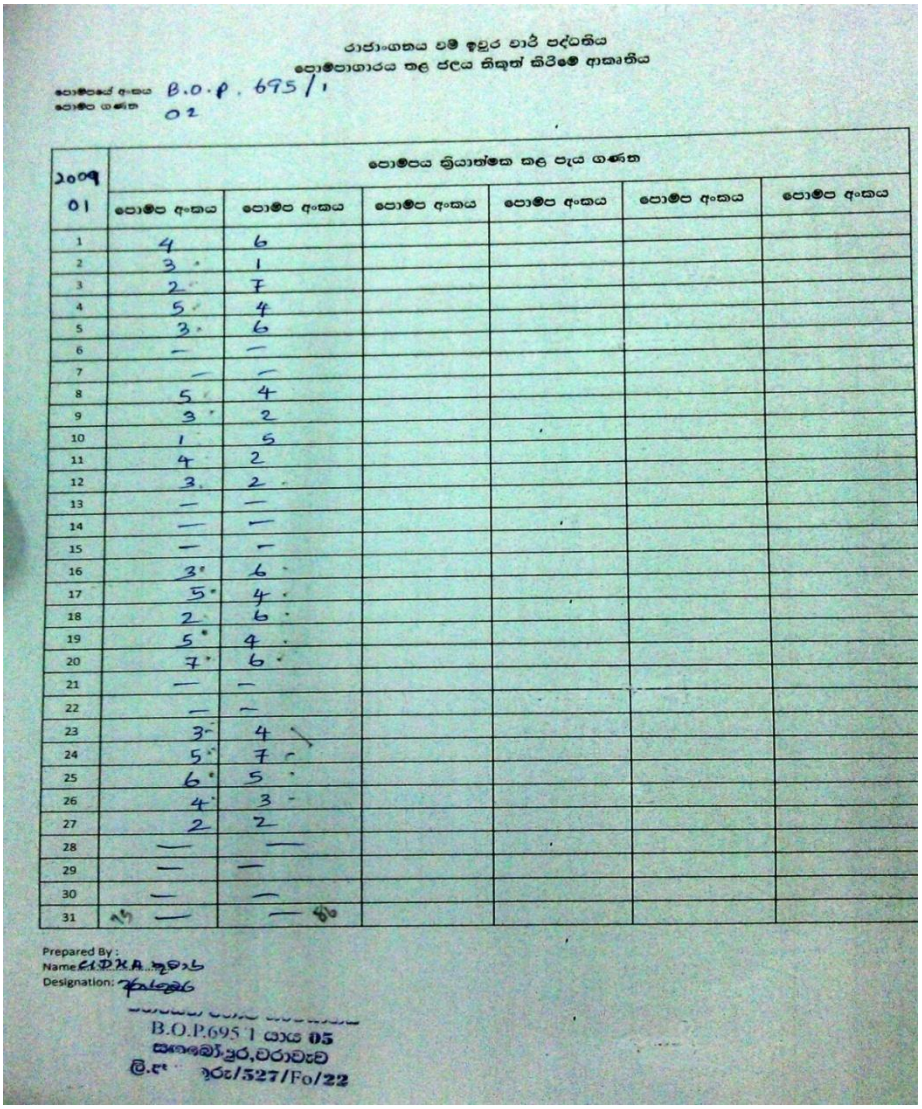
There are two types of operation data corresponding to the study. They are, the water releases from the reservoir to the LB canal, and the operation data of pumps lifting water for upland cultivations. LB canal water releases were obtained from the Irrigation Department Head Office, Anuradhapura Regional Office and the Rajangana Irrigation Engineer's office. Pump Operation data were obtained by conducting field visits, discussions and using the field record books maintained by the Farmer Organizations. Samples of the data collected by these methods are shown in the Figure 5.4.

Table 5-9: Operational Data of Rajangana LB Main Canal

Data Description	Data source	Period
Pump Operation Detail (Hourly)	Farmer Organization	2008/09-2012/13
Pump Details	Field Survey	2008/09-2012/13
LB Sluice Water Releases (Hourly)	ID. (Colombo, Anuradhapura, Rajangana)	2005-2013

5.1.2.1 Pump operation data

At the inception, there had been 18 pumping stations in the Rajangana LB canal. During the study period only 14 pumps were in operation. Operation data of lift irrigation system for the 2008-2013 period were not available in the Irrigation Department and therefore a field survey was carried out. Farmer organization records indicated the pump operation hours of each day (Figure 5.4). During field visits, pump capacities were captured from pump specifications which were available at the respective sites. Water extractions were computed with the use of pump operational hours and pump capacity data. At Rajangana LB canal, there are two types of pumps. One type is with 90 cum/Hr capacity and the other with a capacity of 120 cum/Hr. Volume of water extracted by each pump is shown in the Figure 5.5 to Figure 5.10 and in Appendix 1. Weekly pump data summary are in the Table A2-5, Table A2-6 of Appendix 2. In these Figures, week 1 is the first week of October in the starting year while the 52^{nd} week is the last week of September and it is the end of the calendar year.



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	පොම්ප අංකය	පොම්ප අංකය	පොම්ප අංකය	පොම්ප අංකය	පොම්ප අංකය	පොම්ප අංකය
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2	3	1				
3	2	7				
4	5	4				
5	3	6				
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Figure 5.4: Format for Collection of Hourly Pump Operation Data

5.1.2.2 Pump details

Pump detail of the 18 pumps of CB canal were collected from a field survey and by consulting the Resident Engineers' Office of Rajangana. Pump capacity, Number of Pumps at each station and Pump condition records were collected from the field visits and from Resident Engineers' office (Table 5 10 - Table 5 11).

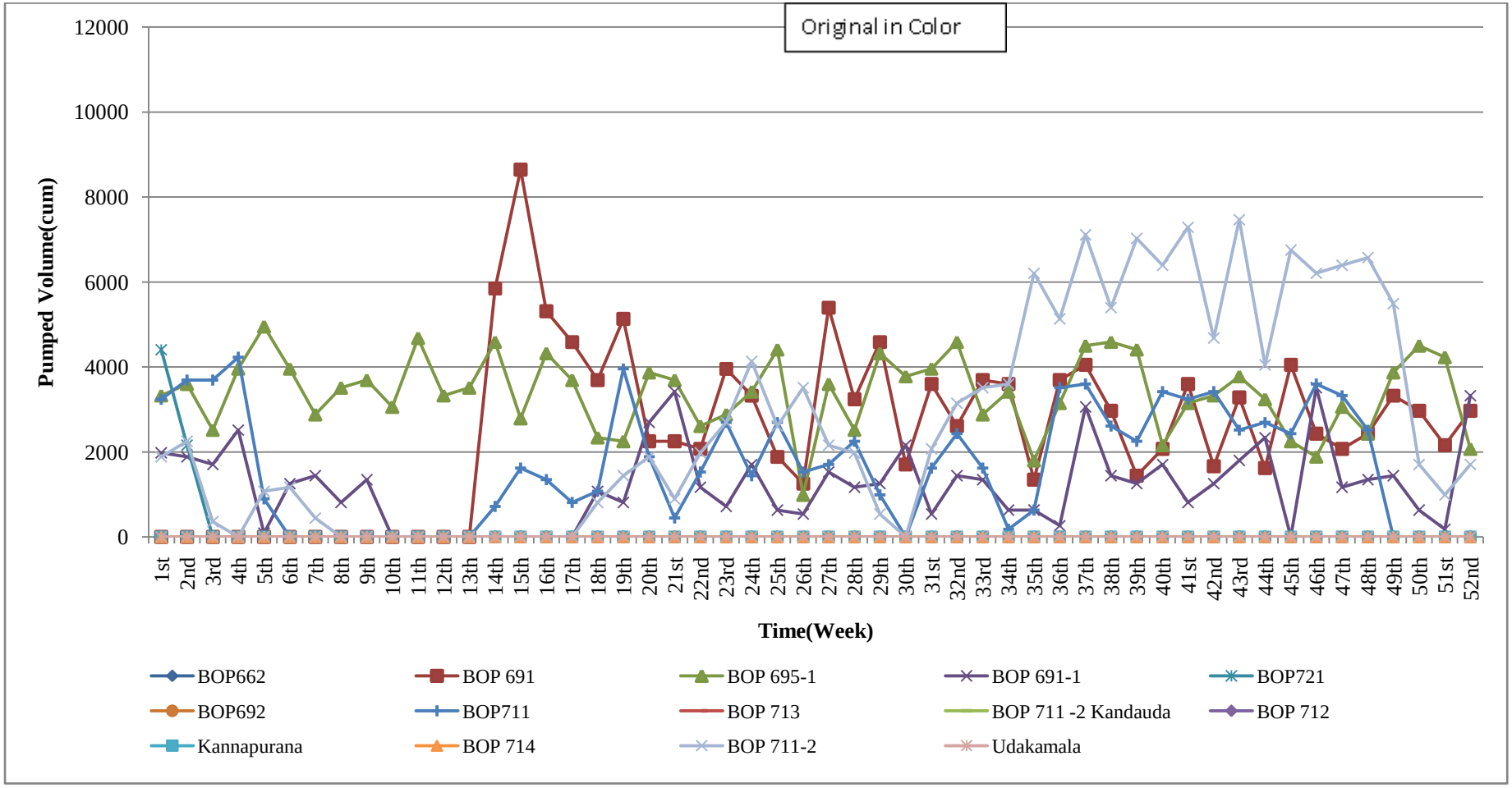

Figure 5.5: Pump Operation Data of L.B Main Canal (2008/09)

Note: Pump Station Details are in Figure 1-1 and 1-2

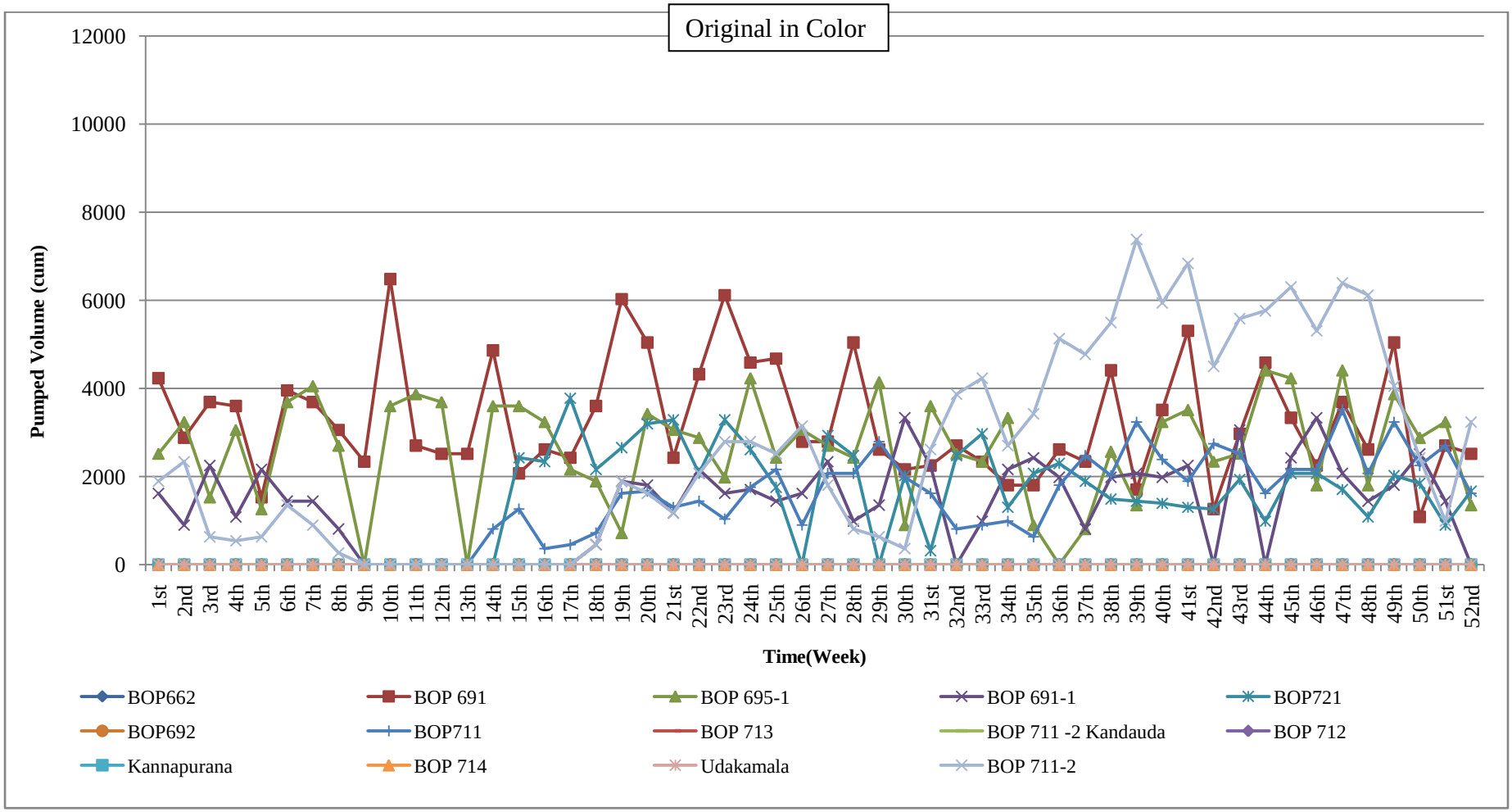

Figure 5.6: Pump Operation Data of Water Year (2009/10)

Note: Pump Station Details are in Figure 1-1 and 1-2

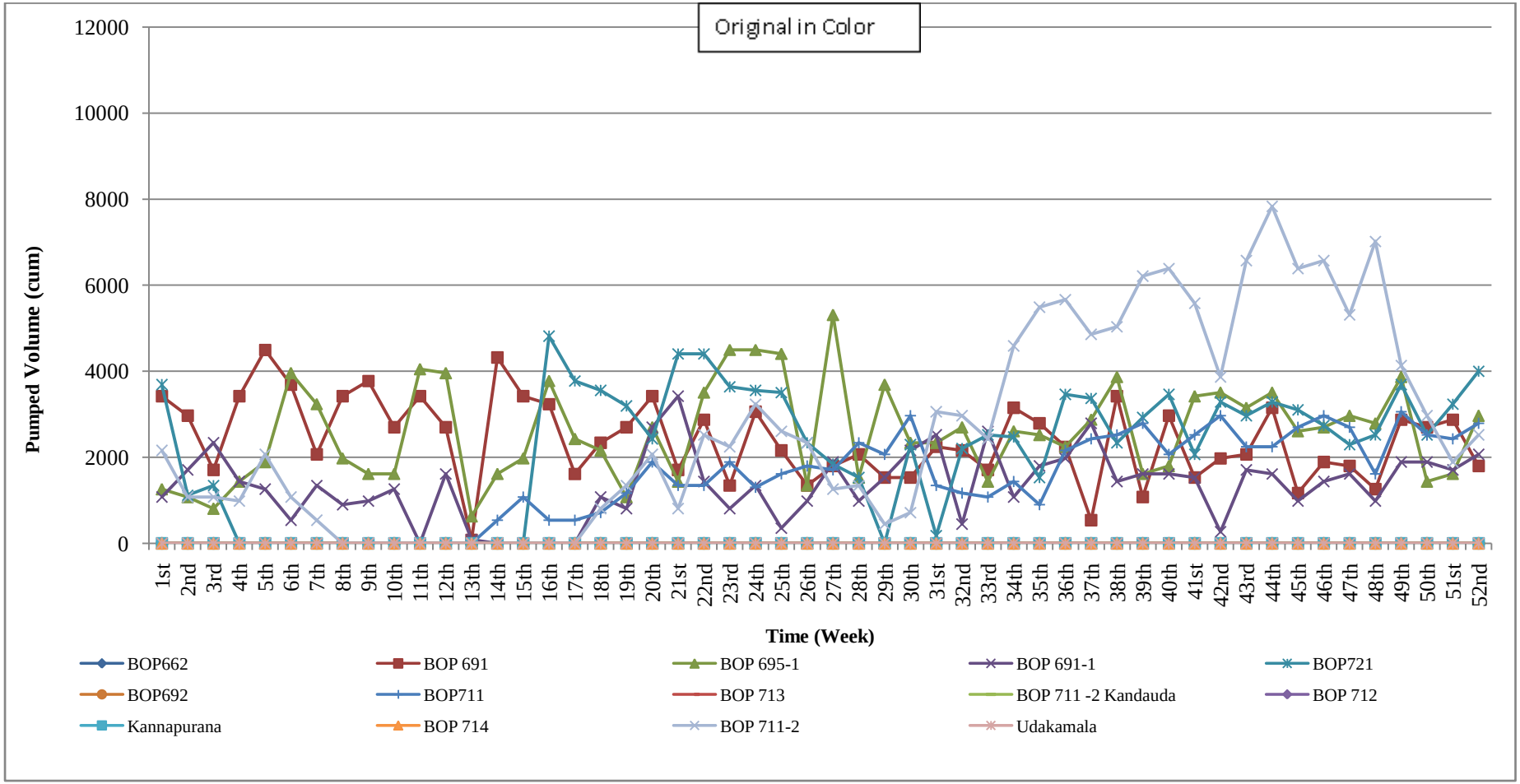

Figure 5.7: Pump Operation Data (2010/11)

Note: Pump Station Details are in Figure 1-1 and 1-2

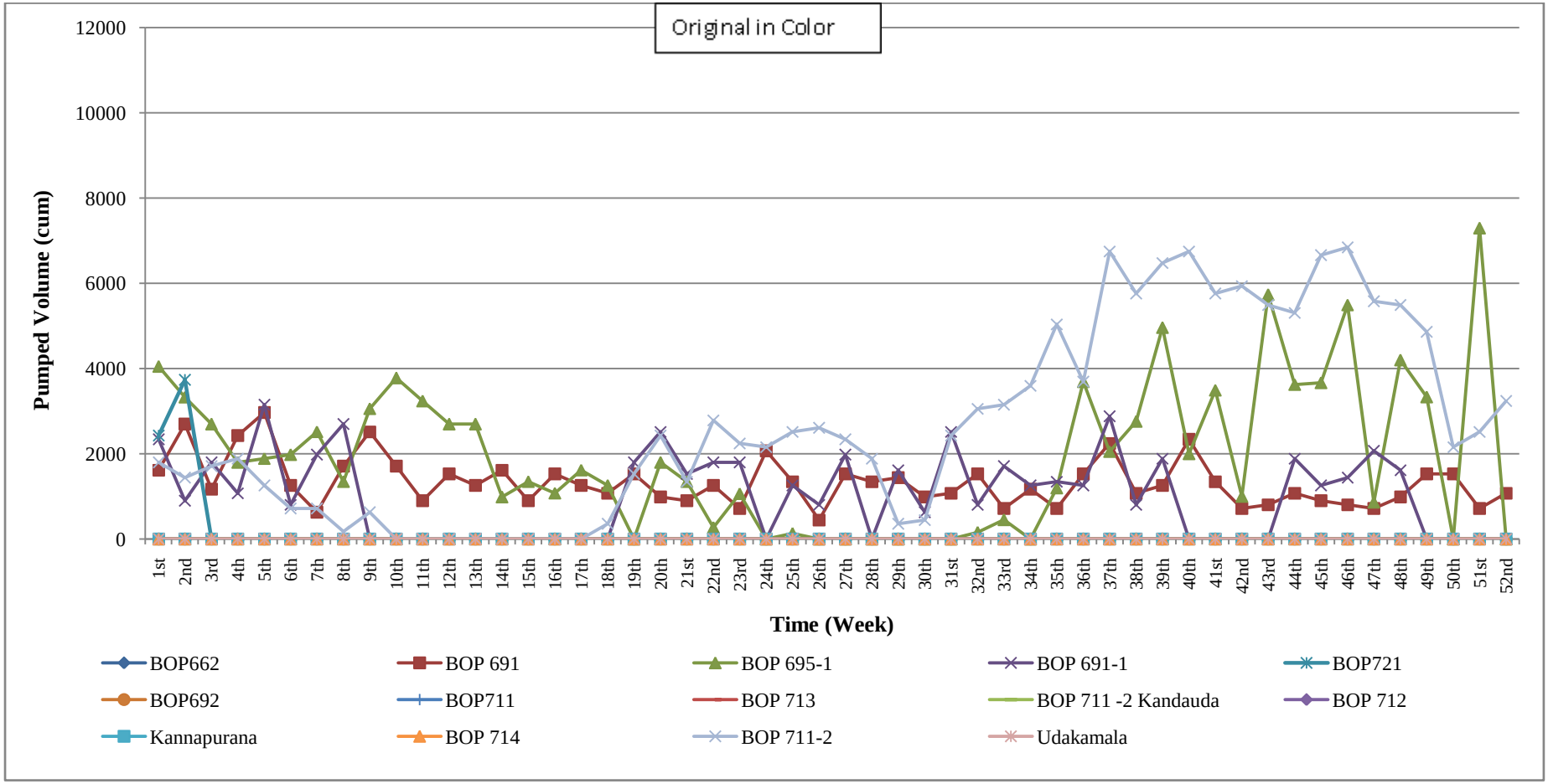

Figure 5.8: Pump Operation Data of (2011/12)

Note: Pump Station Details are in Figure 1-1 and 1-2

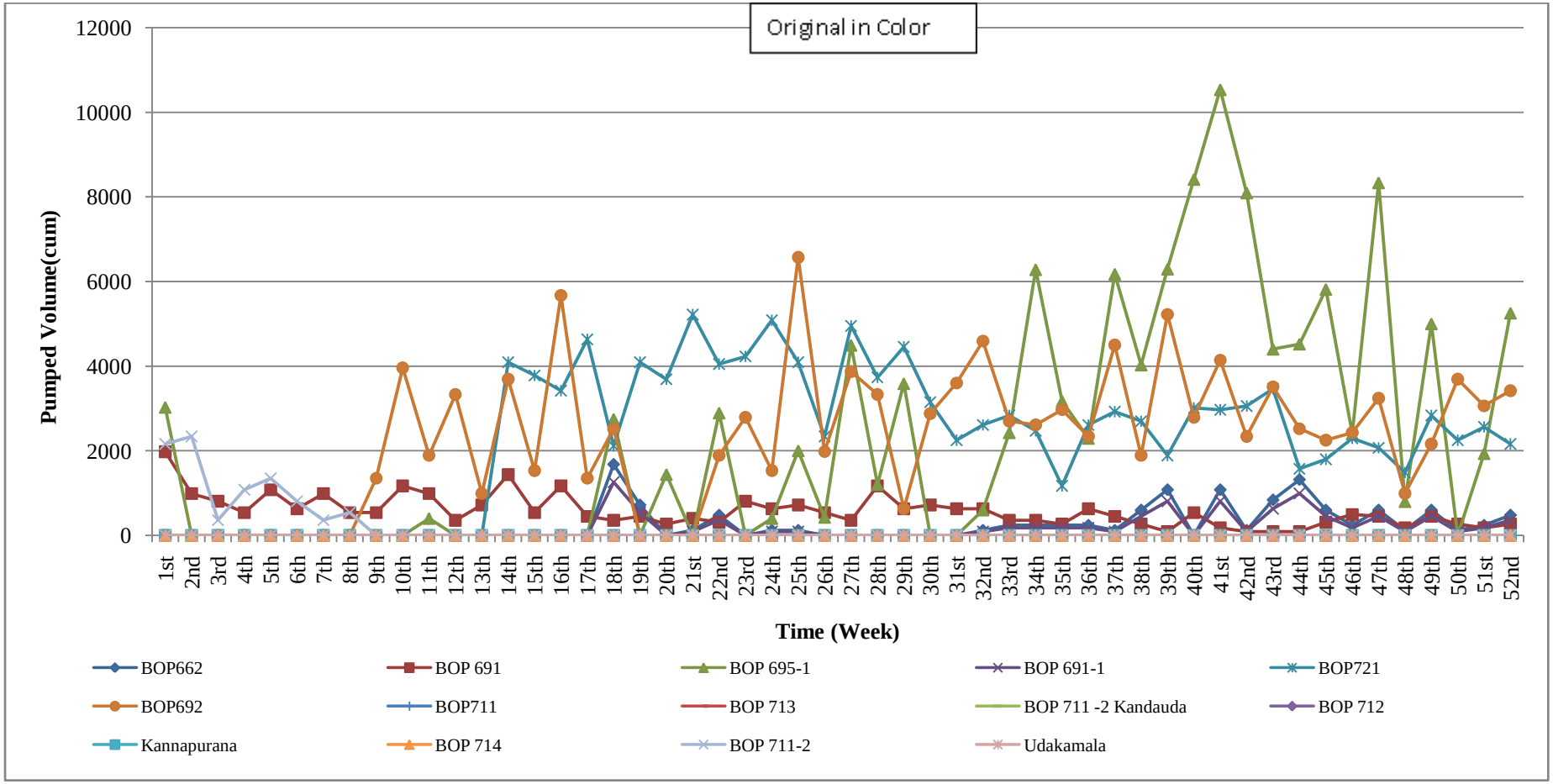

Figure 5.9: Pump Operation Data (2012/13)

Note: Pump Station Details are in Figure 1-1 and 1-2

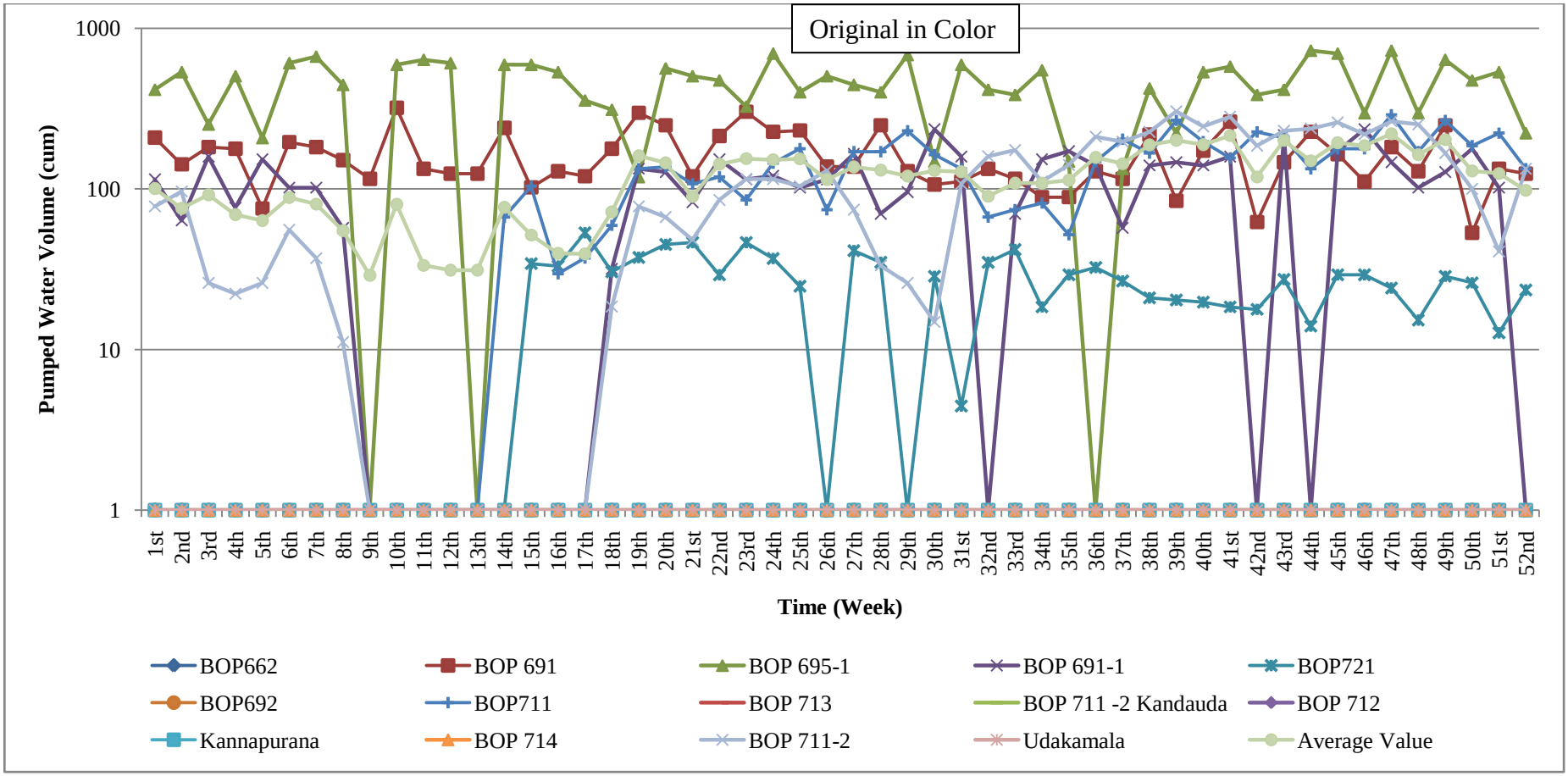

Figure 5.10: Pumped Water Volume per Unit Area of Each Pumping Station before Checking (2009/10

Note: Pump Station Details are in Figure 1-1 and 1-2

Table 5-10: Pump Condition and Upland Cultivation Area Data of 2013 (from Resident Engineers' Office –Rajangana)

No	Pumping Station Identification	Upland Land Extent		Pump Details			
		Total Area (Ha)	Cultivated Area of 2013 (Ha)	Total Pump number in Station	Number of Pumps Not working	Number of Pumps In operation	Number of Electric Pumps
1	BOP 691	40.47	20.23	3	2	1	1
2	Bop 695-1	61.51	6.07	3	2	1	
3	Bop 691-1	23.07	14.6	1	1	-	1
4	Bop 711	46.13	12.14	3	2	1	1
5	Bop 711-2	44.52	40.47	2	1	1	1
6	BOP 721	169.97	70.82	5	4	1	2
7	BOP 692	41.68	26.30	1	-	1	
8	BOP 711-2,Kandauda	44.52	40.47	1	1	-	1
9	BOP 712	52.61	18.21	3	2	1	1
10	BOP 713	70.82	27.52	7	4	3	2
11	BOP 714	45.32	4.05	3	1	2	1
12	BOP 662	113.31	2.43	2	1	1	2
13	Kannapurana	72.84	12.14	3	2	1	1
14	Udakamala	80.94	12.95	1	1	-	1
15	4 Pumps(Not working)	143.66	-	6	6	-	-
Total		1051.37	307.97	44	30	14	15

Table 5-11: Pump Details Collected from the Field Survey

No	Pumping Station Identification	Pump detail	Remarks

		Initial Phase	Operational Pump Type and Nos.		Newly Installed Electric Pumps			
		Nos.	Lister Pitter	KUBOTA	12.5 HP	40 HP	60HP	
1	BOP 711/1	3	1			1		Lister Pitter 6"x4"
2	BOP 711/2Kandauda	2	1			1		
3	BOP 711/2	2	1			1		
4	BOP 712	3	1			1		
5	BOP 713	7	3				2	Currently pump is not used
6	BOP 714	3	1			1		
7	BOP Udakamala	1	0			1		Electric Pump – Not in operation
8	BOP 691	3		1				1500 liter/min
9	BOP 691/1	2	0			1		
10	BOP 662	2	1			2		Operation of electric Pump Lister Pitter 9"x9"-120 cum/hr.
11	BOP 692	1		1				
12	BOP 721	5		4			2	Currently pump is not used
13	BOP 722	2	0		1			
14	BOP 695/1	3		1				
15	BOP 695/2	1	0					Not Working
16	BOP 718	2	0					Not Working
17	Kannapurana	3	1			1		Currently pump is not used
18	Chinese pump	1	0					Not Working

5.1.2.3 Left Bank Sluice Data

Daily water issue data of Rajangana, L.B. sluice from 2008/09 to 2012/13 are the base data of the present study. There are three gates in each sluice at the LB of Rajangana Irrigation Scheme. Typical sluice details are given in Table 5-12.

Table 5-12: Typical Details of L.B. Sluice Operation Received from the Department of Irrigation

Year	2008		Month	October									
	LB SLUICE												
					C =	0.6	Width of Sluice -	3.75					
Date	Head of water at sluice in ft.	Gate (No.01) Opening in inches	Gate (No.02) Opening in inches	Gate (No.03) Opening in inches	Issue Hour		Duration in hrs	Issue in cfs	Issue in Cu.m/sec	Issues in Ac.Ft.	Total Water issue for day (Ac.Ft.)	Water Issue In (mcm)	Total Water Issue to Date in cumec
					From	To							
1	23.00		0	0	7	24	17	0.00	0.00	0.00			
			0	0	0	7	7	0.00	0.00	0.00			
								0.00	0.00	0.00	0.00	0.000	0.000
2	23.0		0	0	7	24	17	0.00	0.00	0.00			
			0	0	0	7	7	0.00	0.00	0.00			
								0.00	0.00	0.00	0.00	0.000	0.000
3	23.0		9	9	7	24	17	128.43	3.63	180.39			
			9	9	0	7	7	128.43	3.63	74.28			
								0.00	0.00	0.00	254.67	0.313	3.604
4	22.8		9	9	7	24	17	127.86	3.62	179.59			
			9	9	0	7	7	127.86	3.62	73.95			
								0.00	0.00	0.00	253.54	0.312	3.588
5	22.6		13	13	7	24	17	183.17	5.18	257.28			
			13	13	0	7	7	183.17	5.18	105.94			
								0.00	0.00	0.00	363.22	0.447	5.140
6	22.4		8	8	7	24	17	112.74	3.19	158.36			
			8	8	0	7	7	112.74	3.19	65.21			
								0.00	0.00	0.00	223.56	0.275	3.163
7	22.1		8	8	7	24	17	111.97	3.17	157.28			
			8	8	0	7	7	111.97	3.17	64.76			
								0.00	0.00	0.00	222.04	0.273	3.142
8	21.9		13	13	7	24	17	180.24	5.10	253.17			
			13	13	0	7	7	180.24	5.10	104.25			
								0.00	0.00	0.00	357.41	0.440	5.057
9	21.7		16	16	7	24	17	220.14	6.23	309.21			
			16	16	0	7	7	220.14	6.23	127.32			
					0	0	0	0.00	0.00	0.00	436.53	0.537	6.177
10	21.4		22	22	7	24	17	298.71	8.45	419.57			
			22	22	0	7	7	298.71	8.45	172.76			
					0	0	0	0.00	0.00	0.00	592.33	0.729	8.382

5.1.3 Other data

5.1.3.1 Cultivation data

Cultivation data collected from the Department of Agrarian Development are in the Table 5-13. Paddy yield of Rajangana Left Bank Canal system collected from the Department of Agriculture at Rajangana are in the Table 5-15. Pump Condition and Cultivation data are shown in

Table 5-11, Table 5-13 and in Figure 5.11 and corresponding cultivation details are shown in the Table 5-14.

Table 5-13: Cultivation Area Detail of Left Bank Canal from 2008/09 to 209/13

Tract No - LB Canal	Seasonal Coverage of Crops 2008/09 (Acres)							Seasonal Coverage of Crops 2009/2010 (Acres)						
	Maha	Yala						Maha	Yala					
	Paddy	Paddy	Green Gram	Com	Pulse	Ground nut	Cow Pea	Paddy	Paddy	Green Gram	Com	Pulse	Ground nut	Cow Pea	Soybean
1	729.2	719.5	1.1	5.1	0.6	0.6	2.3	729.2	682.6	1.8	17.0	2.9	8.5	11.1	5.4
2	834.4	823.3	1.3	5.9	0.7	0.7	2.6	834.4	781.0	2.0	19.4	3.3	9.8	12.7	6.2
3	1730.0	1707.0	2.7	12.2	1.3	1.3	5.4	1730.0	1619.3	4.2	40.2	6.8	20.3	26.4	12.8
4	680.0	671.0	1.1	4.8	0.5	0.5	2.1	680.0	636.5	1.6	15.8	2.7	8.0	10.4	5.0
5	1295.9	1278.7	2.0	9.1	1.0	1.0	4.1	1295.9	1213.0	3.1	30.1	5.1	15.2	19.7	9.6
6	430.0	424.3	0.7	3.0	0.3	0.3	1.3	430.0	402.5	1.0	10.0	1.7	5.0	6.6	3.2
7	625.0	616.7	1.0	4.4	0.5	0.5	2.0	625.0	585.0	1.5	14.5	2.4	7.3	9.5	4.6
	Seasonal Coverage of Crops 2010/11							2011/12							
1	729.2	718.4	5.4	-	2.6	2.0	0.9	729.2	716.4	11.4	-	1.4	-	-	-
2	834.4	822.0	6.2	-	2.9	2.3	1.0	834.4	819.7	13.0	-	1.6	-	-	-
3	1730.0	1704.3	12.8	-	6.1	4.7	2.0	1730.0	1699.6	27.0	-	3.4	-	-	-
4	680.0	669.9	5.0	-	2.4	1.9	0.8	680.0	668.0	10.6	-	1.3	-	-	-
5	1295.9	1276.7	9.6	-	4.6	3.5	1.5	1295.9	1273.1	20.3	-	2.5	-	-	-
6	430.0	423.6	3.2	-	1.5	1.2	0.5	430.0	422.4	6.7	-	0.8	-	-	-
7	625.0	615.7	4.6	-	2.2	1.7	0.7	625.0	614.0	9.8	-	1.2	-	-	-
	Seasonal Coverage of Crops 2012/13														
1	729.2	715.5	4.3	2.9	0.9	3.7	-								
2	834.4	818.8	4.9	3.3	1.0	4.2	-								
3	1730.0	1697.6	10.1	6.8	2.0	8.8	-								
4	680.0	667.3	4.0	2.7	0.8	3.5	-								
5	1295.9	1271.6	7.6	5.1	1.5	6.6	-								
6	430.0	421.9	2.5	1.7	0.5	2.2	-								
7	625.0	613.3	3.7	2.4	0.7	3.2	-								

Table 5-14: L.B. Main Canal Cultivation Area

Water Year	Crops	Maha Extent		Yala Extent	
		Hectare	Percentage	Hectare	Percentage
2008/09	Paddy	2,559.44	100%	2525.44	99%
	OFC	-	0%	33.99	1%
2009/10	Paddy	2,559.44	100%	2395.70	94%
	OFC	-	0%	163.66	6%
2010/11	Paddy	2,559.44	100%	2521.44	99%
	OFC	-	0%	37.96	1%
2011/12	Paddy	2,559.44	100%	2514.40	98%
	OFC	-	0%	44.92	2%
2012/13	Paddy	2,559.44	100%	2511.48	98%
	OFC	-	0%	41.12	2%

Table 5-15: Paddy yield of Rajangana Irrigation Scheme LB Canal System.

Year	2008/2009		2009/2010		2010/2011		2011/2012		2012/2013	
Season	Maha	Yala	Maha	Yala	Maha	Yala	Maha	Yala	Maha	Yala
Production (MT/Ha)	6.9	6.9	7.2	7.5	5.0	8.2	6.3	6.3	6.9	7.2

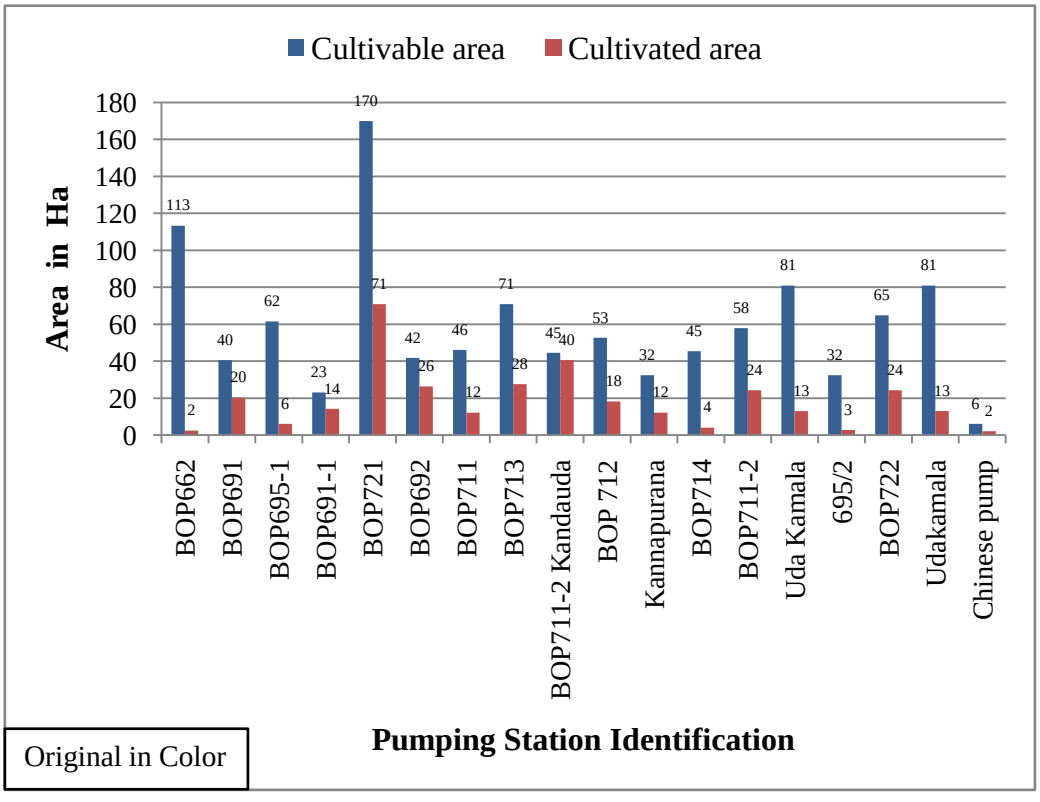

Figure 5.11: Comparison of Upland Cultivation Extent under each Pumping Station

5.1.3.2 Crop Coefficient

Crop coefficient and growth stage data were collected from the Technical Guideline of Irrigation work (Ponrajah, 1988) and the FAO report 24 (Doorenbos and Pruitt, 1977). Corn growth stages mentioned in the FAO 24 were adjusted with interpolation and used as the Crop Coefficient Values. Table 5-16 shows the crop coefficient and growth stage values of Paddy and OFC crops.

Table 5-16: Crop coefficients from Technical Guideline of Irrigation Work (Ponrajah, 1988),

Crop		**Growth Stages**			
		Initial	Development	Mid	Late
Lowland Paddy Maha	Crop Coefficient	1.00	1.15	1.20	0.90
	Crop growth period(Days)	30	40	45	20
Lowland Paddy Yala	Crop Coefficient	1.00	1.15	1.20	0.90
	Crop growth period(Days)	20	30	30	25
Cow Pea	Crop Coefficient	0.70	0.90	1.10	1.00
	Crop growth period(Days)	15	25	35	15
Groundnut	Crop Coefficient	0.65	0.80	1.00	0.80
	Crop growth period(Days)	20	30	40	20
Pulse	Crop Coefficient	15	25	35	15
	Crop growth period(Days)	0.50	0.80	1.05	0.50
Green gram	Crop Coefficient	0.50	0.80	1.05	0.7
	Crop growth period(Days)	15	20	25	15
Soybean	Crop Coefficient	0.65	0.85	1.05	0.75
	Crop growth period(Days)	15	20	50	20

According to the methodology described in the FAO No 24 the crop coefficients values were extracted and are shown in Table 5-17.

Table 5-17: Crop Coefficient Data of FAO No.24

Crop		Crop Growth Stages			
		Initial	Development	Mid	Late
Corn	Crop Coefficient	0.69	0.87	1.05	0.8
	Crop growth period(Days)	20	35	40	30

5.2 Data Processing and Checking

In the present research the computational temporal resolution was taken as weekly. Accordingly data were arranged for the irrigation requirement, weekly based water issues and delivery plans. Prior to computations, basedata were checked visually and numerically for any disparities. Data collected from different agencies were combined to fill the gaps. Pumping stations indicated a set of missing data and those were filled by taking the average of most representative set from the available data.

5.2.1 Evapotranspiration

Monthly pan evaporation data collected from ID Colombo also contained missing data. Meteorological Department data were collected and then compared to fill the missing data. In general a major peak could be noted in August while a peak of a lesser magnitude was observed in April (Figure 5.12). A wide variation of average pan evaporation rate could also be noted. The monthly variation of pan evaporation is shown in Figure 5.12. Average Pan Evaporation decreases at a rate of 0.07 mm/day to 1 mm/day from July to December. It increases from January to March and the range varies from 0.31mm/day to 0.95 mm/day between consecutive months. In April, the rate decreases by 0.2mm/day compared to March. From May to July, it is in an increasing trend and the range is between 0.1mm/day to 0.8mm/day. Minimum values in the rate variations were noted in November and December. Maximum values were noted in July and August. Over the study duration, pan evaporation values within a year varied by approximately 1.5 mm/day during any considered period.

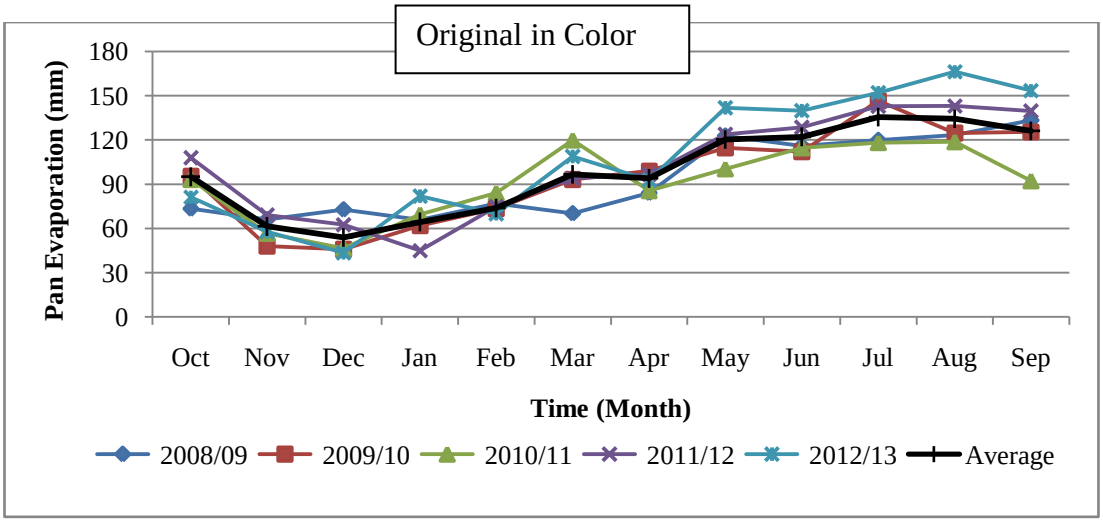

Figure 5.12: Pan Evaporation of Maha-Illupallama from 2008-2013

5.2.2 Rainfall

Daily rainfall data obtained from ID Rajangana and ID Colombo were checked for disparities and were selected for computations. Daily rainfall data were aggregated to compute weekly (Figure 5.13-Figure 5.17), monthly (Table 5-18 and

Table 5-19) and seasonal (Table 5-20) values. According to the available data, the year 2008/09 shows a shifted rainfall peak when compared with the other years (Figure 5.18). The peak in this year had shown a shift to January during North-East monsoon whereas during a three year period, rainfall peak appears in December. Another peak belonging to year 2010/11 was noted to move from March to April. The year 2010/11 while having the usual two peak behavior also shows an additional peak in February. 2012/13 has the rainfall peak shifted to October while in general the peak value appears around November. No efforts were taken to make adjustments to these data though variations were noted. Rainfall data demonstrated a wide variation of rainfall within the 2008 – 2013 period. 75% Probable Rain of ID Technical Guideline of Table 5-21.

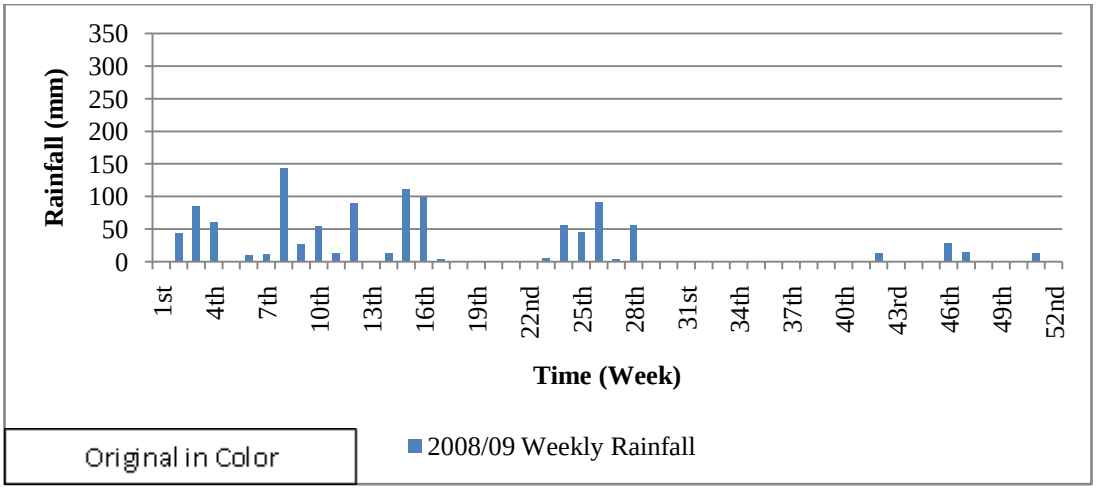

Figure 5.13: Weekly Rainfall Data of Rajangana 2008/09

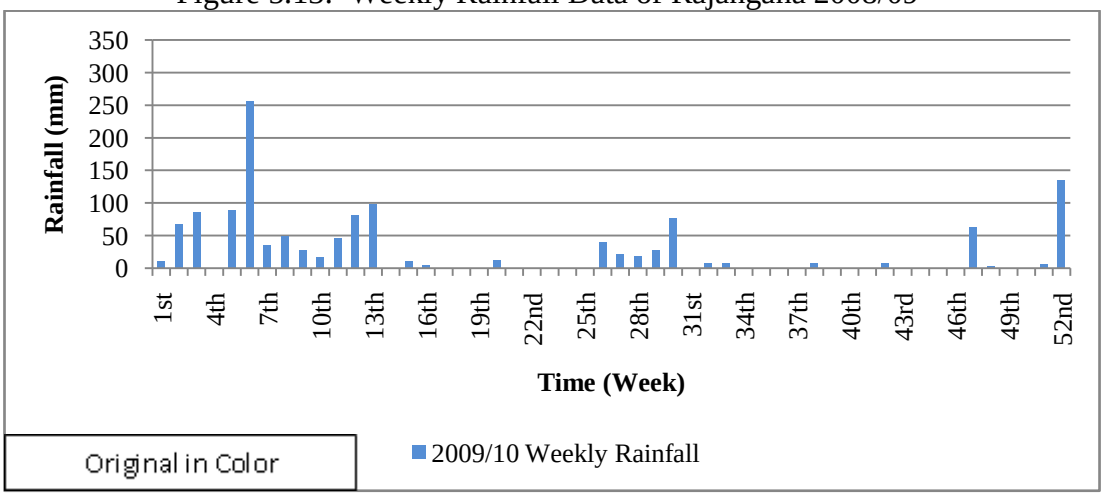

Figure 5.14: Weekly Rainfall Data of Rajangana 2009/10

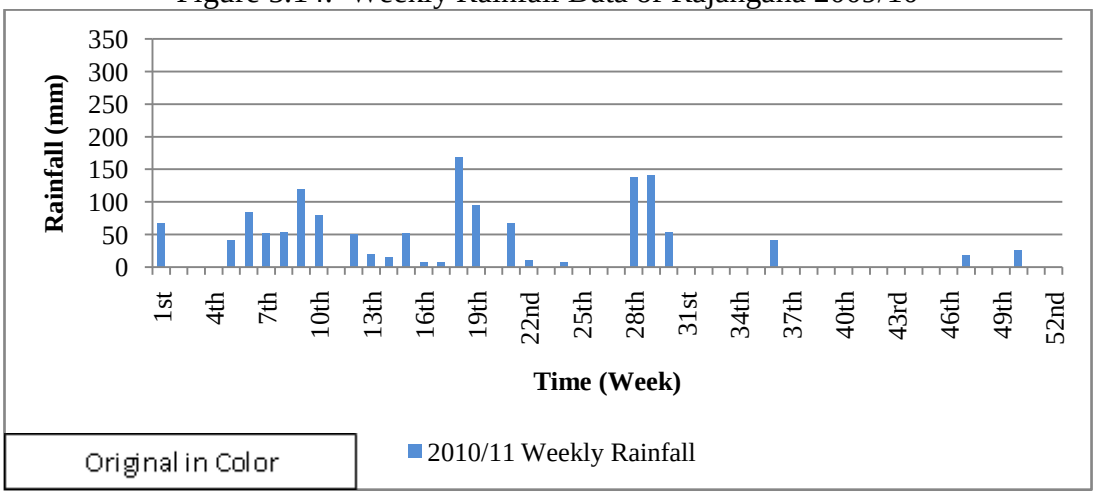

Figure 5.15: Weekly Rainfall Data of Rajangana 2010/11

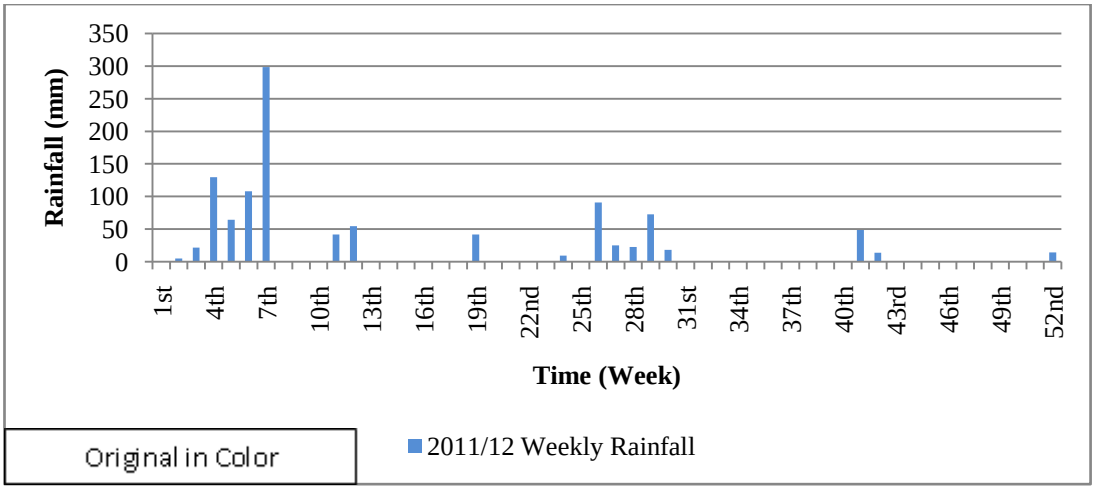

Figure 5.16: Weekly Rainfall Data of Rajangana 2011/12

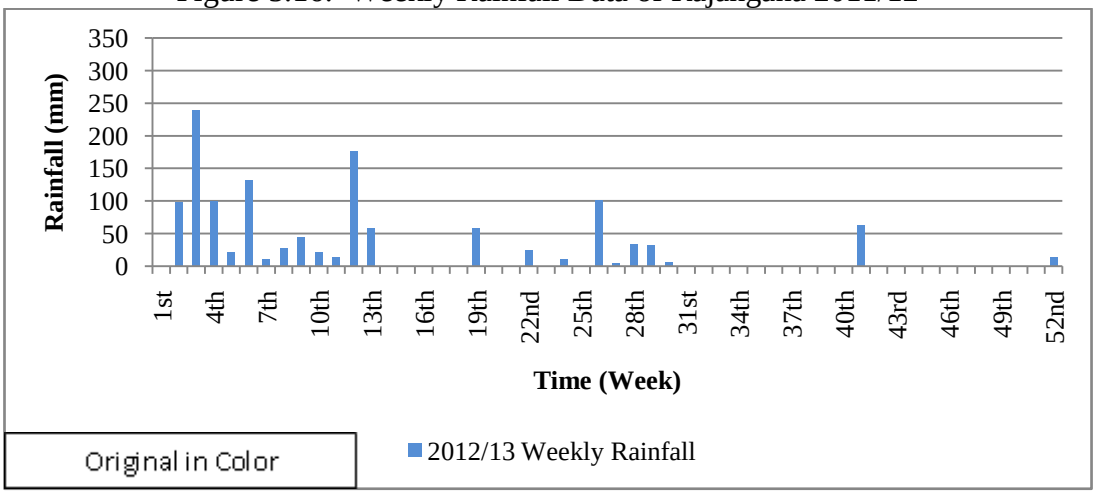

Figure 5.17: Weekly Rainfall Data of Rajangana 2012/13

Table 5-18: Monthly Rainfall at Rajangana Gauging Station in Maha Season

Year	Monthly Rainfall of Rajangana Station in Maha Season (mm/Month)					
	Oct	Nov	Dec	Jan	Feb	Mar
2008/09	188.10	190.80	156.00	226.00	0.00	198.30
2009/10	162.80	447.10	250.30	16.00	12.50	39.00
20010/11	101.00	268.70	195.10	115.30	305.00	7.50
20011/12	171.20	245.90	96.00	0.00	41.90	100.10
2012/13	455.40	216.90	267.40	0.00	82.30	110.40
Average	215.70	273.88	192.96	71.46	88.34	91.06

Table 5-19: Monthly Rainfall at Rajangana Gauging Station in Yala Season

Year	Monthly Rainfall of Rajangana Station in Yala Season (mm/Month)					
	Apr	May	June	July	Aug	Sept
2008/09	59.60	0.00	0.00	13.50	43.20	13.50

2009/10	143.50	14.00	7.50	7.50	65.50	139.30
2010/11	331.50	0.00	40.00	0.00	18.00	25.00
2011/12	138.10	0.00	0.00	62.30	0.00	14.30
2012/13	74.40	0.00	0.00	62.30	0.00	14.31
Average	149.42	2.80	9.50	29.12	25.34	41.28

Table 5-20: Seasonal Rainfall at Rajangana Gauging Station

Year	**Seasonal Rainfall of Rajangana (mm)**	
	Maha Season	Yala Season
2008/09	959.20	129.80
2009/10	927.70	377.30
2010/11	992.60	414.50
2011/12	655.10	214.70
2012/13	1132.40	151.01
Average	933.40	257.46

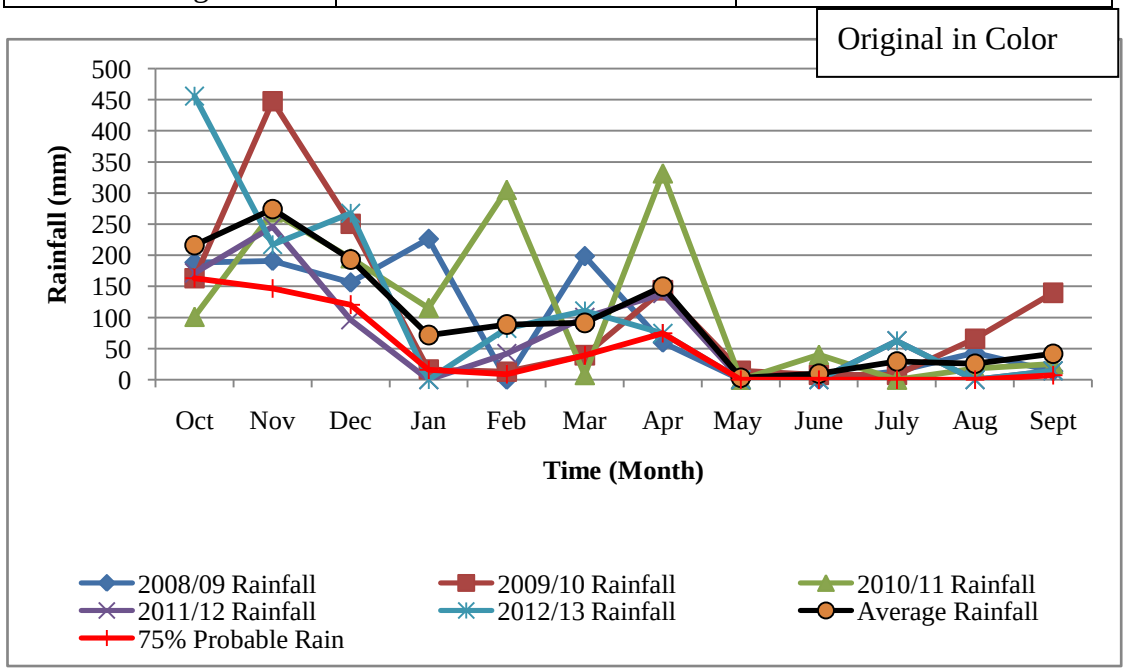

Figure 5.18: Monthly Rainfall Variation from 2008/09 to 2012/13

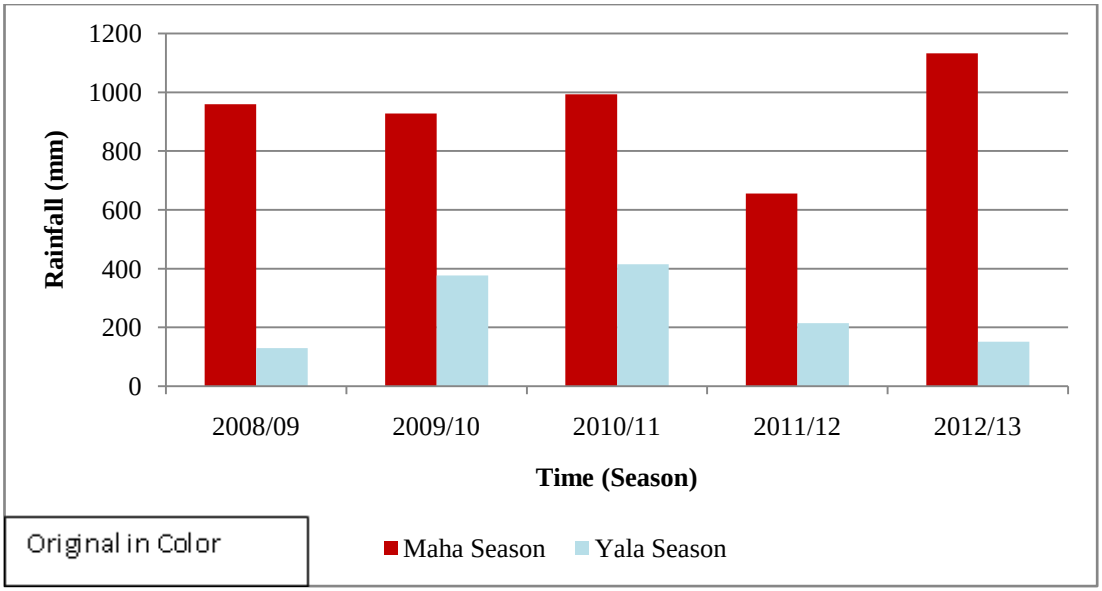

Figure 5.19: Seasonal Rainfall Variation from 2008/09 to 2012/13

Table 5-21: Monthly 75% probable rainfall of DL1 in ID Technical Guideline

Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept
75%Probable Rainfall (mm)	127	152	127	76	25	51	127	51	13	0	13	25

5.2.3 Command area and cultivation data

Command area data from ID Rajangana were checked with the BOP map. Collected cultivation data were also compared and visual checks were done with the data of Department of Agrarian Development responsible for Anuradhapura region.

5.2.4 Pump data

During the field data collection, pumping data were captured by distributing a carefully designed field data format as shown in Figure 5.4. This format enabled easy collection of pump operation data and cropping details. Data were compared but abnormalities or significant disparities could not be identified. Pumping data gaps were filled with the average of most reliable pumping data per unit command area. The pump BOP 695-1 had a comparatively very high per unit area pumping quantity while the pump BOP 721 had extremely low values. These outliers were not considered for missing data filling of the other pumps. In order to fill data, only the pumps BOP 691, 695-1, 691-1, 711-2, 711, 721 were used. Variation of data after the filling of missing data is shown in the Figure 5.20. In the same Figure, the

rainfall received at Rajangana is shown and corrections had been effected to data from 2008/09 to 2012/13. Details are presented in the Appendix 1. As expected the observed data shows that the pumping quantities had reduced during the rains. This was also taken as a check for data validity. The total pumped water by all the pumping stations were summarized as weekly quantities and are shown in the Figure 5.21.

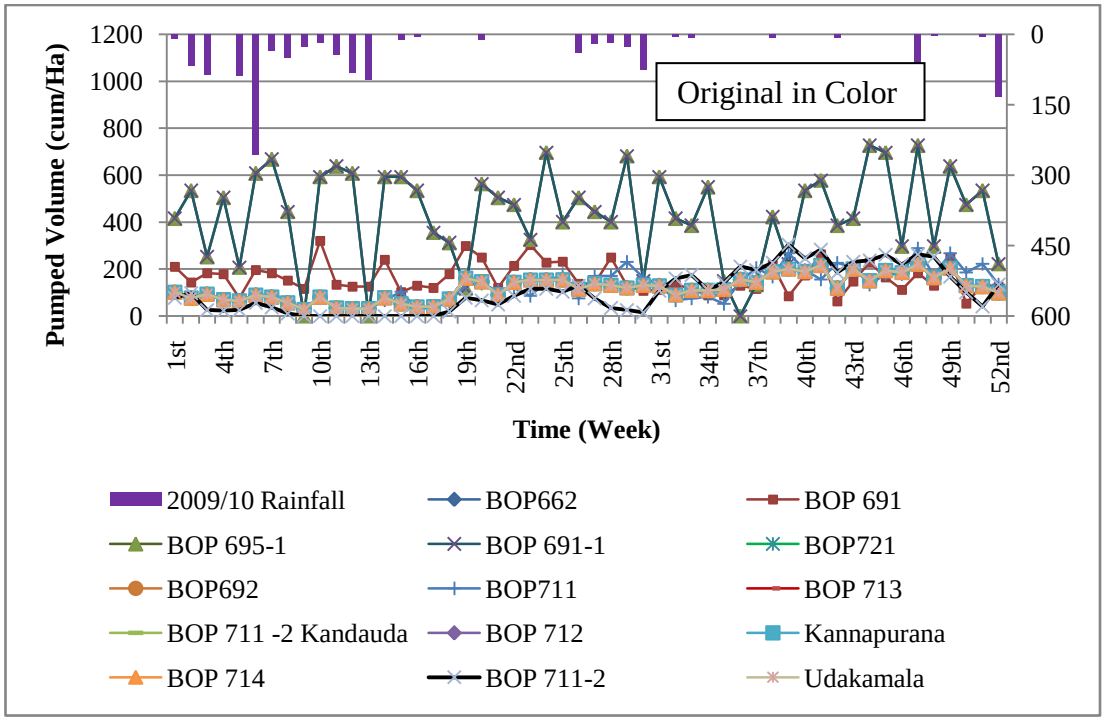

Figure 5.20: Corrected Pump Operation Data of 2009/10

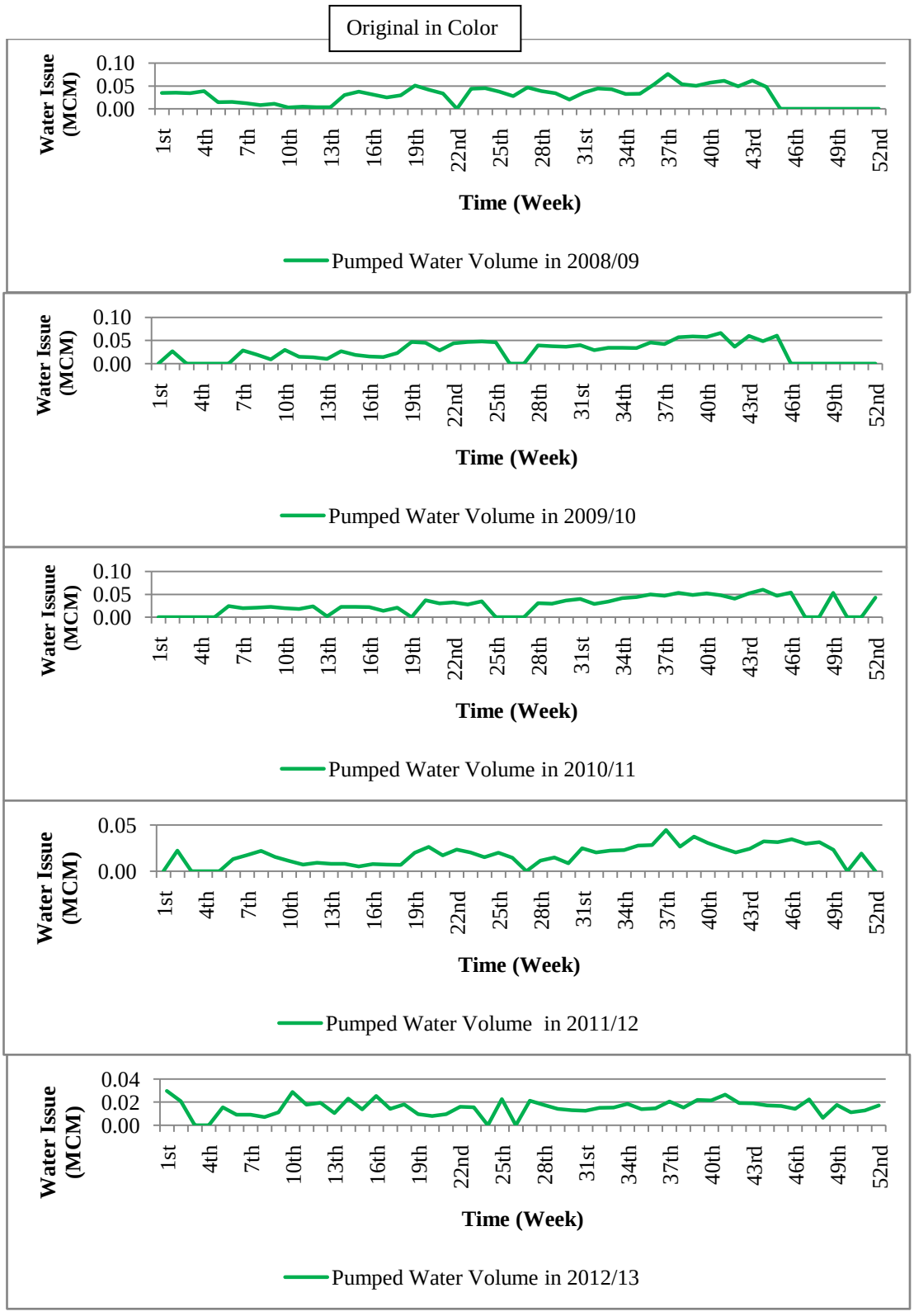

Figure 5.21: Quantity Used by the Entire Lift Irrigation System 2008/2009 2012/2013

5.2.5 Water issue data

In order to check the water issue data, actual reservoir releases computed on an area basis were plotted together with rainfall (Figure 5.22 to Figure 5.26). Farmers and officials indicated that the water releases are normally reduced during the rains unless the reservoir is spilling. Rajangana reservoir has two sluices as the left and right bank contributing to the cultivation of the left and right bank command areas. Each sluice has three gates of 1.143m x 1.143m to deliver water for cultivation. LB canal water issues were collected from the Irrigation Department offices in Colombo and Anuradhapura. The discharge equation used by the Irrigation Department to measure irrigation water is as shown below.

Discharge,

$$Q = C_d \times B \times H_2 \times \left[2g\left(H_1 - \frac{H_2}{2}\right)\right]^{\frac{1}{2}} \ldots\ldots\ldots\ldots\ldots \text{Eq (4)}$$

Where, Q is the sluice discharge, C_d is the coefficient of discharge, B is the width of gate, H_1 is the total water head at the sluice gate, H_2 is the depth at the sluice/orifice opening. In the computation of discharge, C_d is taken as 0.6. Water issue is recorded daily and the issues vary with the season and the crop. Daily water issues in MCM totaled as weekly issues are plotted in Figure 5.22 to Figure 5.26 corresponding values are shown in Table A2-1 and Table A2-2. These values comprise both irrigation water issued to the gravity irrigation network and to the lift irrigation system.

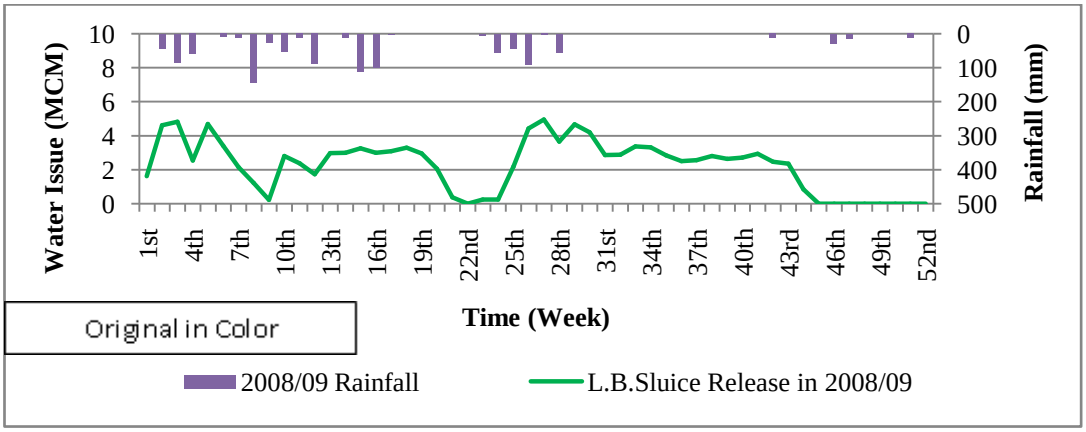

Figure 5.22: Total Water Issue of L.B. Sluice in 2008/09

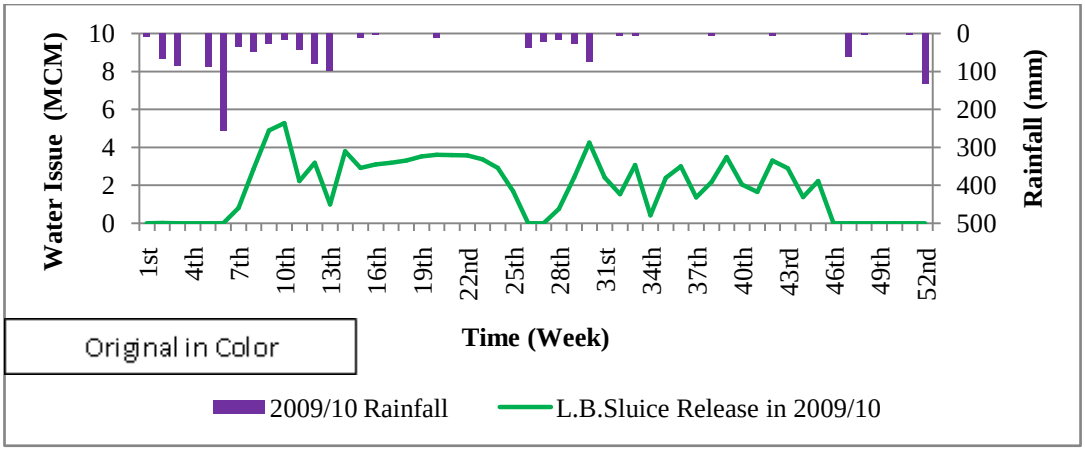

Figure 5.23: Total Water Issue of L.B. Sluice in 2009/10

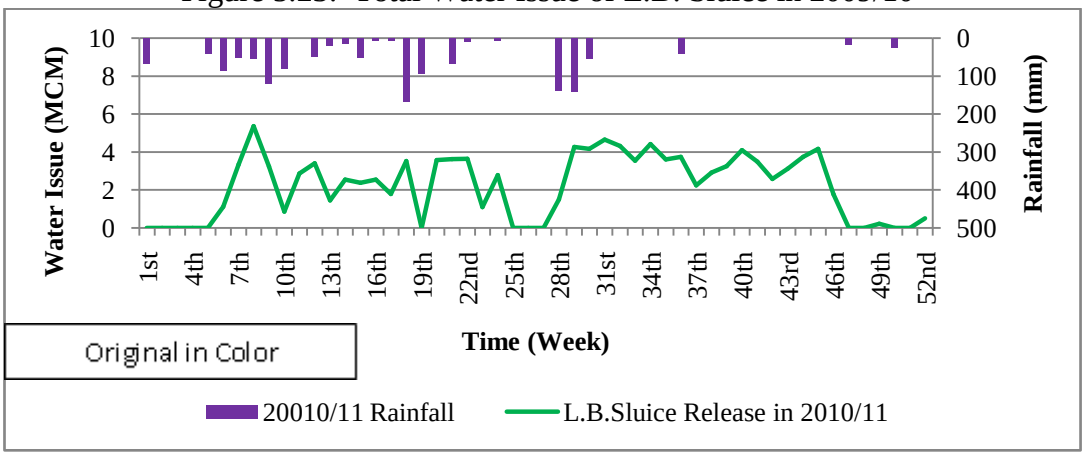

Figure 5.24: Total Water Issue of L.B. Sluice in 2010/11

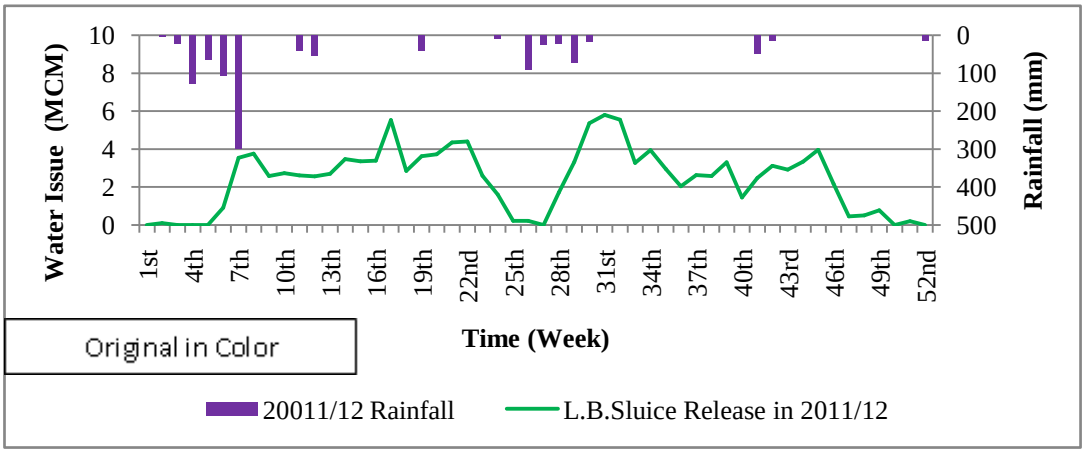

Figure 5.25: Total Water Issue of L.B. Sluice in 2011/12

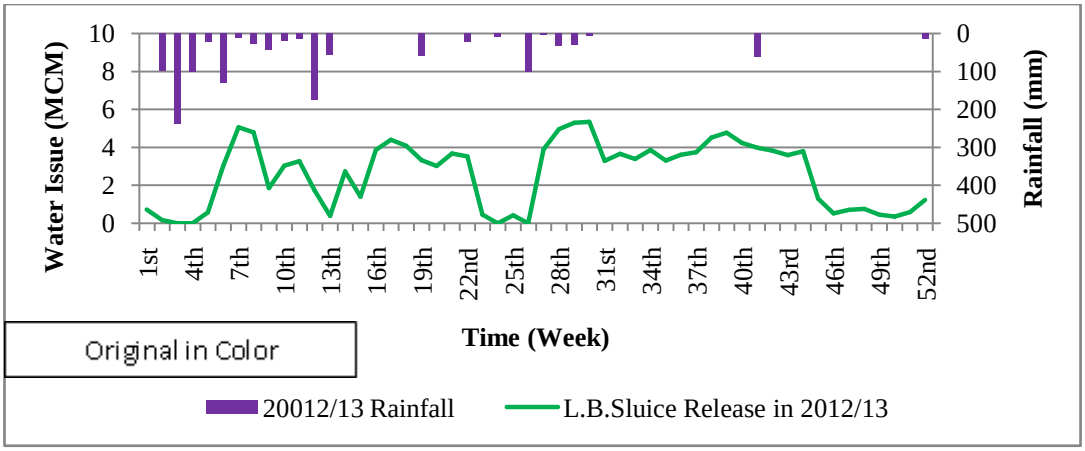

Figure 5.26: Total Water Issue of L.B. Sluice for 2012/13

Figures demonstrate that the water issue volumes decrease after rain and then increase afterwards. Another observation from five datasets was the relation to land preparation period. In actual practice cultivation is commenced after the rain occurs. In the case of land preparation period with little rain, water issue is initially uniform and at the end of period, water consumption is small. This water issue was compared with the irrigation requirement. After harvesting the crop, there is no requirement for water but in the Rajangana a small water volume could be noted after harvesting. When verified with the actual practices in the field, it was found that it is necessary to release water for the groundwater recharge and for environmental purposes. This was verified with the ID Rajangana Plan in which this quantity had been included at the planning stage.

5.2.6 Comparison of L.B. Water issue and the pumped water

Total water release of L.B. Canal in each year and the total of pumped water from L.B canal for Lift irrigation were plotted in order to study the variations and the order of magnitude with respect to each other (Figure 5.27 to Figure 5.31). Comparison between the total water issue and Pumped volume corresponding to L.B canal show that the volume pumped for Lift irrigation is very low.

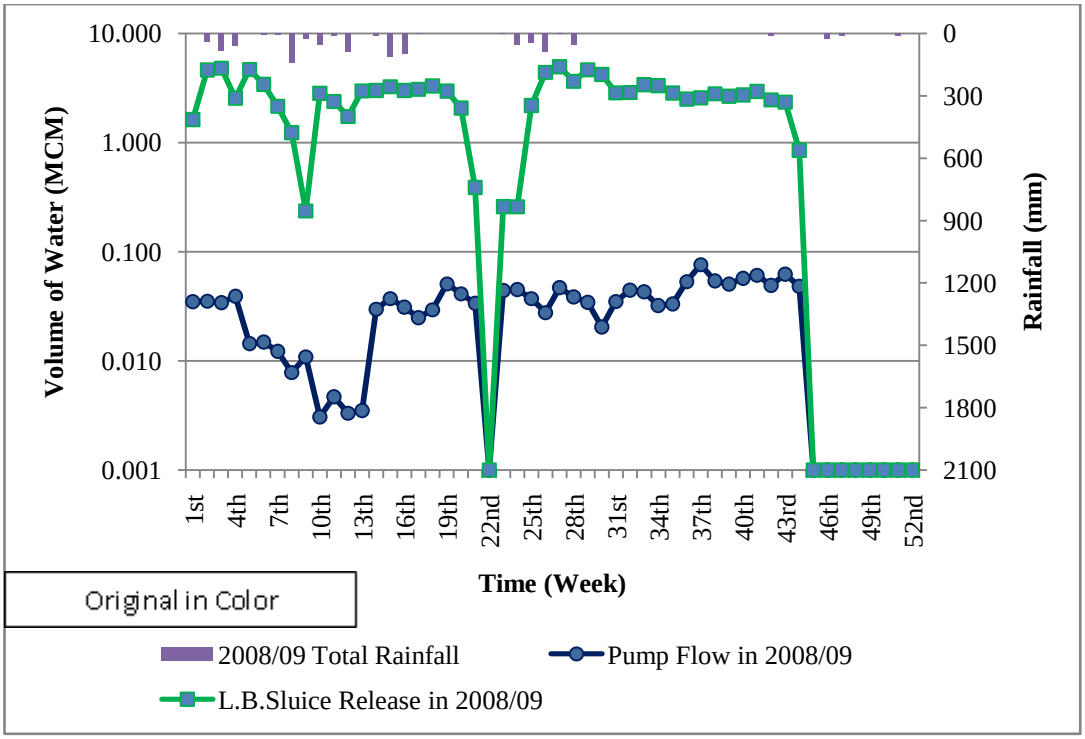

Figure 5.27: Total Water Issue of L.B Sluice and Pumped Quantity in L.B Canal -2008/09

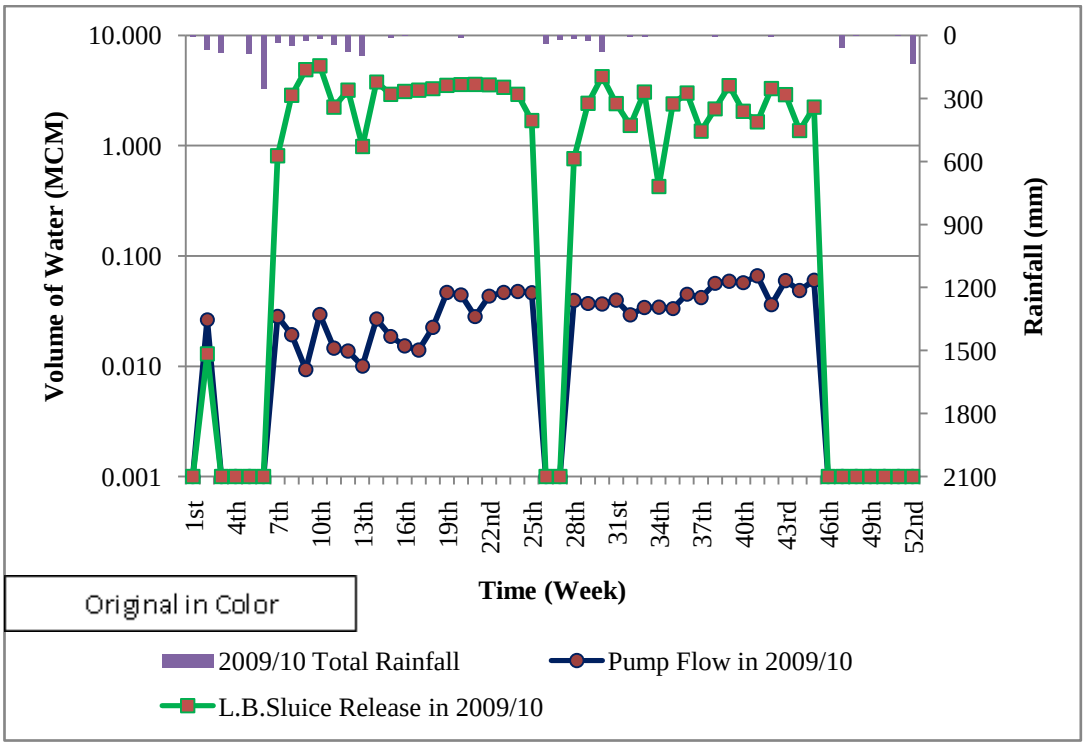

Figure 5.28: Total Water Issue of L.B Sluice and Pump Flow in L.B Canal-2009/10

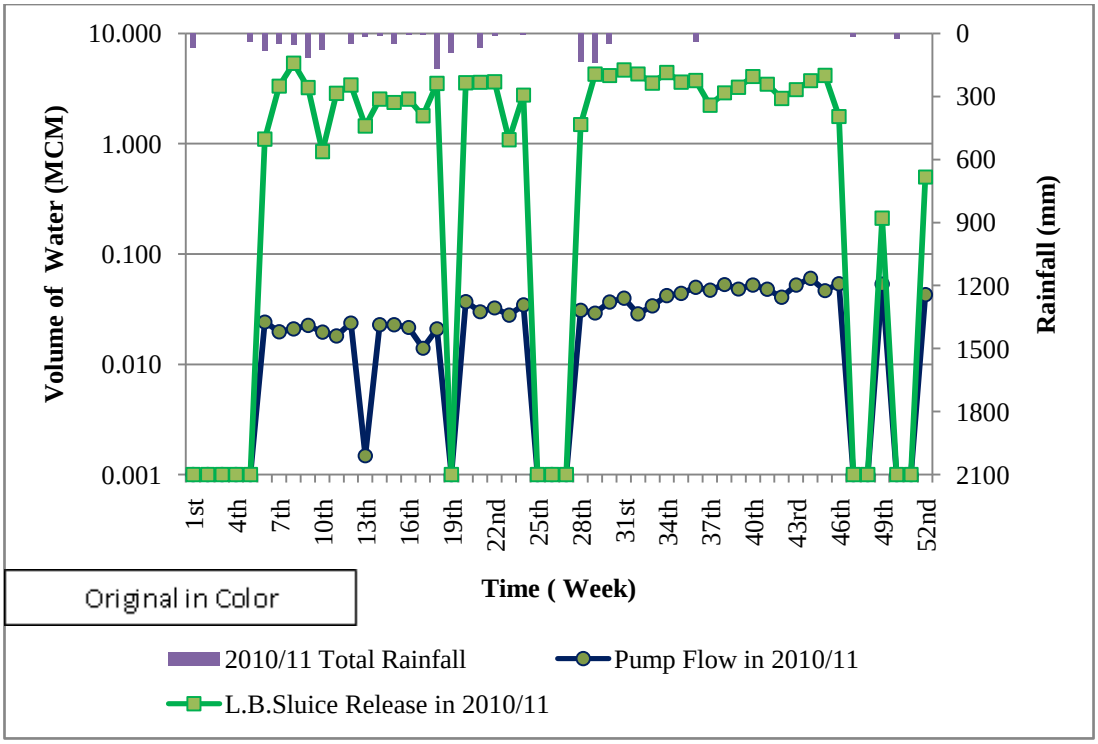

Figure 5.29: Total Water Issue of L.B Sluice and Pump Flow in L.B Canal - 2010/11

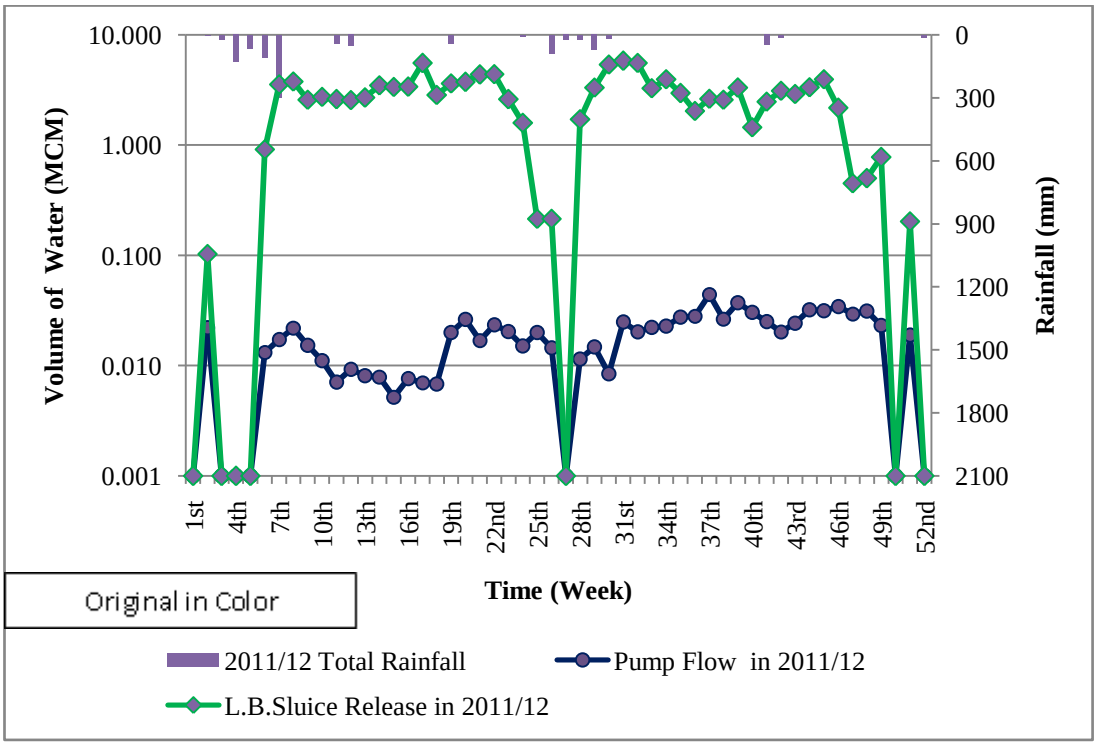

Figure 5.30: Total Water Issue of L.B Sluice and Pump Flow in L.B Canal - 2011/12

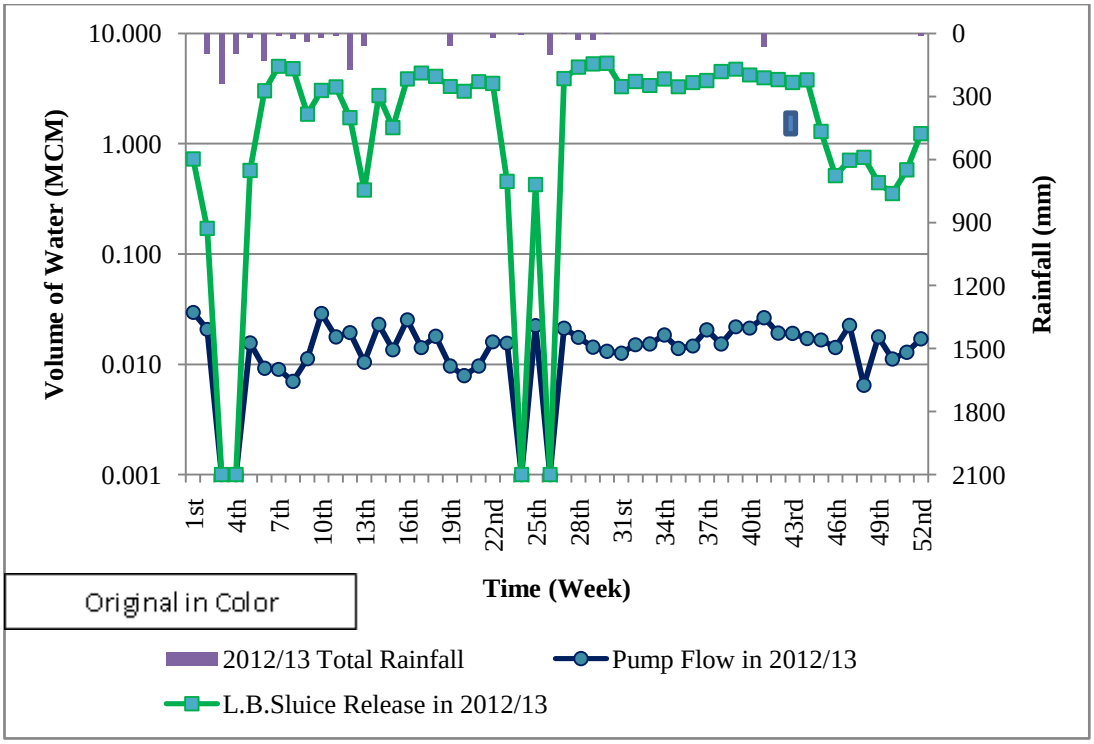

Figure 5.31: Total Water Issue of L.B Sluice and Pump Flow in L.B Canal - 2012/13

Figure 5.32 to Figure 5.37 shows the rainfall and actual water issue for the five years selected for the research. Comparison of actual water issue data and guideline recommendations showed two main factors with regards to actual and planned water issues. One is the difference in cultivation commencement dates. The other is the use of paddy variety.

5.2.7 Verification of crop type and calendar

Table 5-22: Changes Made to Crop Type and Calendar Subsequent to Evaluation

Year and Season	**Guideline Recommended Crop Variety**	**Adjusted Crop Variety**	**Guideline Expected End of Season**	**Adjusted End of Season**	**Other Adjustment**
2008/09 Maha	135 day paddy	105 day paddy	2009 March 1st Week	2009 February 2nd Week	Starting time shifted to November 2nd Week,2009
2008/09 Yala	105 day paddy	105 day paddy	2009 August 1st Week	2009 July 4th Week	Land Preparation shifted to March 3rd -4th Week, 2009.
2009/10 Maha	135 day paddy	105 day paddy	2010 April1st Week	2010 March 3rd Week	Starting time shifted to December 1st Week,2009
2009/10 Yala	105 day paddy	105 day paddy	2010 July 3rd Week	2010 August 1st Week.	Time delay - One Week for Starting time.
2010/11Maha	135 day paddy	105 day paddy	2010 March 4th Week	2010 March 2nd Week	Starting time shifted to November 4th Week,2010
2010/11Yala	105 day paddy	105 day paddy			Starting time shifted 1st Week of May 2011.
2011/12Maha	135 day paddy	105 day paddy	2012 April 1st Week	2012 March 2nd Week	Starting period shifted to December 1st week, 2012.
2012/13Maha	135 day paddy	105 day paddy	2013 March 4th Week	2013 March 1st Week	Starting time shifted to November 4th week.
2012/13Yala	105 day paddy	105 day paddy			Land Preparation shifted to April 1st week, 2013.

There are two paddy verities usually cultivated in Sri Lanka. These are with 135 days and 105 days duration and are recommended for cultivation in Maha and Yala seasons respectively (Ponrajah, 1988). During field visits and discussion with farmers, it was indicates that the practice does not vary from the guidelines. However there were indicators of an occasional change in practice because some farmers mentioned that water volume is the main factor which supports the selection of a variety for cultivation. A closer investigation in the field, revealed that if the water volume is high, then the Rajangana Irrigation Engineer recommends longer duration paddy. If it is felt that the water availability in the tank is critical, then the recommendation is for the farmers to select the short duration paddy.

Plots of rainfall and LB sluice total water issues on a weekly basis were compared with the guideline expected commencement and harvesting dates. Observations showed a clear identification of the end of seasons because there was either stoppage or a marked reduction in water releases.

Though there were indications that environmental flow releases were carried out after the cultivation seasons, it was not possible to note such releases except for the year 2012/2013. In 2012/2013, there had been water issues at the end of the Yala season and this volume was taken as a special release.

Actual water issue pattern also demonstrated a contradiction with respect to the paddy variety. It appeared that the farmers of Rajangana LB Canal had opted to cultivate the shorter paddy variety during the Maha season.

In all study years, land preparation period was distinctly visible but the durations displayed variability. Variations did not provide a clear indication of the time at which land preparation ended. Season commencement week in the entire study period had varied from the guideline expectations and this could be expected because in practice the commencement of cultivation usually coincided with the onset of rains or with the expectation of rains.

These observations with regards to actual measurements revealed that in order to compare actual water releases with the guideline recommendations, it is necessary to

match the paddy variety and the calendar with the actual. Though the curves appear to create ambiguities with respect to the commencement dates, it is possible to carry out a comparison by adjusting the guideline based computations to ensure the same end of season observed in the actual data.

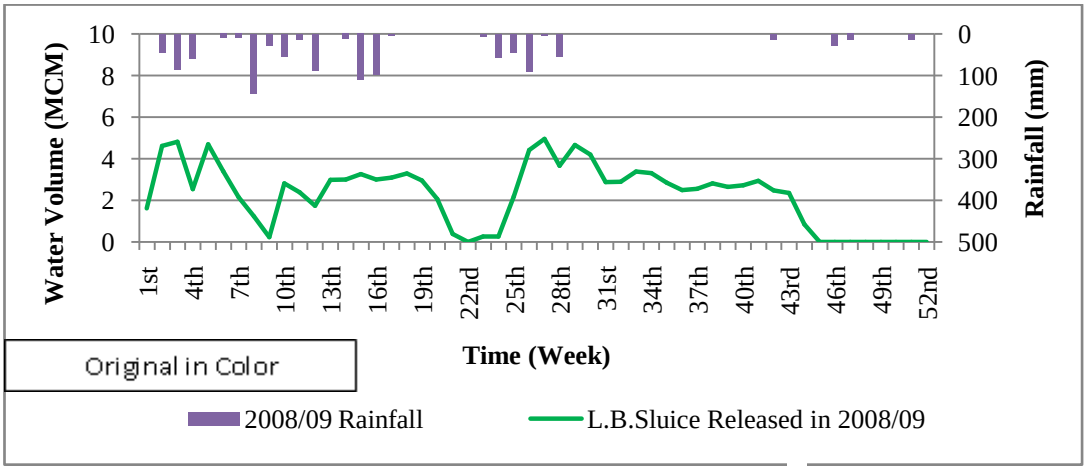

Figure 5.32: Observed Rainfall of Rajangana and Actual Water Issue through the L.B. Sluice in 2008/09

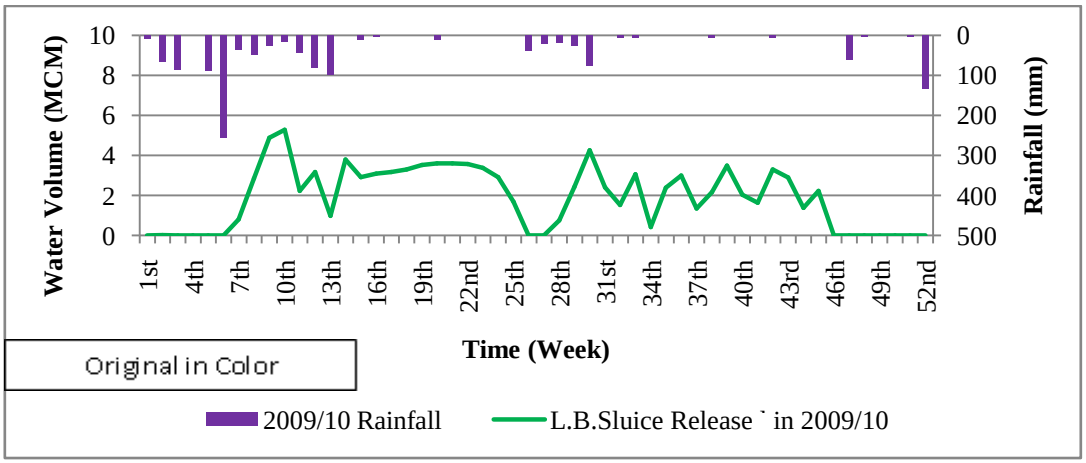

Figure 5.33: Observed Rainfall and LB Canal Water Release at Rajangana Reservoir for 2012/13

Figure 5.34: Observed Rainfall of Rajangana and Actual Water Issue through the L.B. Sluice in 2009/10

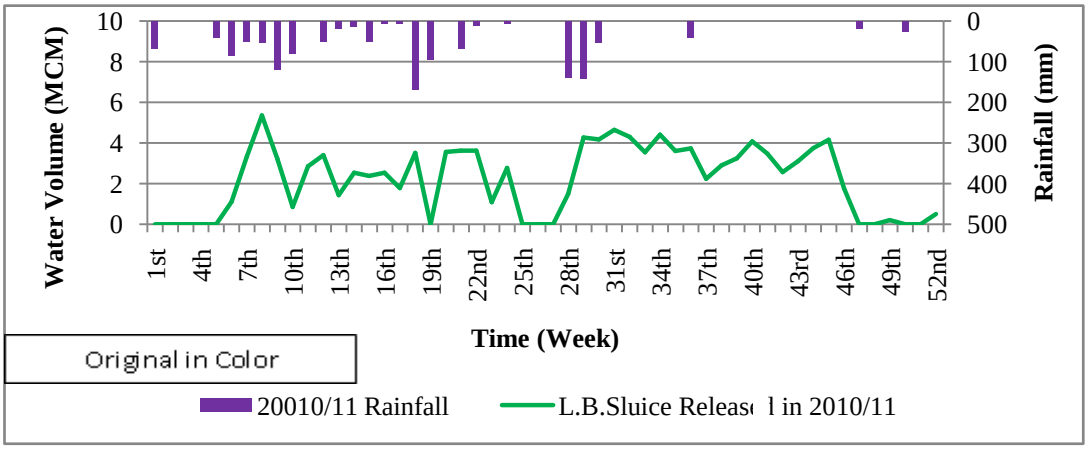

Figure 5.35: Observed Rainfall of Rajangana and Actual Water Issue through the L.B. Sluice in 2010/11

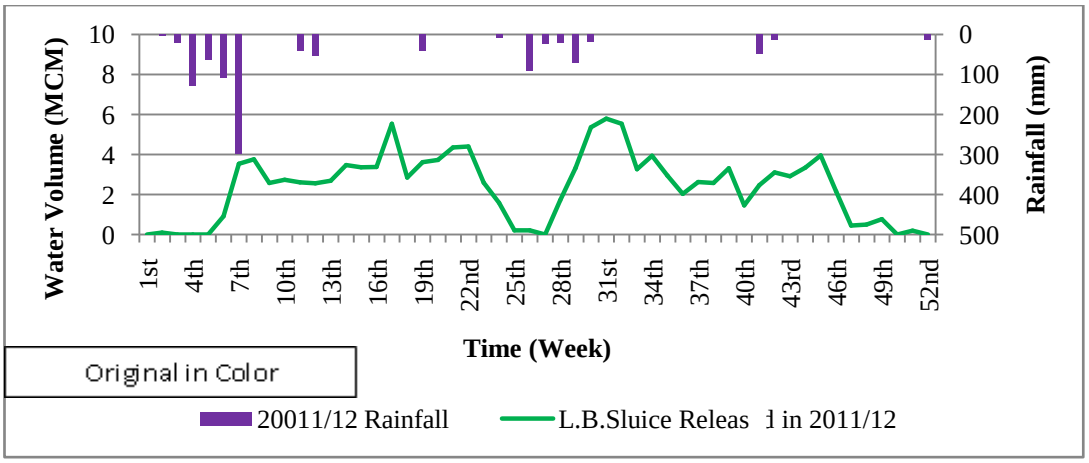

Figure 5.36: Observed Rainfall of Rajangana and Actual Water Issue through the L.B. Sluice in 2011/12

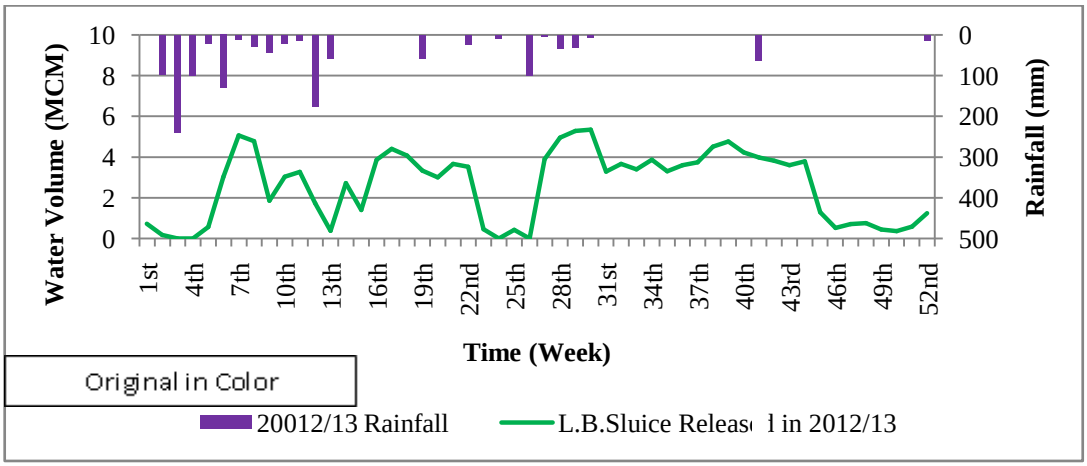

Figure 5.37: Observed Rainfall and LB Canal Water Release at Rajangana Reservoir for 2012/13

6 ANALYSIS AND RESULTS

6.1 Irrigation Water Requirement

In this study, one of the objectives is to compare guideline based water demand in the Rajangana LB main canal of Irrigation scheme with the actual water use. The guideline presently used by the irrigation water managers is that of Ponrajah (1988). Hence, in order to fulfill the objectives; an analysis according to the Technical Guidelines was carried out for the study period. This analysis looks at the computation of irrigation requirement according the guideline recommendations in which the effective rainfall values and the evapotranspiration values were taken from the Tables in Ponrajah (1988). This was used to make a comparison with the water issue plan developed by the IE Rajangana. In this analysis, the actual cultivation area, crop types, and season commencement dates of a given year, are the corresponding values used for computations. In order to fulfill another objective, a comparison is also made between the guideline recommendations and the actual water issues. For this guideline based computation, the actual evaporation and rainfall in the project area and the actual crop type, pattern, extents and dates are used. Collected Field data, field visits and discussions with officials, revealed that the full extent of LB command area is cultivated in both Yala (April - September) and Maha (October - March) seasons.

6.1.1 Crop Evapotranspiration (ETc)

In this study reference evapotranspiration (ET_0) for the study area was computed with the use of Class A Pan Evaporation data of Maha-Illupallama station. The location of this station is approximately 20 Km by air from Rajangana reservoir.

In case of crop factors (K_c), values in the Table 5-16 corresponding to Irrigation Department Technical guideline of (Ponrajah, 1988) and those extracted from FAO No-24 report were used (Table 5-17). It is important to note that the growth periods and crop coefficient values for crops differ from each other. In Maha season (October to March), farmers usually cultivate paddy in the entire command area while in Yala season (April to September) which has less rainfall, the crop types are

varied to match water availability. Inter monsoon (March-April) rain is the primary support for the farmers to carryout initial work for Yala season cultivation. On average during the Yala season an area of 97.5% is cultivated with rice. Only a small extent (2.5% of the cultivation area) is cultivated with OFC (Table 5-14). During field visits farmers mentioned that the preferred paddy variety is the longer duration variety which takes a period of 3.5 months in Maha. In Yala season, it is common to use the shorter variety which last only 3 months. During verification, it was revealed that paddy variety selection has a heavy dependence on the availability of water and the farmers of Rajangana LB had used the shorter variety during the entire study period.

In Rajangana, OFC varieties used by farmers are Ratakaju (Groundnut), Undu (Pulse), Irringu (Corn), Green Gram, Cowpea and Soybean. As indicated previously, Crop coefficient and growth period values were identified from the Irrigation Department guideline and the FAO 24 report.

For all crops other than Corn, irrigation guidelines provide crop growth details for ETc computations. However, for Corn the crop coefficient curve shown in Figure 6.1 was computed utilizing the FAO 24 procedure and with other values reported in literature.

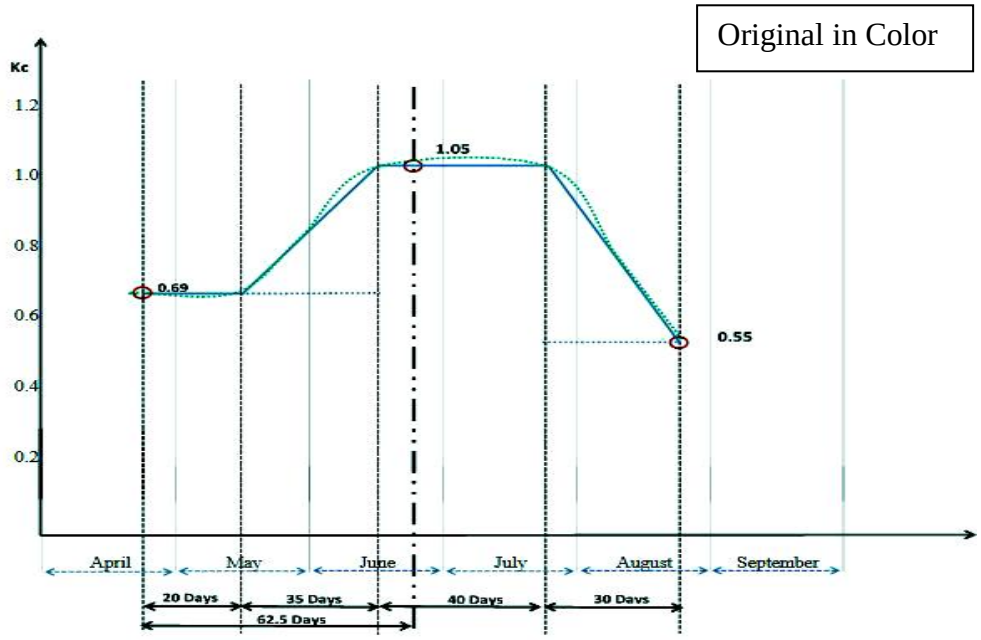

Figure 6.1: Crop coefficient of Corn used for the Analysis

For the average value of Yala evapotranspiration which is 3.36 mm/day, the assumption of needing an irrigation interval of 3-4 days (Ranaweera et al., 2002), resulted the Kc value of 0.69 for the initial crop growth stage. There are different types of corn growth stages mentioned in literature, but growth stages of Indian grown Corn having the 20/35/40/30 day distribution (Doorenbos and Pruitt, 1977) was assumed as the condition which is similar to Sri Lanka. Ranaweera et al. (2002) indicated a good match of Sri Lankan corn with that of Indian corn and this enabled the computation of K_c values for mid-season and harvesting. The computation resulted in values 1.05 and 0.55 respectively for mid seasonal harvesting. Final crop coefficient curve was developed by plotting these values and then carrying out interpolations.

In the project area, an average temperature is 29°C and temperature rises up to 34°C. In the coldest month January, temperature is within the range of 14°C to 17°C. Average annual rainfall is within 1230mm (WWO, 2014) and planting season of corn in this area is in Yala. Accordingly, the Crop coefficients for corn were taken on 0.69, 0.87, 1.05 and 0.8 for the initial stage of 20 days, Crop Development stage of 35 days, Mid-Season period of 40 days, and the 30 days late stage respectively.

6.1.2 Selection of stagger

Practice in many irrigation schemes is to utilize a stagger to optimize the canal capacities and manage the machine power requirements for farming. This has been mentioned in the ID guidelines as, "For management of the overloading condition of the canal and to manage machines and draft power, stagger is recommended as equal or unequal stagger of total extent of cultivation" (Ponrajah, 1988). However the present practice of Rajangana Irrigation System does not incorporate a stagger. The sufficiency of water and carrying capacity in canals to cater the entire system at once are the reasons cited for the lack of a stagger. Therefore computations in the present research did not use a stagger when computing the irrigation requirement.

6.1.3 Land preparation water requirement

According to the Irrigation Department, information for land preparation work given in the ID guidelines are generally used for the irrigation system planning and design in Sri Lanka, In Rajangana, reddish brown earth (RBE) soils are found in upland and low humic gleys (LHG) are prevalent in the low land area (WMS, 1982). Based on Irrigation Department Guidelines (Ponrajah 1981), water depth of 7 inch for land preparation and a duration of 15 days were adopted for weekly water requirement computations in the case of lowland paddy cultivation.

At Rajangana, rainfall is a major factor for land preparation work in Yala season during which OFC crops are also cultivated. During discussions, the staff of Rajangana ID indicated that the field practices demonstrated an usual land preparation time of about one week and a cultivation pattern similar to upland farming. In case of upland farming soil saturation is not practiced.

The Irrigation Guideline is focused on paddy cultivation. Information available on OFC does not enable a reasonable comparison with paddy. In the case of OFC, grown in upland area a 1.5 inch (38 mm) water depth has been recommended for land preparation to be issued within 15 day duration. According to Irrigation Department guidelines, upland cultivation requires water only for tillage and the indicated period is 4.27 days. A land preparation water quantity of 38 mm in one week was taken as the guideline recommended amount for OFC cultivation in uplands.

6.1.3.1 Farm loss

In case of farm loss, Irrigation Department Guideline (Ponrajah, 1988) has recommended quantities of 4 inches (101.6 mm) and 6 inches (152.4mm) for Maha and Yala respectively. Guidelines do not provide direct information to determine the farm loss in case of OFC crops. Values corresponding to farm loss for OFC could not be found for work done elsewhere in the world.

In the present work, Farm loss for OFC crops were based on several assumptions. In Sri Lanka, basin irrigation is used for paddy cultivation. Once a basin is sufficiently wet, the remaining water is drained to fulfill the soil water deficit in the next basin.

This practice which is commonly used for rice, arranges basins to closely follow contours. In the Basin irrigation practice, farm loss generally occurs due to the deep percolation and runoff losses. Paddy fields of HsuehChia Experimental Station of Taiwan had recorded deep percolation values of 295mm and 273mm for first and second rice crop cultivations respectively (Kuo, Ho& Liu. 2005). Naderi et al. (2013) found that in Iran a wheat farm had an average deep percolation and runoff loss amounting to 52.9% and 6.7% of the total applied respectively. These evidences show that the surface irrigation has a high deep percolation loss. Surface Irrigation has a 40%-60% application efficiency in basin irrigation while, field and drip irrigation demonstrate a higher application efficiency between 80% to 95% (Irmaket al., 2011). In practice, low flow rate methods such as micro Irrigation techniques, small pipe irrigation and small ditch irrigation etc., are generally used for OFC cultivation. During the Yala OFC cultivation where the water is scarce, it can be safely assumed that the runoff losses are very low when compared with Paddy. Reported values mention that the losses in case of micro irrigation are in the range of 5%-20% while, in the case of basin irrigation the same would be around 40%-60%. As such average farm loss in micro irrigation is approximately 25% of basin irrigation. Therefore a value of 38mm which is 25% of 152 mm was considered as the farm loss for OFC.

6.1.3.2 Effective rainfall

Effective rainfall computations were carried out using the empirical equations recommended by Irrigation department guidelines. To compare the water plans of the Rajangana ID and the Guideline Recommendations, computations were carried out with the use of 75% probable rainfall of the DL1 agro ecological region given in the ID guideline. Effective rainfall values of each year using 75% probable values of ID guideline are shown in the Figure 6.2. As the computations were carried out at a weekly temporal resolution, the ID guideline recommended monthly empirical equation was proportionately converted to compute weekly effective rainfall values. To compare actual water issue with the guideline recommendation, effective rainfall values for each year were computed using actual values of rainfall recorded at Rajangana for the period 2002 - 2013.

Weekly effective rainfall experienced at Rajangana was computed using observed rainfall values are shown in the

Table 6-1 and in Figure 6.4 to Figure 6.8. Average weekly effective rainfall experienced at Rajangana gauging station is shown in Figure 6.3.

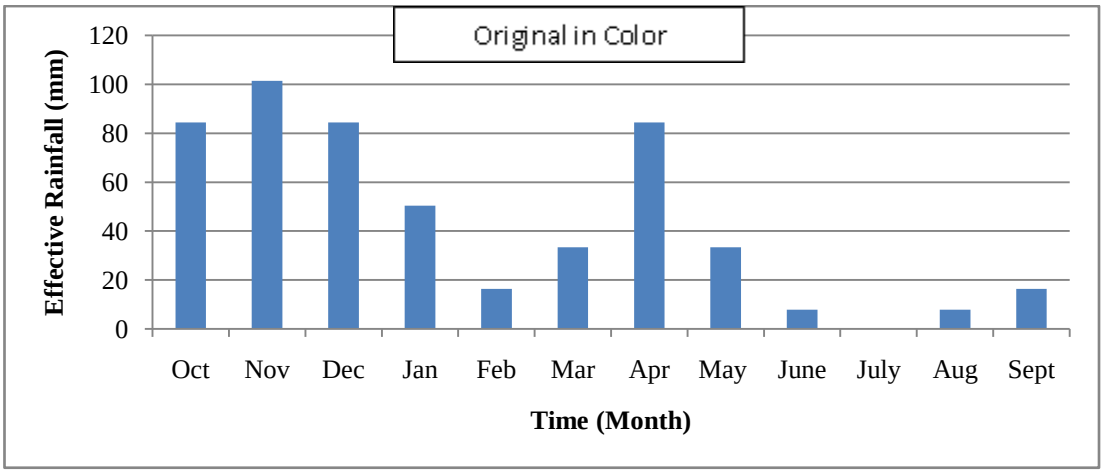

Figure 6.2: Effective Rainfall Computed according to ID Guidelines and using 75% Probable Rainfall of DL1.

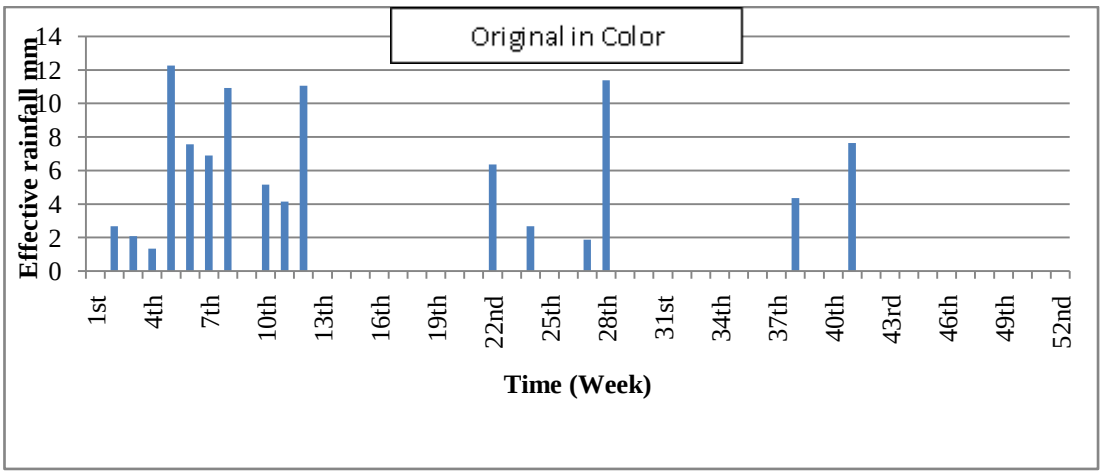

Figure 6.3: Average Weekly Effective Rainfall for Rajangana Computed with Rainfall Experienced at Rajangana (2002/03-2012/13)

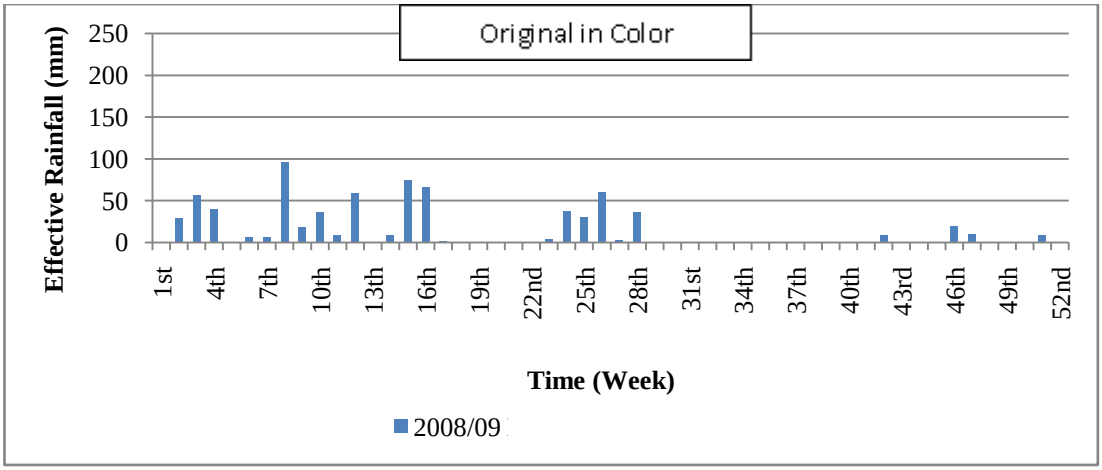

Figure 6.4: Effective Rainfall Computed with Actual Rain (2008/09)

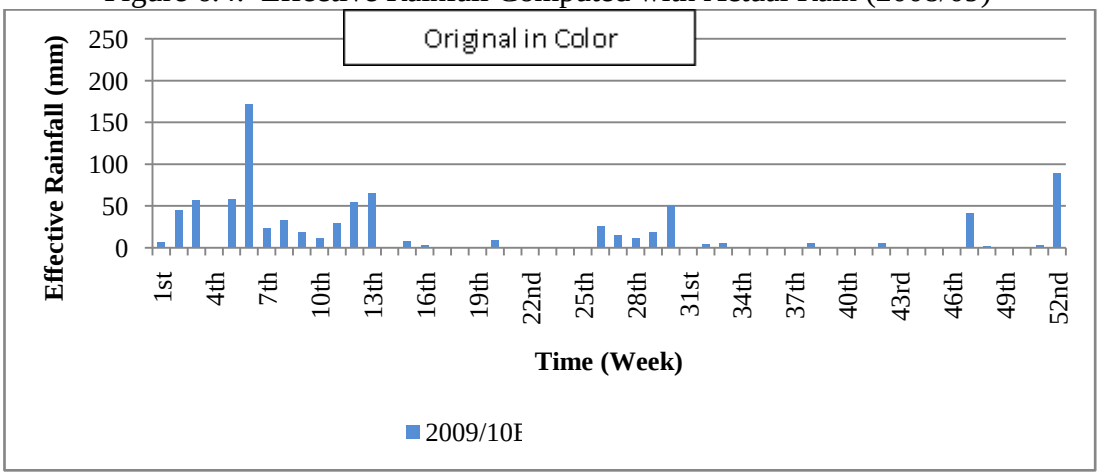

Figure 6.5: Effective Rainfall Computed with Actual Rain (2009/10)

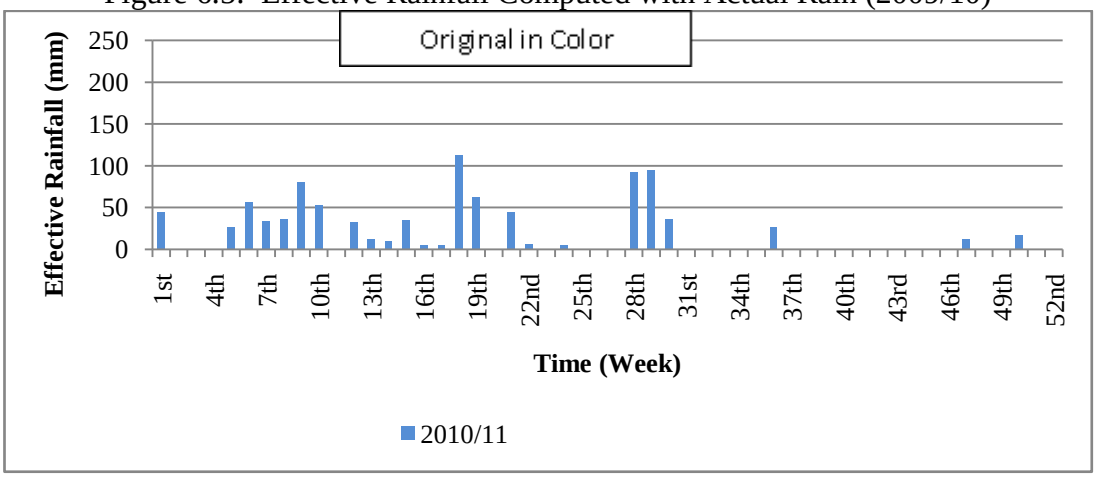

Figure 6.6: Effective Rainfall Computed with Actual Rain (2010/11)

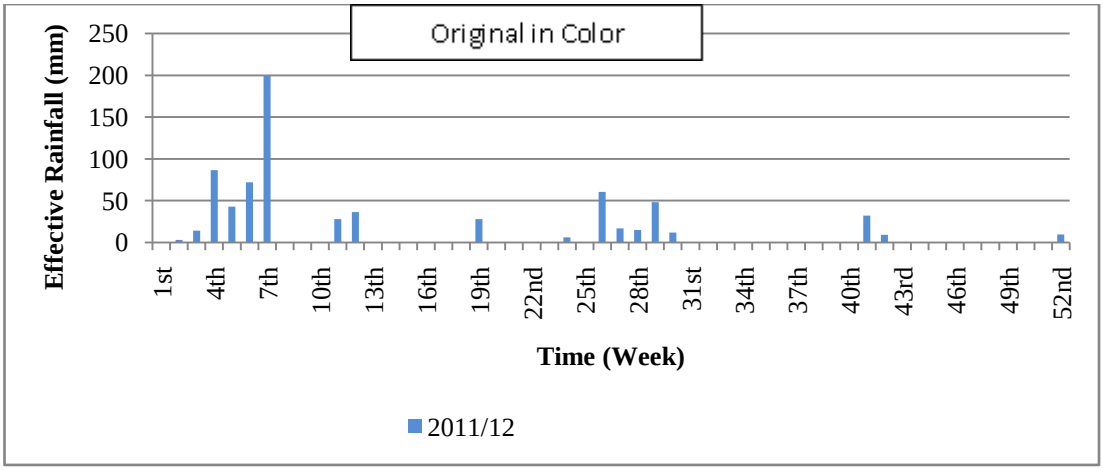

Figure 6.7: Effective Rainfall Computed with Actual Rain (2011/12)

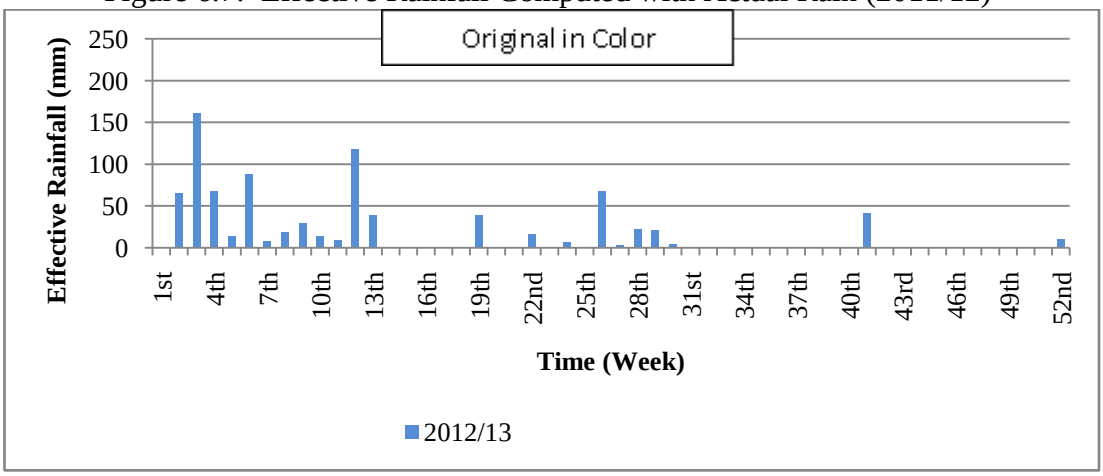

Figure 6.8: Effective Rainfall Computed with Actual Rain (2012/13)

Table 6-1: Comparison of Monthly Effective Rainfall Computed with 75% Probable Rainfall and Actual Rainfall (2002/03-2012/13)

Effective Rainfall (mm)	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept
75% Probable Rain (ID Guideline)	84	101	84	50	16	33	84	33	8	0	8	16
Actual Rainfall of Rajangana	108	97	80	10	5	25	49	0	0	0	0	4

6.1.3.3 Canal efficiency

Irrigation demand values at the headworks were computed with the application of canal conveyance efficiency to canals on the field irrigation requirement. In the

present work, computations were carried out with an overall canal conveyance efficiency of 70% (covering the network of primary, secondary and tertiary canals) as recommended by Ponrajah (1980).

6.1.3.4 Gravity flow system

Remaining quantity of water in the LB Canal after deducting the quantity extracted for Lift Irrigation is the water transferred to the gravity irrigation system. The present study evaluated the behavior of gravity flow system. Therefore the total quantity of gravity flow was computed with the use of water release data and the pumped water quantities in each year. Results for all years showing the components are shown in Figure 6.9 to Figure 6.13 and weekly value Tables are given in the Appendix 2. Gravity flow quantities in each year are in the Table 6-2 and Table 6-3. Comparison of pumped water and the total water releases indicate that in general pumped water quantity varies from 0.14% - 0.36% per week. In order to present all the values in a comparative graphic the logarithmic plots are used.

Table 6-2: Net Water Issue for Gravity Flow System in Maha (MCM)

Water Year	**Water Issue for Gravity Flow System in Maha Season (MCM/Month)**					
	October	November	December	January	February	March
2008/09	15.47	9.58	10.40	13.67	6.68	6.97
2009/10	0.01	7.07	13.54	14.24	14.01	9.34
2010/11	0.00	12.01	9.77	10.80	10.68	5.34
2011/12	0.08	9.98	11.77	16.84	15.34	6.43
2012/13	1.09	14.44	9.24	14.23	13.71	2.35

Table 6-3: Net Water Issue for Gravity Flow System in Yala (MCM)

Water Year	**Water Issue for Gravity Flow System in Yala Season (MCM/Month)**					
	April	May	June	July	August	September

2008/09	18.15	13.47	11.10	10.61	0.46	0.00
2009/10	8.01	8.26	10.49	10.22	2.93	0.00
2010/11	11.17	17.95	12.96	14.64	7.93	0.62
2011/12	12.03	18.86	11.26	11.26	8.76	1.00
2012/13	20.35	15.51	17.49	17.14	5.25	2.65

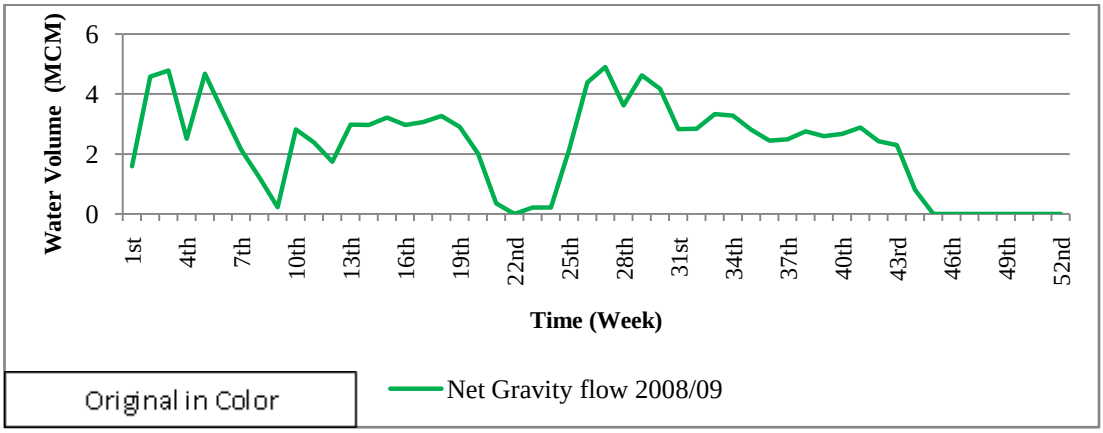

Figure 6.9: Water Used for Gravity Irrigation and Lift Irrigation at Rajangana 2008/09

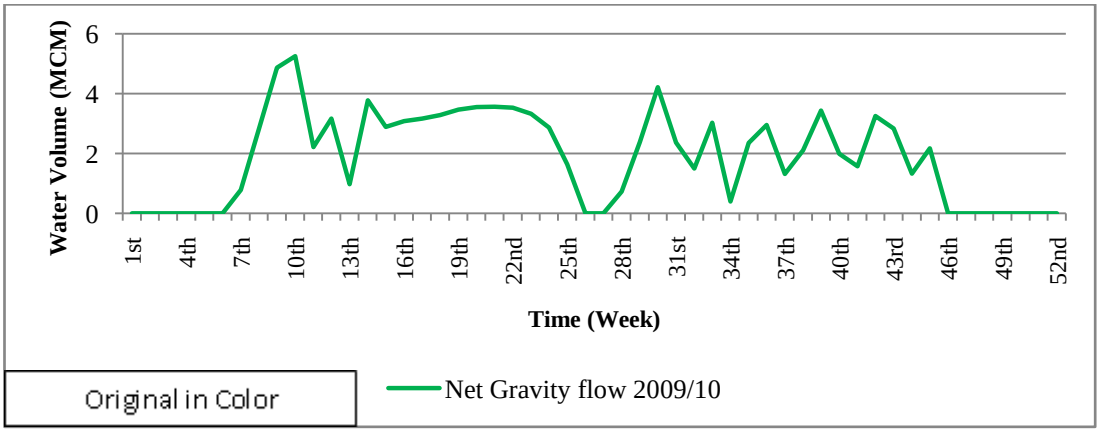

Figure 6.10: Water Used for Gravity Irrigation and Lift Irrigation at Rajangana 2009/10

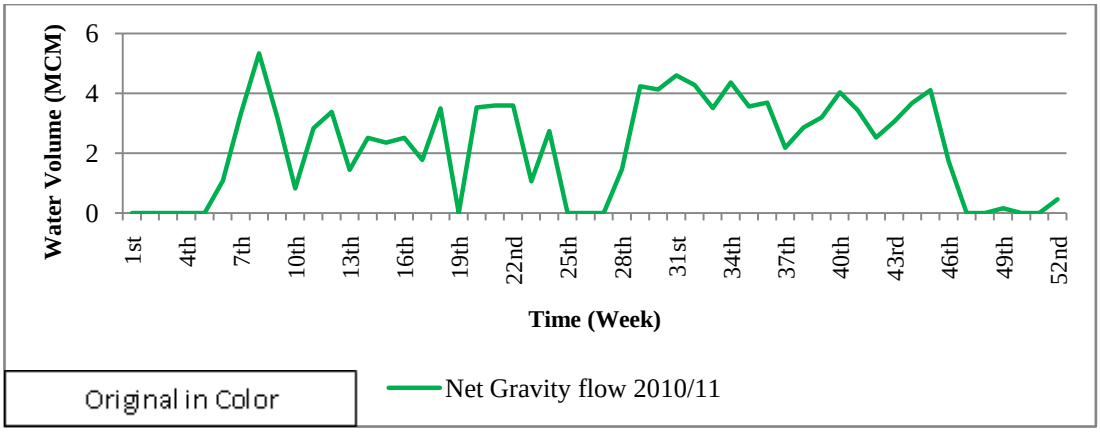

Figure 6.11: Water Used for Gravity Irrigation and Lift Irrigation at Rajangana 2010/11

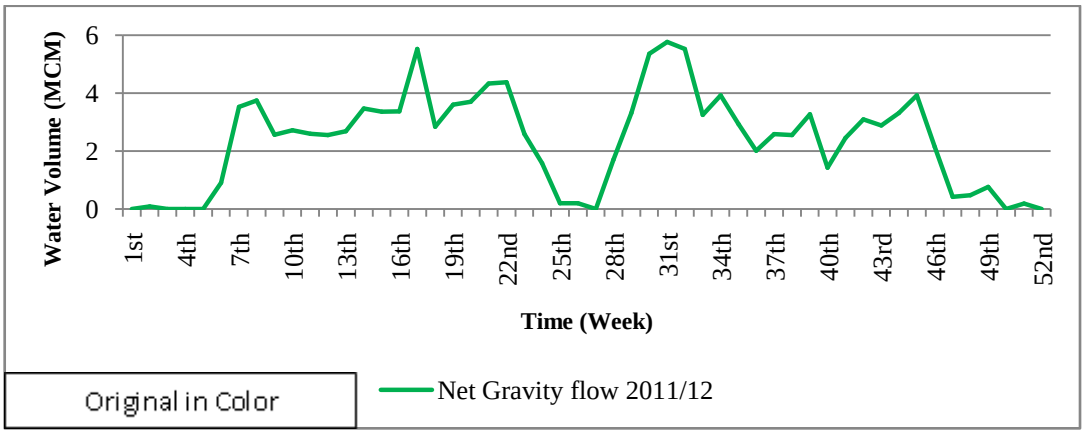

Figure 6.12: Water Used for Gravity Irrigation and Lift Irrigation at Rajangana 2011/12

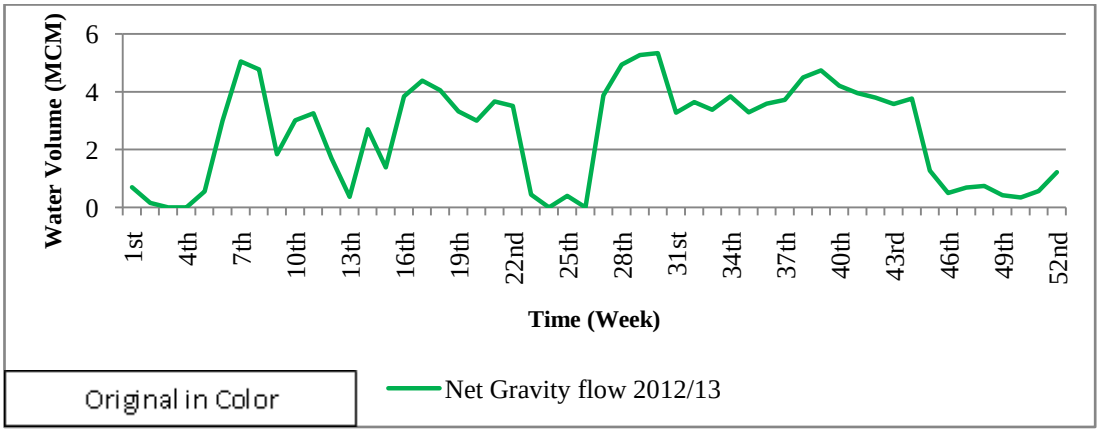

Figure 6.13: Water Used for Gravity Irrigation and Lift Irrigation at Rajangana 2012/13

6.1.4 Irrigation water requirement

LB main canal of the Rajangana irrigation scheme consists of two types of water issues. One is for the lift irrigation system and the other is for the gravity irrigation

system. In the case of lift irrigation system, reliable data of crop types, cultivation periods and cultivation extents could not be found. With the availability of water extraction data for the lift irrigation system, Irrigation water requirements in the gravity fed system were computed as previously described. Availability of crop and cultivation data also restricted the comparative evaluation in the present study to the gravity fed irrigation system of the Rajangana LB canal. Computation of irrigation water requirements were done using spreadsheets prepared in line with the ID guideline. A typical format demonstrating the use of Crop Calendar, Crop Coefficients, Crop Evapotranspiration, Land Preparation, Farm Loss, Effective Rainfall, Canal Efficiencies are shown in the Table 6-4. Appendix 9 shows the stepwise computational method used in the study and associated spreadsheets. Computations were done for each crop at each tract and then results were summed to capture the variations at the LB canal level. Availability of actual water issues for the gravity fed irrigation system enabled a comparison.

Table 6-4: Spread Sheet Format for Computation of Irrigation Water Requirement of Paddy Cultivation for Yala Season.

Water Year :2012/13																				
Start time:		29/10/2012	5/11/2012	12/11/2012	19/11/2012	26/11/2012	3/12/2012	10/12/2012	17/12/2012	24/12/2012	31/12/2012	7/1/2013	14/1/2013	21/1/2013	28/1/2013	4/2/2013	11/2/2013	18/2/2013	25/2/2013	4/3/2013	11/3/2013
End Time :		4/11/2012	11/11/2012	18/11/2012	25/11/2012	2/12/2012	9/12/2012	16/12/2012	23/12/2012	30/12/2012	6/1/2013	13/1/2013	20/1/2013	27/1/2013	3/2/2013	10/2/2013	17/2/2013	24/2/2013	3/3/2013	10/3/2013	17/3/2013
Pump Discharge																				
	Season																			
	Week	5th	6th	7th	8th	9th	10th	11th	12th	13th	14th	15th	16th	17th	18th	19th	20th	21st	22nd	23rd	24th
	ET_0	24.78	23.24	23.24	23.24	22.70	21.34	21.34	21.34	21.34	21.69	21.75	21.75	21.75	23.42	25.65	25.65	25.65	27.14	29.13	29.13
	Assuming 1staggers and a 15 day for each section land preparation																				
	Stagger 1		15 days 1		6 20 days Kc=1			30 Days Kc=1.15 2				5 30 Days Kc=1.2 4				3 25 Days Kc=0.9 1					
	Kc	-	-	-	1	1	1	1.15	1.15	1.15	1.15	1.175	1.2	1.2	1.2	1.175	0.9	0.9	0.9	0.9	0
	ET (S_1)	-	23.24	23.24	19.92	26.10	24.54	24.54	24.54	24.54	24.94	25.78	26.09	26.09	28.10	27.48	27.48	23.09	24.43	3.75	
	ET_c	-	23.24	23.24	19.92	26.10	24.54	24.54	24.54	24.54	24.94	25.78	26.09	26.09	28.10	27.48	27.48	23.09	24.43	3.75	
	LP (Land Preparation)	11.87	83.07	83.07																	
	Farm loss	4.90	34.32	34.32	29.42	34.32	34.32	34.32	34.32	34.32	34.32	34.32	34.32	34.32	34.32	34.32	34.32	34.32	34.32	4.90	
	FWR (8+9+10)	16.77	140.63	140.63	49.34	60.42	58.86	58.86	58.86	58.86	59.26	60.11	60.42	60.42	62.42	61.80	61.80	57.41	58.75	8.65	
	ER	-	-	23.67	23.67	22.35	19.06	19.06	19.06	19.06	12.47	11.37	11.37	11.37	8.25	4.10	4.10	4.10	-	-	-
	FIR (FWR-ER)	16.77	140.63	116.96	25.67	38.07	39.80	39.80	39.80	39.80	46.79	48.73	49.04	49.04	54.17	57.71	57.71	53.31	58.75	8.65	-
	ID	23.96	200.90	167.09	36.67	54.39	56.86	56.86	56.86	56.86	66.85	69.62	70.06	70.06	77.39	82.44	82.44	76.16	83.93	12.35	-

Original in Color

6.1.5 Water requirement computations

Irrigation water requirement for each crop was computed on a weekly basis for all Tracts under the LB Main Canal. Total water demands were evaluated by using two methods. One method is to evaluate the planned water quantities at the beginning of each season. The other method is to evaluate the actual water issue with the anticipated water use during the season when actual evaporation and rainfall are taken into consideration.

The two methods in details are as described below,

Method 1: In this Method, the recommended irrigation water in the plan is computed.

Recommended Irrigation Plan (DL1): - This is the water plan that a water manager would prepare prior to a cultivation season. With the availability of Crop type, Cropping Calendar, Extent of Cultivation, a manager would have to estimate the evaporation and rainfall. In this method, for these estimates, Guideline quoted values is utilized. In the Irrigation Department guideline, 75% probable rainfall is given on the basis of agro ecological zones of Sri Lanka. Rajangana reservoir falls in to the agro ecological zone DL1. Hence the method 1 is termed as "Recommended Irrigation Plan (DL1). This plan also uses the evaporation values of Kalawewa which are given in the guidelines as the values corresponding to the location closest to Rajangana.

Method 2: This Method computes the anticipated water use.

Anticipated Water Use: - This is a modification of the recommended water issue plan to reflect how the system has performed with the receipt of actual rainfall and evaporation. In other words, a good and efficient irrigation water manager would make attempts to issue more water when the actual rainfall is less than the 75% probable rainfall and vice versa. This method enables the understanding of whether such changes are significant; therefore the anticipated water use which is calculated with historical data, considers the field reality with the knowledge of actual Crop type, Cropping

Calendar, Extent of Cultivation, Rajangana rainfall and Evaporation at Maha Illupallama. Closest location to Rajangana having evaporation data was at Maha-Illupallama.

6.1.6 Recommended irrigation plan (DL1)

Monthly rainfall and evaporation values are given in the Irrigation Department Guideline (Ponarjah, 1988). In the computations, these values were evenly distributed between each week of a given month. Spreadsheets prepared for weekly computations were used to calculate the water volume. Weekly values were then aggregated as monthly values for a comparison with the Rajangana ID Plan which is at a monthly temporal resolution.

Recommended Irrigation plan for paddy and OFC crops, and for both, are shown in the Figure 6.14 to Figure 6.16 and corresponding outputs are in Appendix 4. The comparisons indicate that the order of magnitude of Paddy and OFC are significantly different. Monthly total water issue of Recommended Irrigation Plan (DL1) together with the ID Guideline posed effective rainfall are shown in Figure 6.45, and corresponding outputs are in Appendix 4. Water volumes of Recommended Irrigation Plan (DL1) were calculated (Table 6-5 and Table 6-6). Seasonal water volume according to the Recommended Irrigation Plan (DL1) are in the summarized Table 6-7.

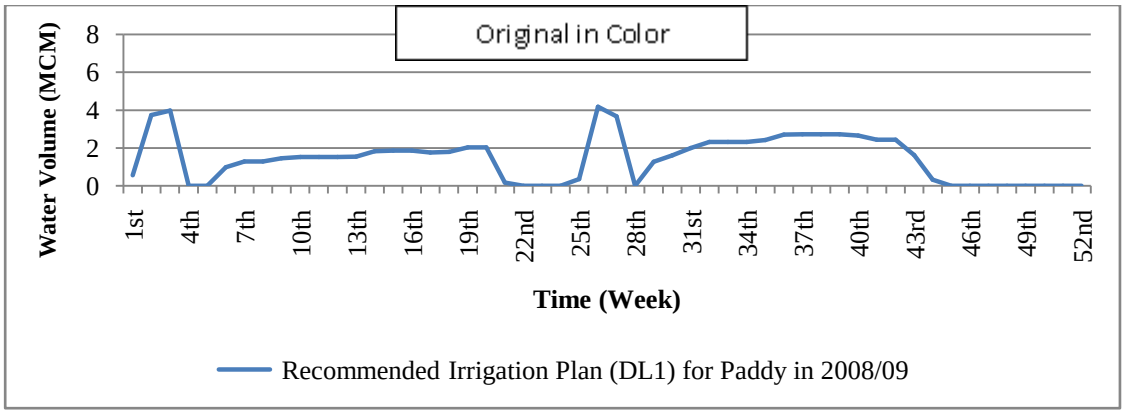

Figure 6.14: Water Volume of Recommended Irrigation Plan (DL1) for Paddy in 2008/09

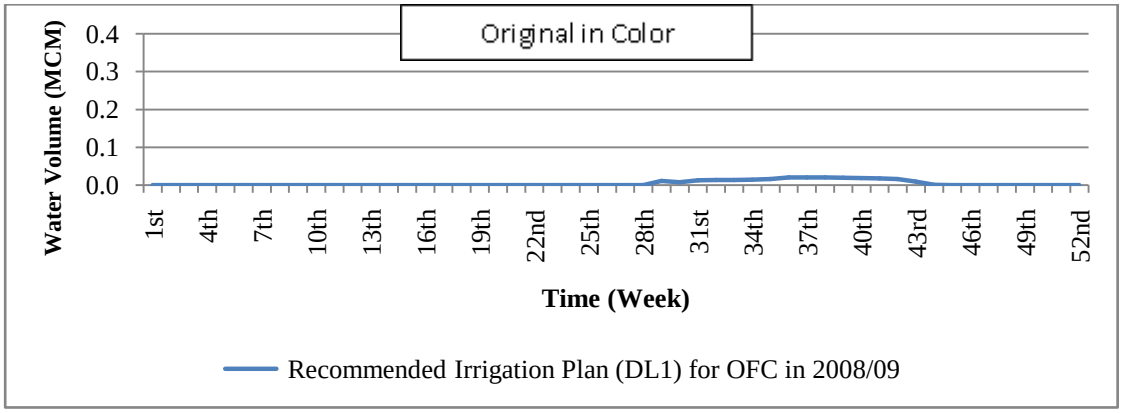

Figure 6.15: Water Volume of Recommended Irrigation Plan (DL1) for OFC in 2008/09

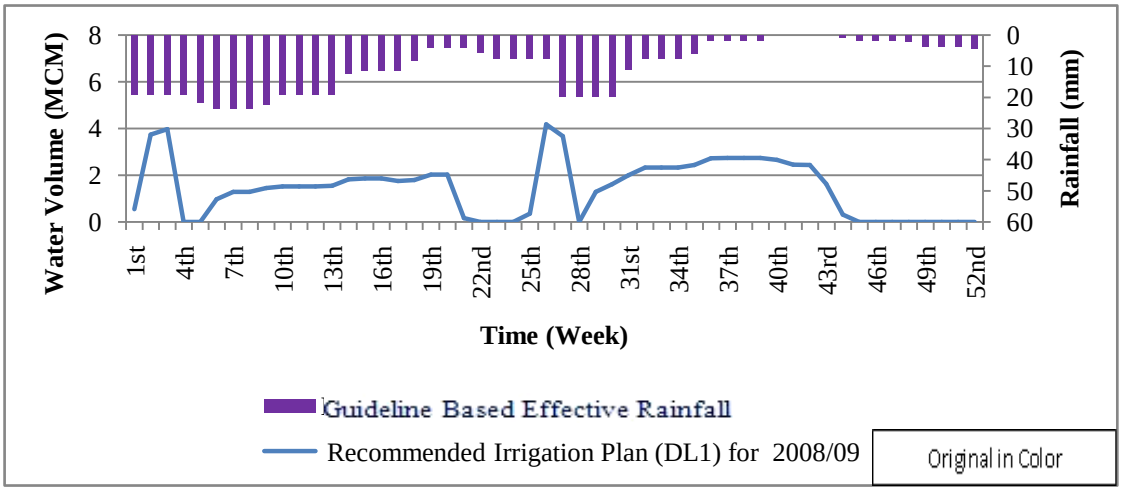

Figure 6.16: Total Water Volume for Recommended Irrigation Plan (DL1) in 2008/09

Table 6-5: Monthly Recommended Irrigation Plan (DL1) in Maha Season

Water Year	Recommended Irrigation Plan (DL1) Water (MCM/Month)					
	October	November	December	January	February	March
2008/09	8.26	4.58	6.75	8.07	4.98	4.53
2009/10	0.00	5.89	6.12	7.88	8.69	5.71
2010/11	0.00	7.73	5.90	7.92	8.45	4.09
2011/12	0.00	7.94	6.01	7.92	8.41	3.77
2012/13	0.26	11.69	6.46	7.97	8.25	1.24

Table 6-6: Monthly Recommended Irrigation Plan (DL1) in Yala Season

Water Year	Recommended Irrigation Plan (DL1) Water (MCM/Month)					
	April	May	June	July	August	September
2008/09	7.14	10.14	11.64	9.30	0.18	0.00
2009/10	8.21	9.20	10.85	9.96	3.18	0.00
2010/11	8.04	8.92	11.06	11.36	4.22	0.00
2011/12	8.54	7.56	11.01	11.67	6.23	0.00
2012/13	8.92	9.44	11.05	11.15	3.90	0.00

Table 6-7: Seasonal Water Volume according to Recommended Irrigation Plan (DL1)

Water Year	Recommended Plan (DL1) (MCM) Difference				
	Maha	Yala	Total	Quantity (MCM)	Difference %
2008/09	32.64	42.92	75.56	10.28	31%
2009/10	34.29	41.39	75.68	7.1	21%
2009/11	34.08	43.61	77.69	9.53	28%
2010/12	34.05	44.99	79.04	10.94	32%
2012/13	35.88	44.44	80.32	8.56	24%
Maximum	35.88	44.99	80.32	10.94	32%
Minimum	32.64	41.39	75.56	7.1	21%
Average	34.19	43.47	77.66	9.28	27%

6.1.7 Anticipated water use

Anticipated water use for the study period considering rainfall experienced at the Rajangana Irrigation Scheme and considering evaporation values of Maha Illupallama period are shown in the Figure 6.17 – Figure 6.31and in Appendix 3. These Figures show the irrigation water requirements for Paddy, OFC and the total for both. Effective rainfall values which are plotted with the total Anticipated Water Use are those computed using observed rainfall measured at Rajangana. Weekly values of effective rainfall and water volume were aggregated as monthly data. Monthly plots

and value tables of anticipated water use are in Appendix 3. Seasonal variations of total Anticipated Water Use are given in the

Table 6-10. Irrigation water requirement per unit command area corresponding to the Anticipated Water Use are given in the Table 6-8 and Table 6-9.

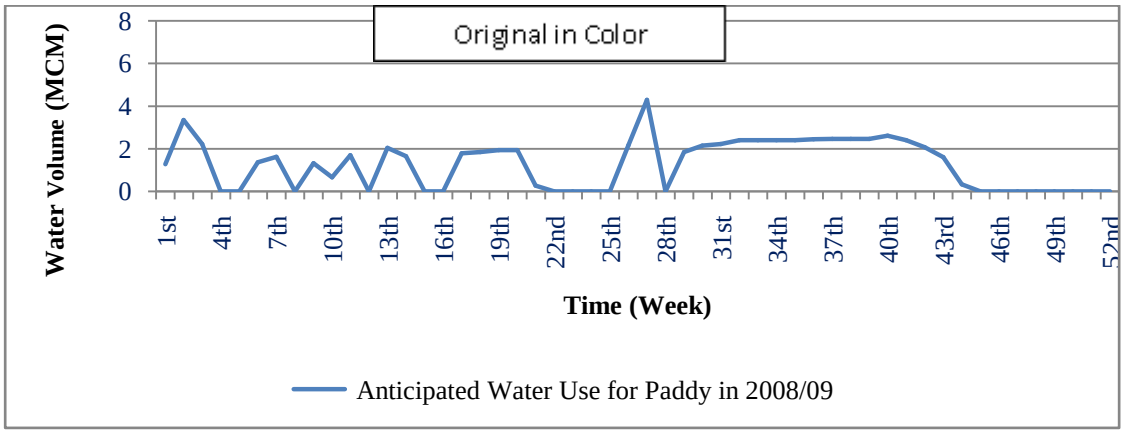

Figure 6.17: Anticipated Water Use for Paddy Cultivation in 2008/09

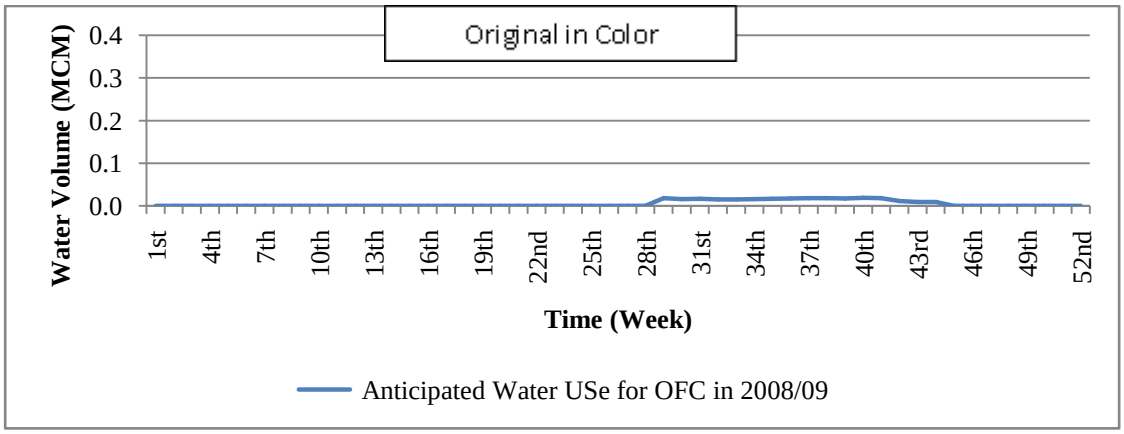

Figure 6.18: Anticipated Water Use for OFC Crop Cultivation in 2008/09

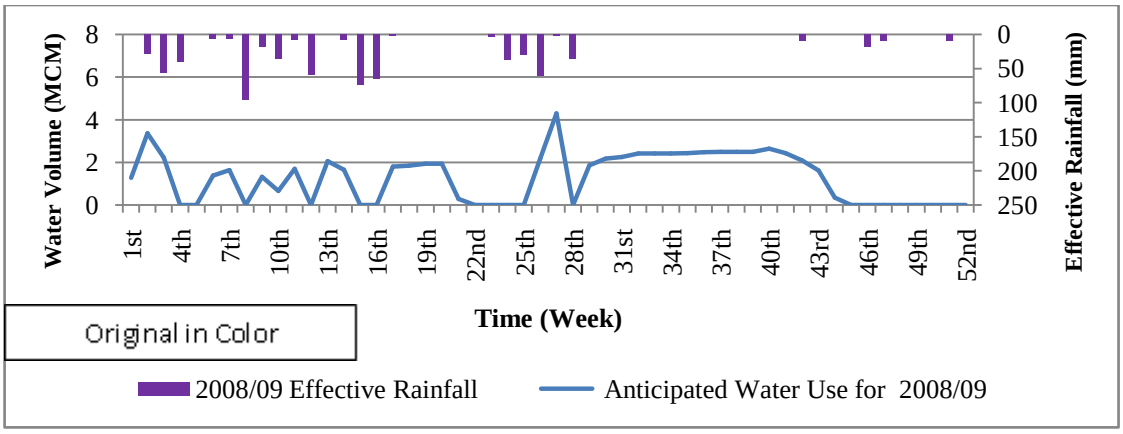

Figure 6.19: Total Anticipated Water Use for Crop Cultivation in 2008/09

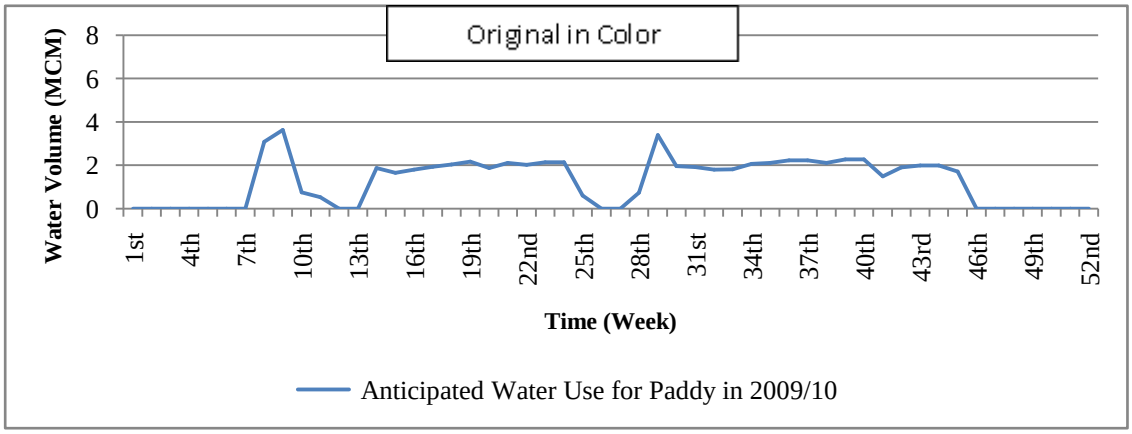

Figure 6.20: Anticipated Water Use for Paddy Cultivation in 2009/10

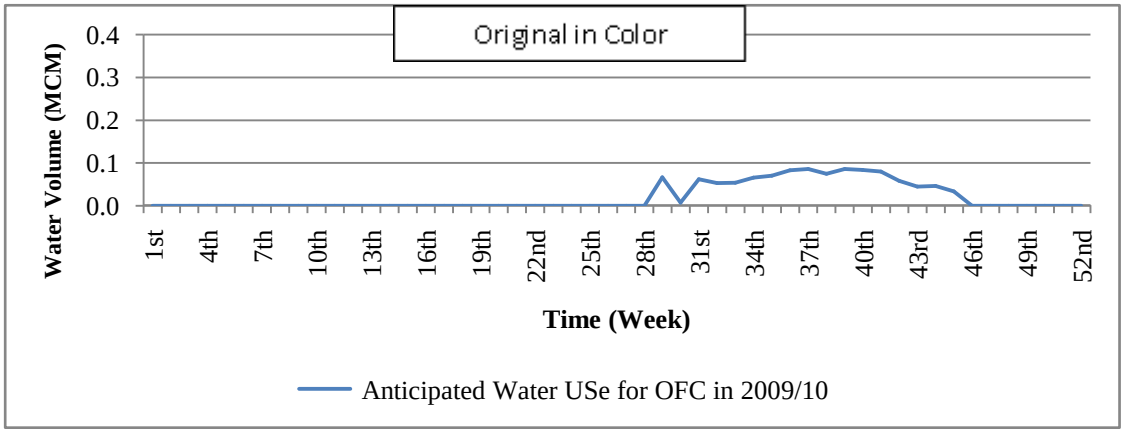

Figure 6.21: Anticipated Water Use for OFC Crop Cultivation in 2009/10

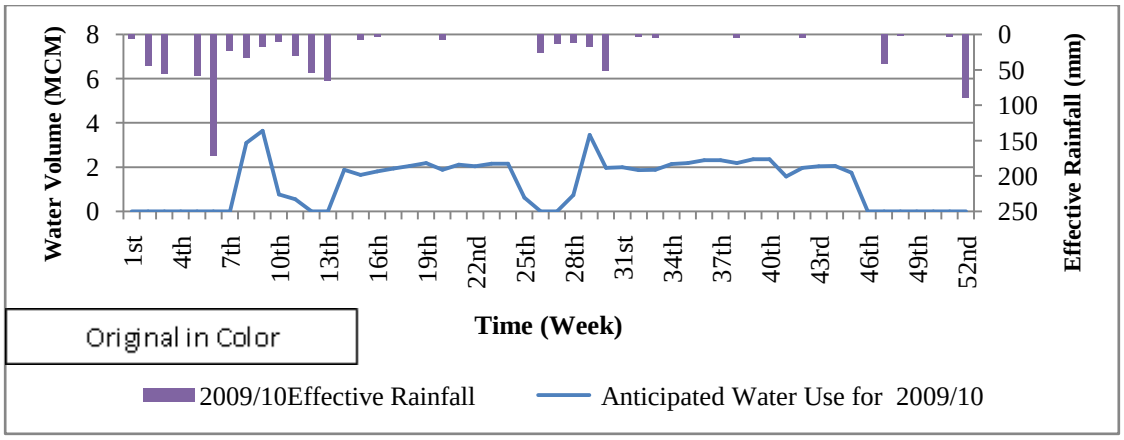

Figure 6.22: Total Anticipated Water Use for Crop Cultivation in 2009/10

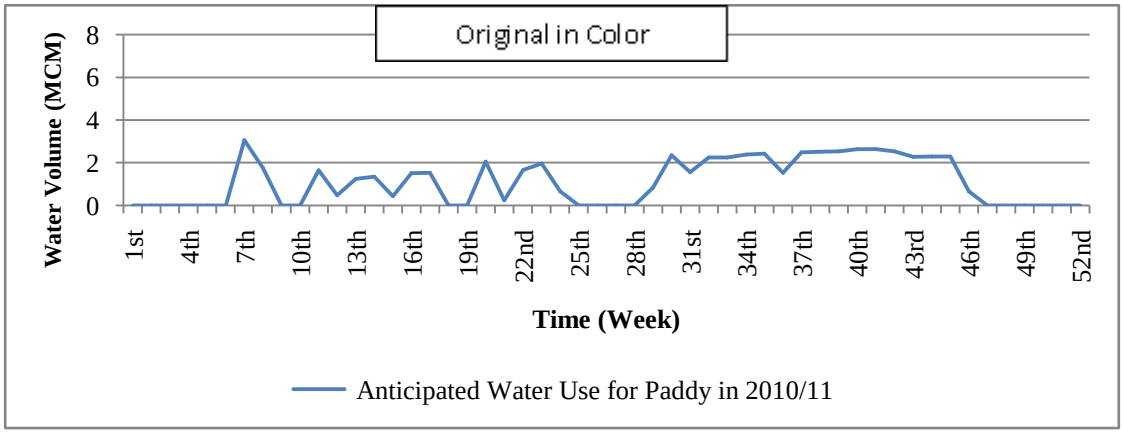

Figure 6.23: Anticipated Water Use for Paddy Cultivation in 2010/11

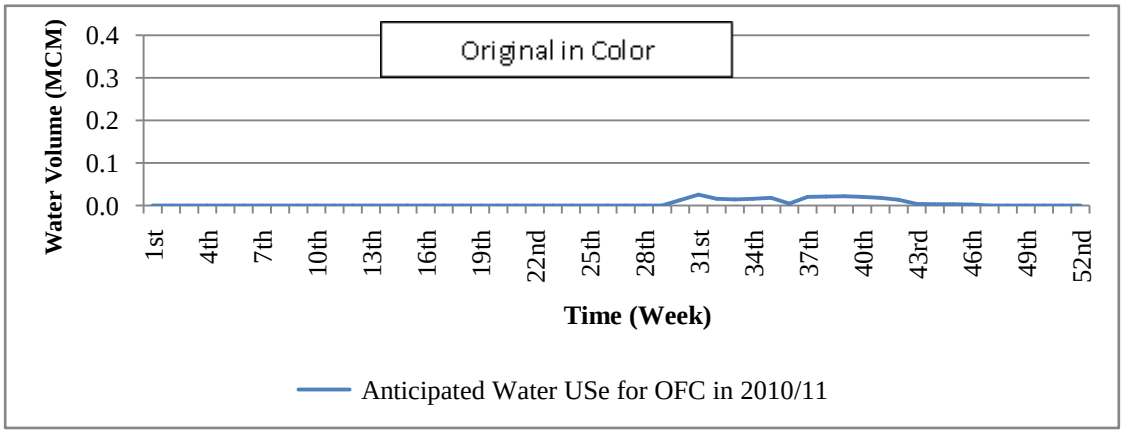

Figure 6.24: Anticipated Water Use for OFC Crop Cultivation in 2010/11

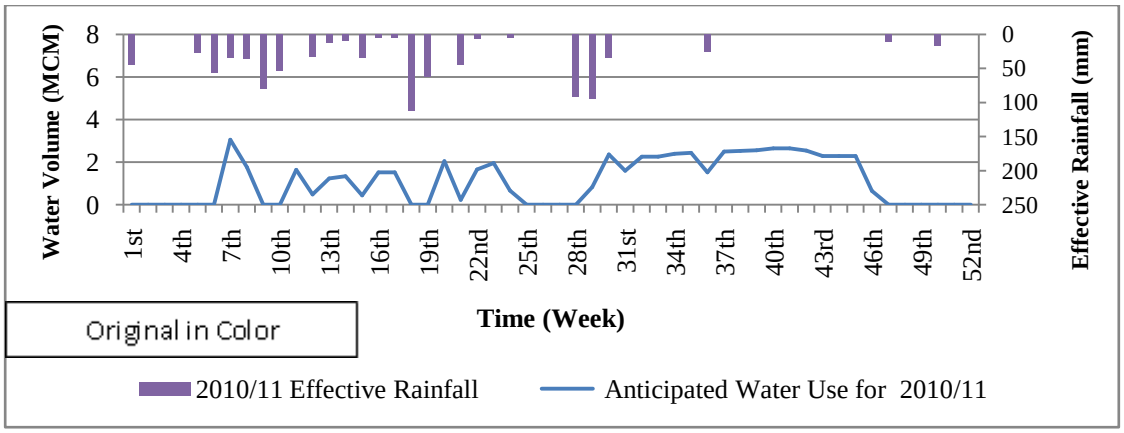

Figure 6.25: Total Anticipated Water Use for Crop Cultivation in 2010/11

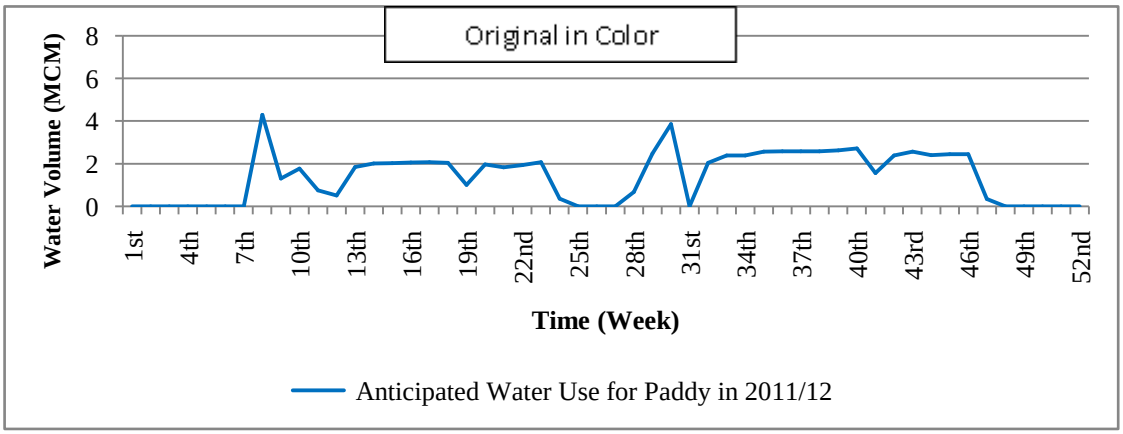

Figure 6.26: Anticipated Water Use for Paddy Cultivation in 2011/12

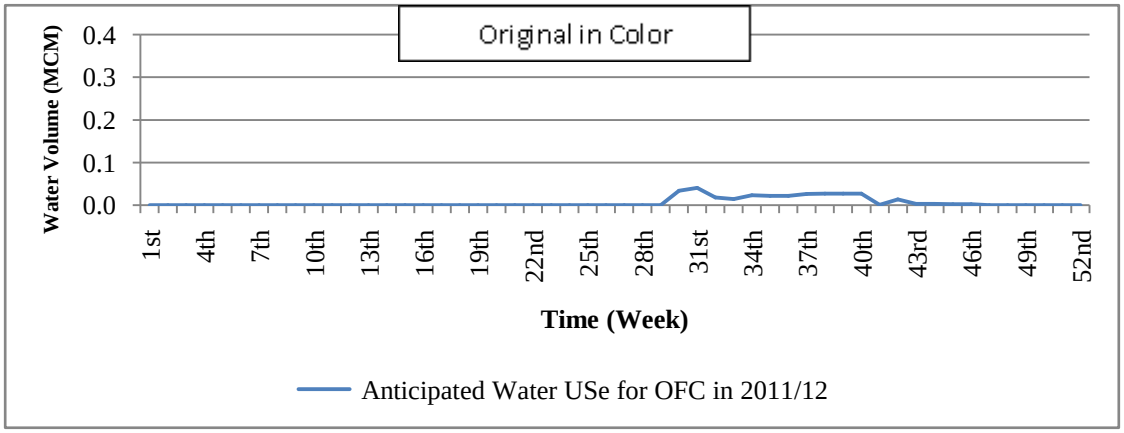

Figure 6.27: Anticipated Water Use for OFC Crop Cultivation in 2011/12

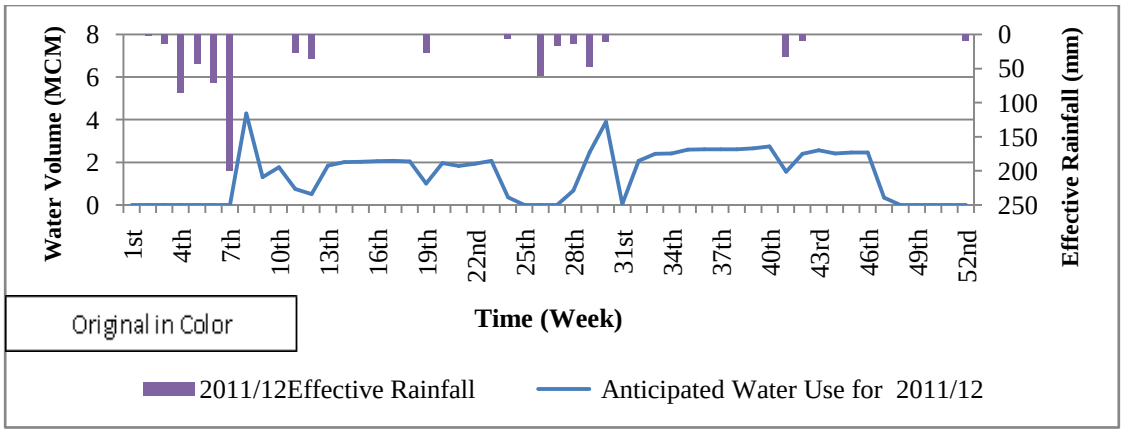

Figure 6.28: Total Anticipated Water Use for Crop Cultivation in 2011/12

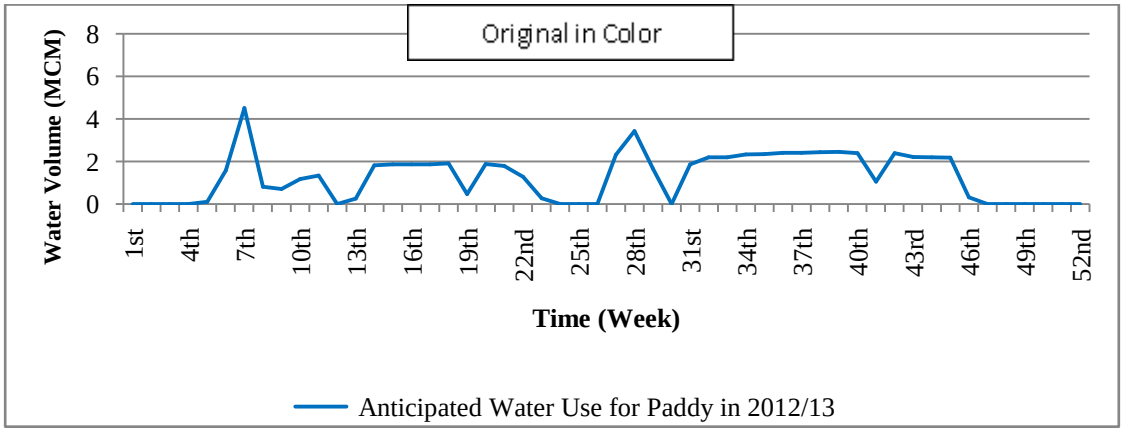

Figure 6.29: Anticipated Water Use for Paddy Cultivation in 2012/13

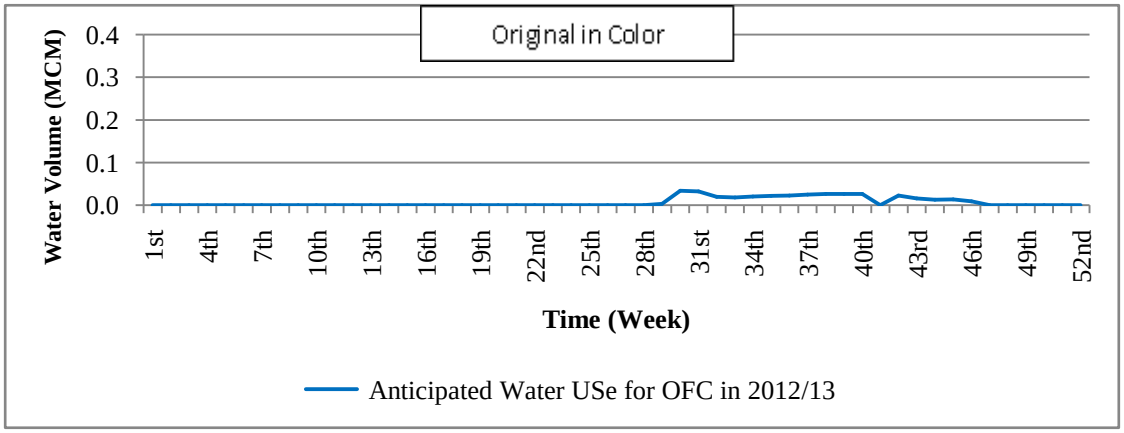

Figure 6.30: Anticipated Water Use for OFC Crop Cultivation in 2012/13

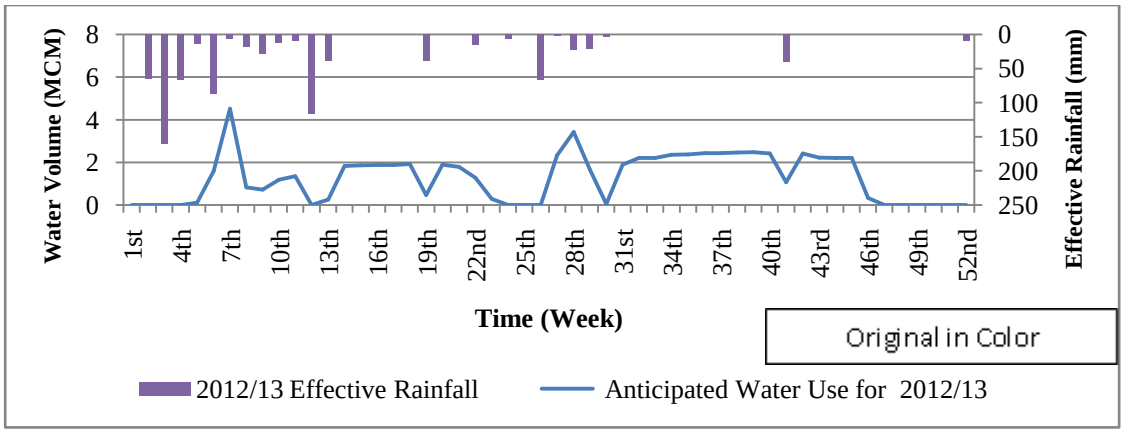

Figure 6.31: Total Anticipated Water Use for Crop Cultivation in 2012/13

Table 6-8: Anticipated Water Use per Month per Unit Area in Maha (m^3/Ha)

Water Year	Anticipated Water Use per Month for Unit Area in Maha (m^3/Ha)					
	October	November	December	January	February	March
2008/09	2673.05	1536.69	1957.32	1664.48	1927.46	842.00
2009/10	0.00	2214.19	1022.14	3190.63	3204.06	2257.70
2010/11	0.00	1877.17	1383.65	1806.35	1258.79	1298.97
2011/12	0.00	2038.23	2168.44	3532.47	2649.63	1272.21
2012/13	17.55	2924.35	1265.63	3227.61	2220.81	323.08

Table 6-9: Anticipated Water Use per Month per Unit Area in Yala (m^3/Ha)

Water Year	Anticipated Water Use per Month for Unit Area in Yala (m^3/Ha)					
	April	May	June	July	August	September
2008/09	3507.83	4129.17	4147.21	3478.05	75.19	0.00
2009/10	2634.43	3447.20	3828.12	3442.22	1138.22	0.00
2010/11	1428.36	3813.08	3834.08	4340.38	1658.73	0.00
2011/12	2757.32	3414.36	4389.15	4022.56	2590.97	0.00
2012/13	3116.84	3828.11	4096.03	3538.28	1475.08	0.00

Table 6-10: Seasonal Variation of Anticipated Water Use from 2008/09 to 2012/13

Year	Anticipated Water Use (MCM)				
	Maha	Yala	Total	Difference MCM	% Difference
2008/09	24.98	41.41	66.39	16.43	66%
2009/10	30.43	37.09	67.52	6.66	22%
2010/11	19.52	38.58	58.10	19.06	98%
2011/12	29.85	43.92	73.77	14.07	47%
2012/13	25.54	41.06	66.6	15.52	61%
Maximum	30.43	43.92	73.77	19.06	98%
Minimum	19.52	37.09	58.10	6.66	22%
Average	26.06	40.41	66.48	14.35	59%

6.1.8 Comparison of Rajangana ID plan and recommended irrigation plan (DL1)

Comparative monthly plots of monthly water quantities corresponding to Rajangana ID plan (RID) and Recommended Irrigation Plan (RIP) and the monthly effective rainfall computed using 75% probable rainfall of DL1 and their values are in Appendix 5. The summery of differences between the Rajangana ID Plan and Recommended Irrigation Plan (DL1) are shown in Table 6-11 and Table 6-12. These graphs demonstrate that irrespective of the season, there is an over estimation in most of the months while in some months especially in Yala season, there is an under estimation when compared with the ID Guideline recommended values. Comparison of the variation of differences over the year, there is a significant deviation in the Yala season and on average the deviation is approximately 2 MCM per month (Figure 6.34, Figure 6.36 and Table 6-12). Annual variations shows a general increase in the recent year except for 2009/10 (Figure 6.35). These differences increase with the rainfall (Figure 6.36).

The water duty comparison for Maha and Yala seasons for these two cases are shown in Figure 6.37 - Figure 6.39 and in Table 6-13. On average water duty estimations in the Rajangana Irrigation Division Plan were 1.83m and 2.13m respectively for Maha and Yala seasons. Same from the Recommended Irrigation Plan were 1.34 m and 1.70m respectively for Maha and Yala seasons (Table 6-13).

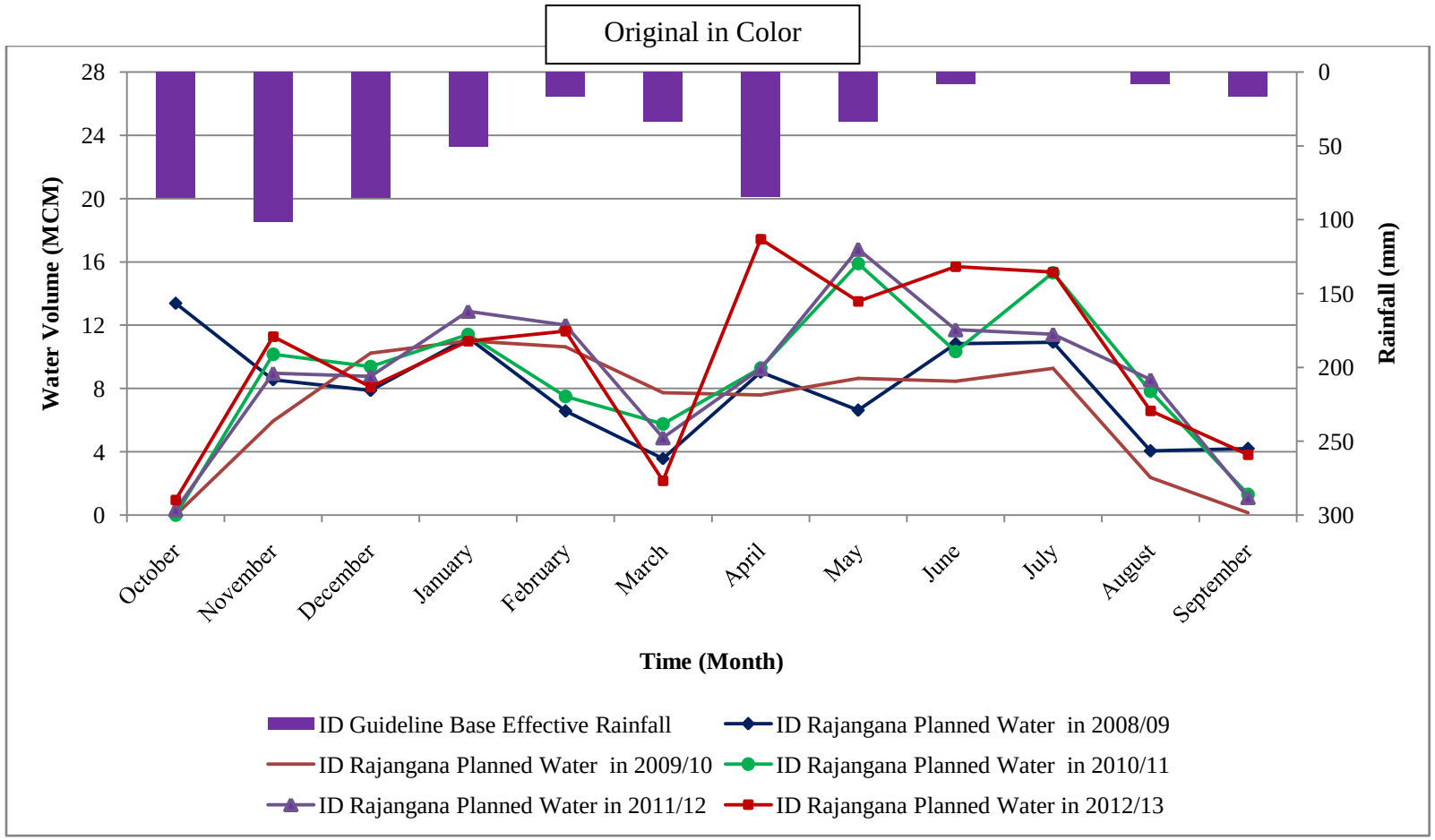

Figure 6.32: Comparison of ID Rajangana Plan from 2008/09-2012/13

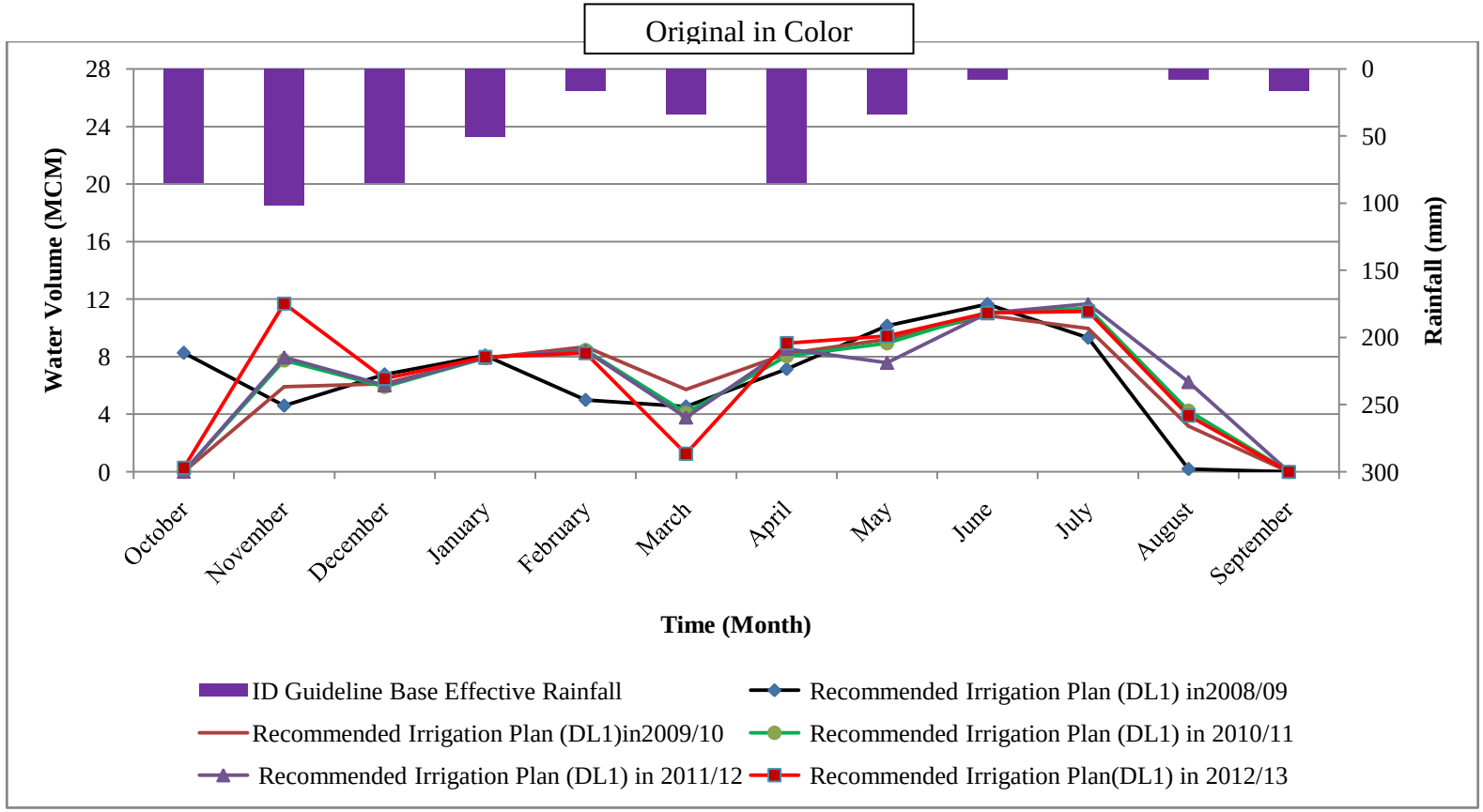

Figure 6.33: Comparison of Recommended Irrigation Plan (DL1) from 2008/09-2012/13

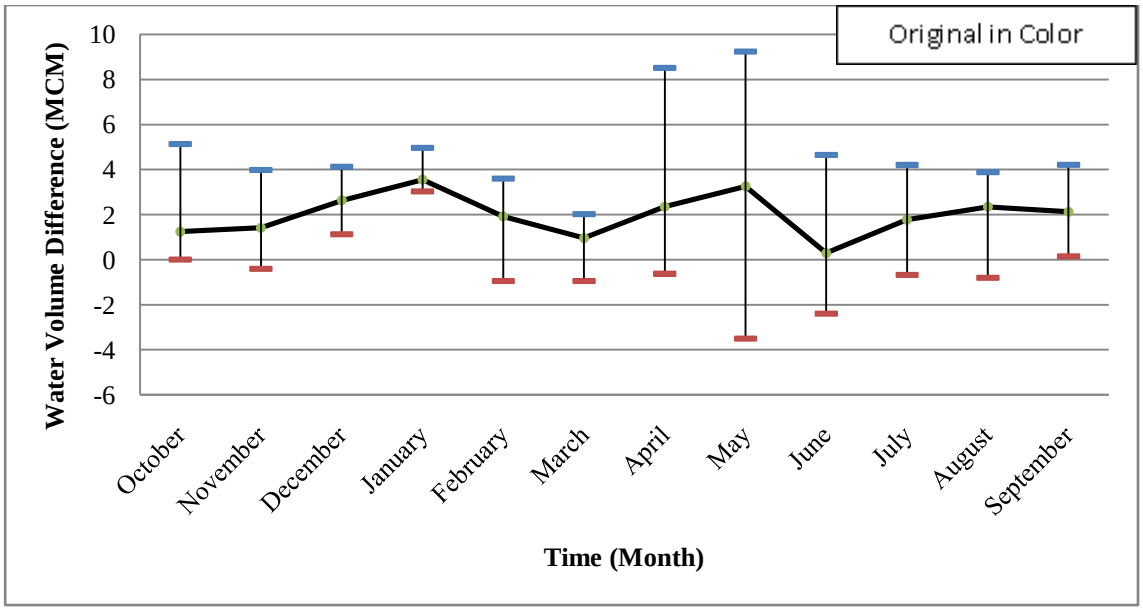

Figure 6.34: Water Volume Differences between Rajangana ID Plan and Recommended Irrigation Plan (DL1)-2008/09 to 2012/13

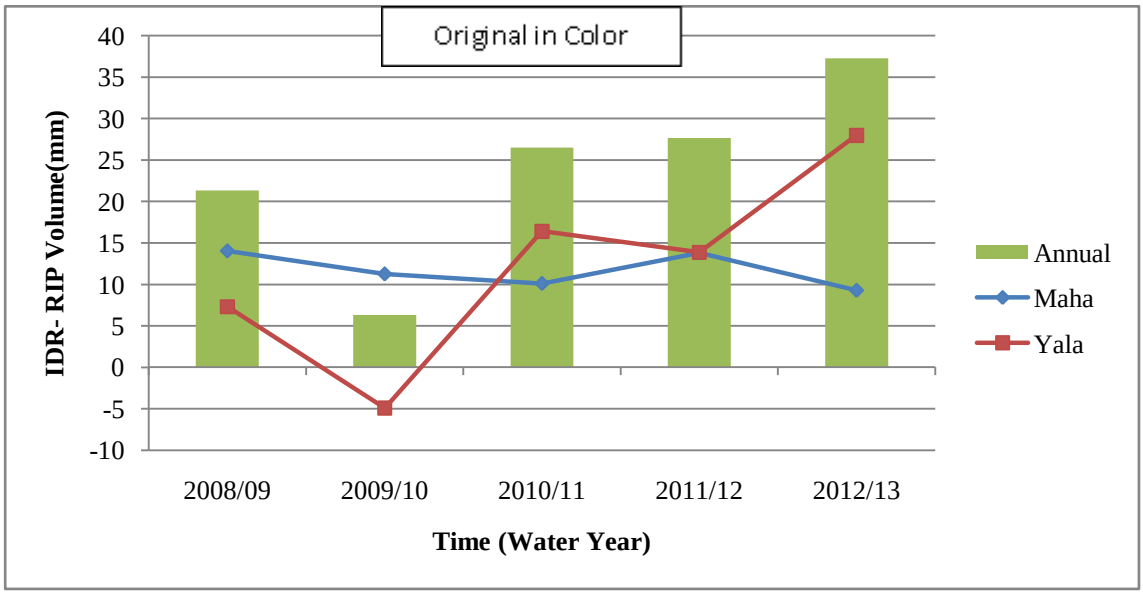

Figure 6.35: Variation of Differences between Rajangana ID Plan and Recommended Irrigation Plan (DL1) both Seasonally and Annually

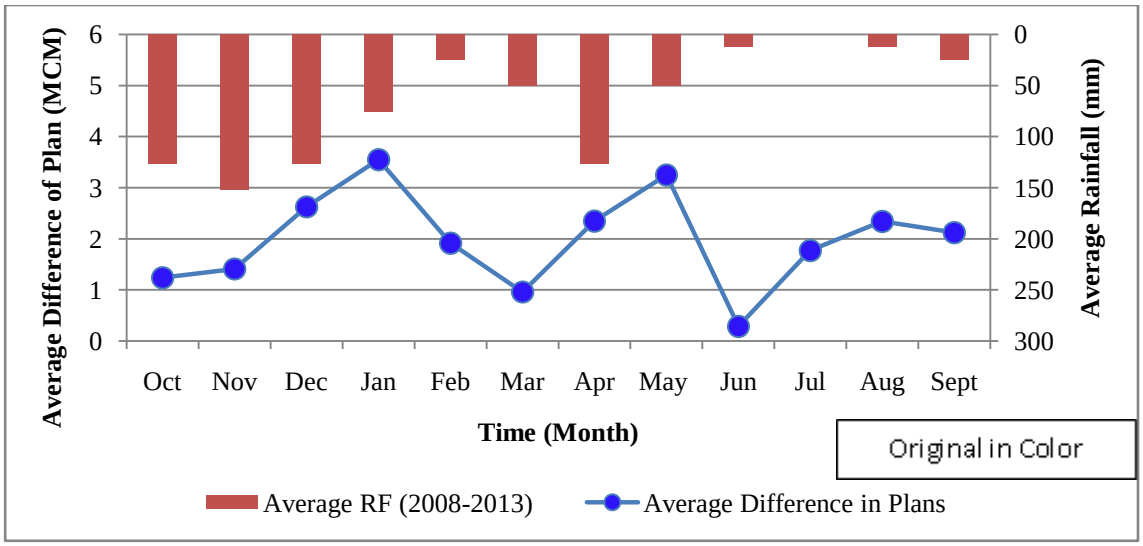

Figure 6.36: Variation of Planning Differences with Corresponding Rainfall at Rajangana

Table 6-11: Differences between ID Rajangana Plan and Recommended Irrigation Plan (DL1) for Maha Season (MCM)

Water Year	RID-RIP in Maha Season (MCM)					
	October	November	December	January	February	March
2008/09	5.13	3.98	1.13	3.14	1.60	-0.95
2009/10	0.00	0.05	4.12	3.13	1.94	2.02
2010/11	0.00	2.42	3.48	3.49	-0.95	1.67
2011/12	0.34	1.01	2.76	4.96	3.60	1.12
2012/13	0.71	-0.41	1.63	3.03	3.38	0.94
Maximum	5.13	3.98	4.12	4.96	3.60	2.02
Minimum	0.00	-0.41	1.13	3.03	-0.95	-0.95
Average	1.23	1.41	2.62	3.55	1.91	0.96

Table 6-12: Differences between ID Rajangana Plan and Recommended Irrigation Plan (DL1) for Yala Season (MCM)

Water Year	**RID-RIP in Yala Season (MCM)**					
	April	May	June	July	August	September
2008/09	1.90	-3.51	-0.81	1.62	3.88	4.21
2009/10	-0.63	-0.55	-2.40	-0.68	-0.81	0.14
2010/11	1.24	6.98	-0.71	3.96	3.61	1.31
2011/12	0.71	9.24	0.71	-0.25	2.34	1.11
2012/13	8.52	4.08	4.65	4.20	2.69	3.83
Maximum	8.52	9.24	4.65	4.20	3.88	4.21
Minimum	-0.63	-3.51	-2.40	-0.68	-0.81	0.14
Average	2.35	3.25	0.29	1.77	2.34	2.12

Table 6-13: Water Duty Comparison of Rajangana ID Plan (RID) and Recommended Irrigation Plan (DL1) (RIP) from 2008/09 to 2012/13

Water Year	Maha Season				Yala Season			
	Water Duty (m)		Difference		Water Duty (m)		Difference	
	ID Rajangana Plan	Recommended Plan (DL1)	Difference Duty(m)	Percentage	ID Rajangana Plan	Recommended Plan (DL1)	Difference Duty(m)	Percentage
2008/09	2.00	1.28	0.72	57%	1.78	1.68	0.10	6%
2009/10	1.78	1.34	0.44	33%	1.42	1.62	-0.20	-12%
2010/11	1.73	1.33	0.40	30%	2.34	1.70	0.64	38%
2011/12	1.87	1.33	0.54	41%	2.3	1.76	0.54	31%
2012/13	1.76	1.40	0.36	26%	2.83	1.74	1.09	63%
Maximum	2.00	1.40	0.72	57%	2.83	1.76	1.09	63%
Minimum	1.73	1.28	0.36	26%	1.42	1.62	-0.20	-12%
Average	1.83	1.34	0.49	37%	2.13	1.70	0.43	25%

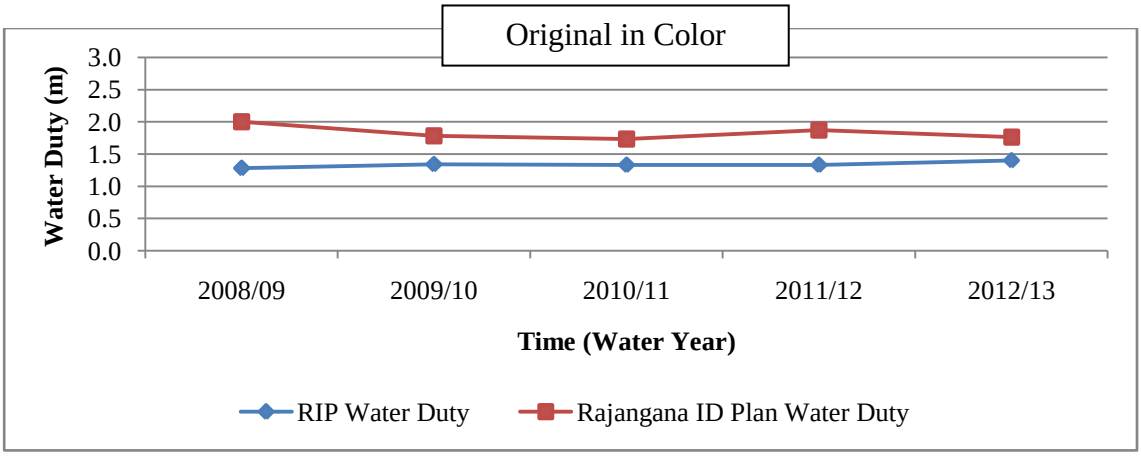

Figure 6.37: Water Duty of ID Rajangana Plan and Recommended Irrigation Plan (DL1) during Maha Season

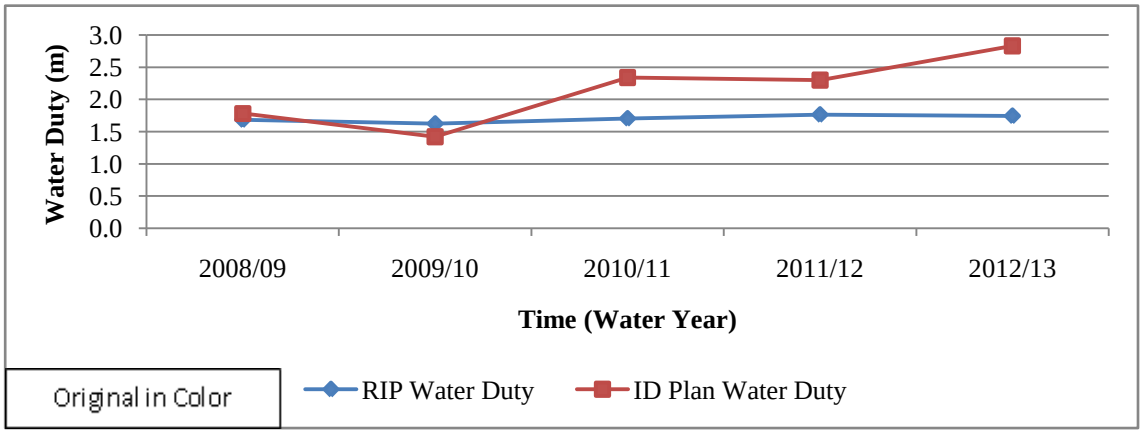

Figure 6.38: Water Duty of ID Rajangana Plan and Recommended Irrigation Plan (DL1) during Yala Season

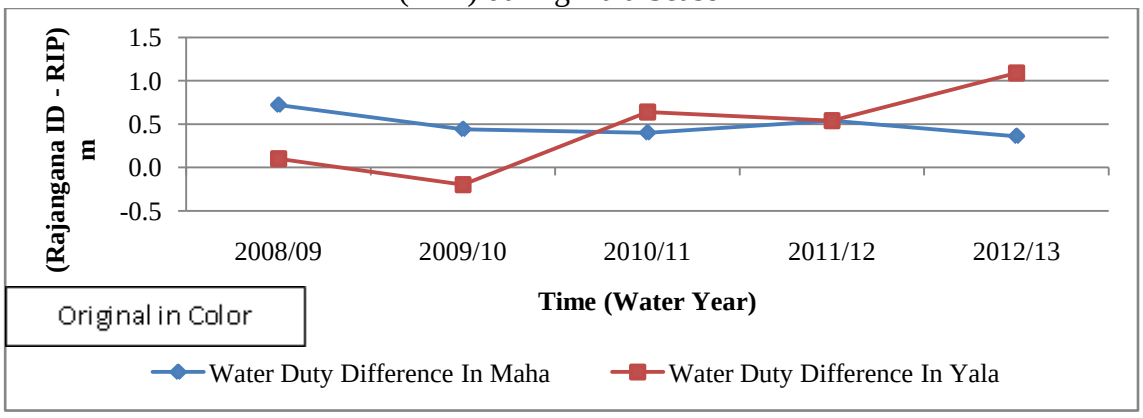

Figure 6.39: Water Duty of ID Rajangana Plan and Recommended Irrigation Plan (DL1) during Yala Season

6.1.9 Comparison of Actual Water Use and Recommended Irrigation Plan (DL1)

Actual weekly water use values of Gravity Irrigation System of L.B. Canal (Figure 6.9 - Figure 6.13 and Table A2.3) were aggregated as monthly and seasonal data in order to carry out a quantitative evaluation. Actual water issues showed that there are water releases even after the cultivation seasons had ended. These water quantities were taken as environmental flow releases. Environmental flow quantities were not separated when seasonal and annual comparisons were done. Water quantities of Rajangana Irrigation Plan, Actual water use, and RIP (DL1) weekly values were plotted on the same graph (Figure A6-1 – Figure A6-5). Monthly Actual Water Use plotted with monthly effective rainfall received at Rajangana are in Figure 6.40 - Figure 6.44. Monthly values of Recommended Irrigation Plan compared with guideline recommended values of effective rainfall for DL1 are shown in Figure 6.45. Values and the differences are shown in Figure 6.46 - Figure 6.51, Table A6-1 - Table A6-9 and Figure A6-6 - Figure A6-8 of the Appendix 6. The water duty comparison for Maha and Yala seasons for these two cases are shown in the Figure 6.52 - Figure 6.54 and in Table A6-10 of Appendix 6. Comparative evaluation of water issues computed for each crop growth stage are given in Figure 6.46 - Figure 6.48 and in Appendix 6. Seasonal and annual variation was found according to the Figure 6.49 - Figure 6.51 and Table A6-8 to Table A6-9 of Appendix 6.

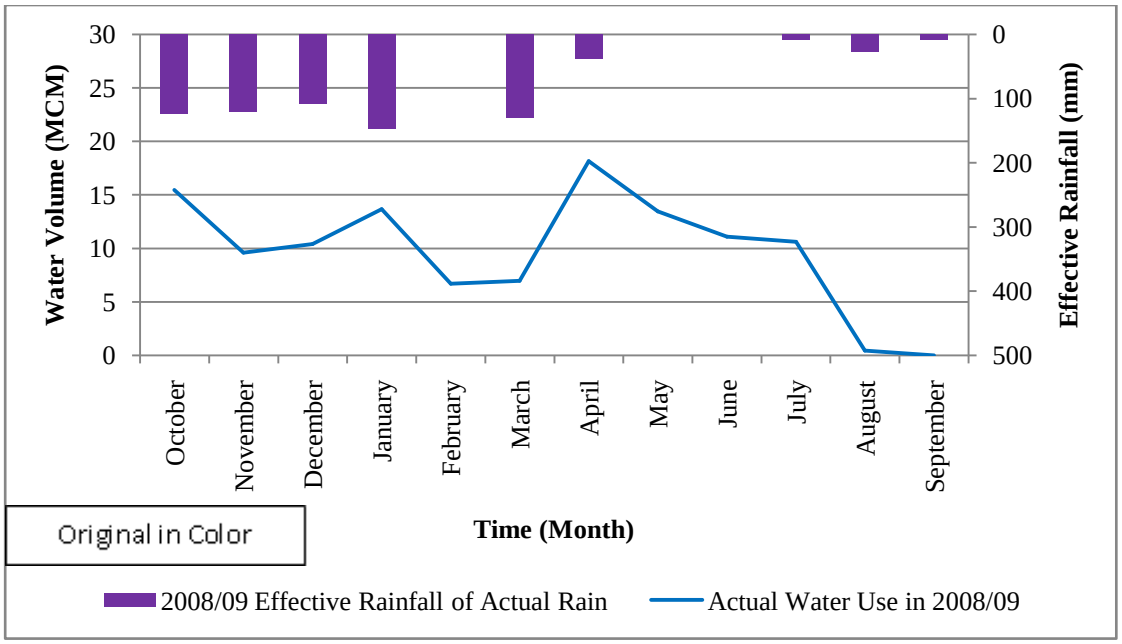

Figure 6.40: Monthly Actual Water Use in 2008/09

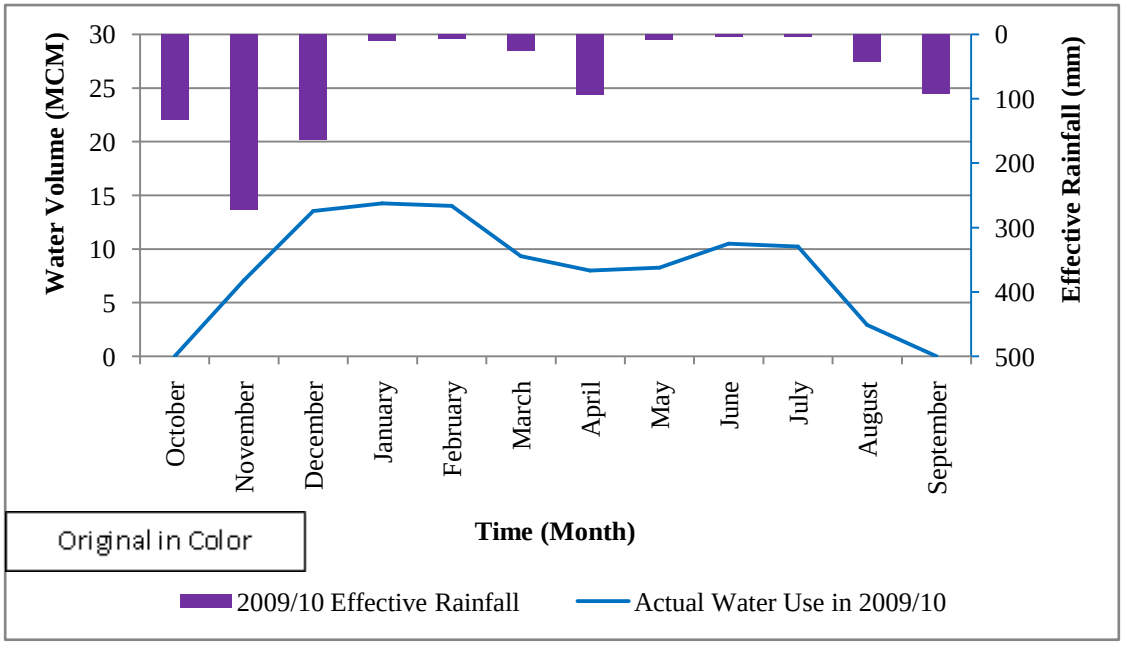

Figure 6.41: Monthly Actual Water Use in 2009/10

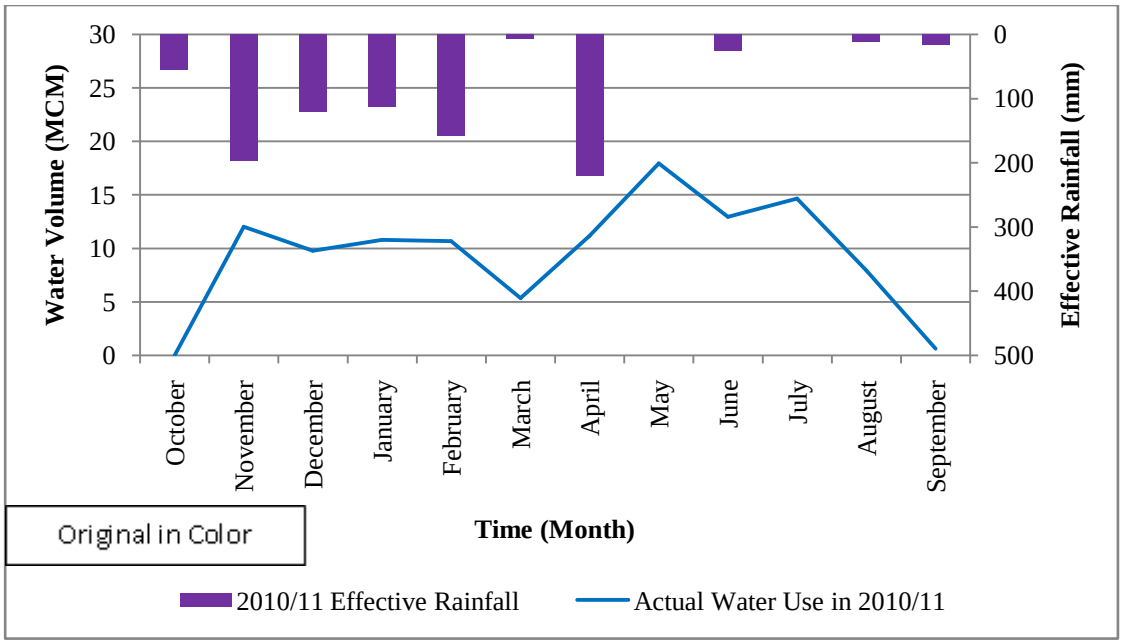

Figure 6.42: Monthly Actual Water Use in 2010/11

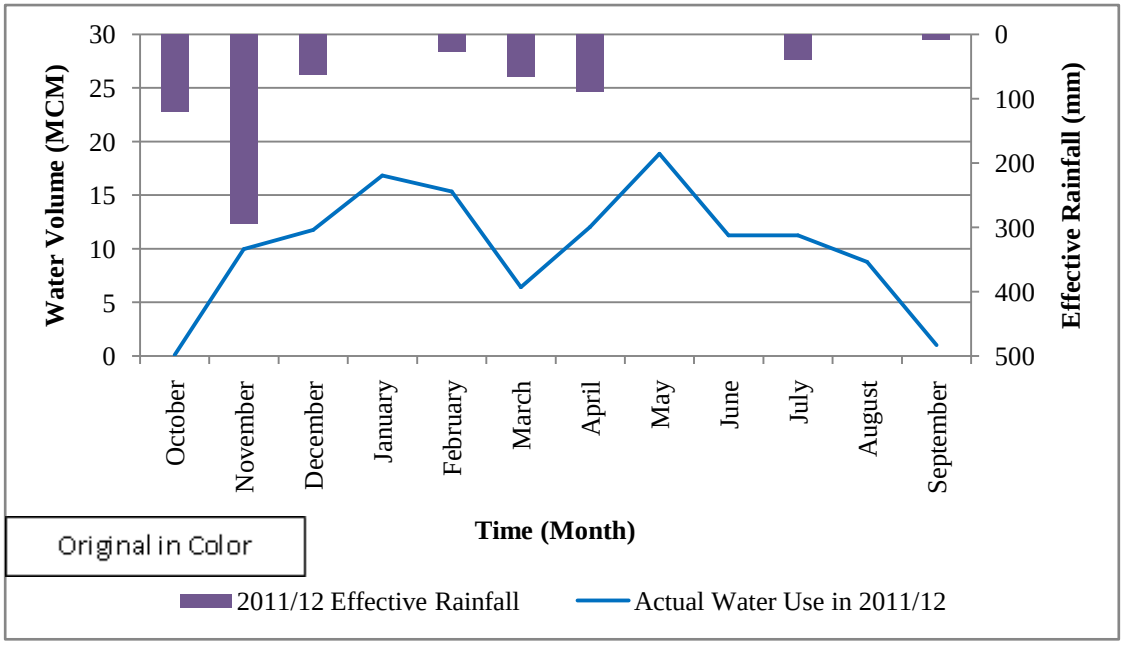

Figure 6.43: Monthly Actual Water Use in 2011/12

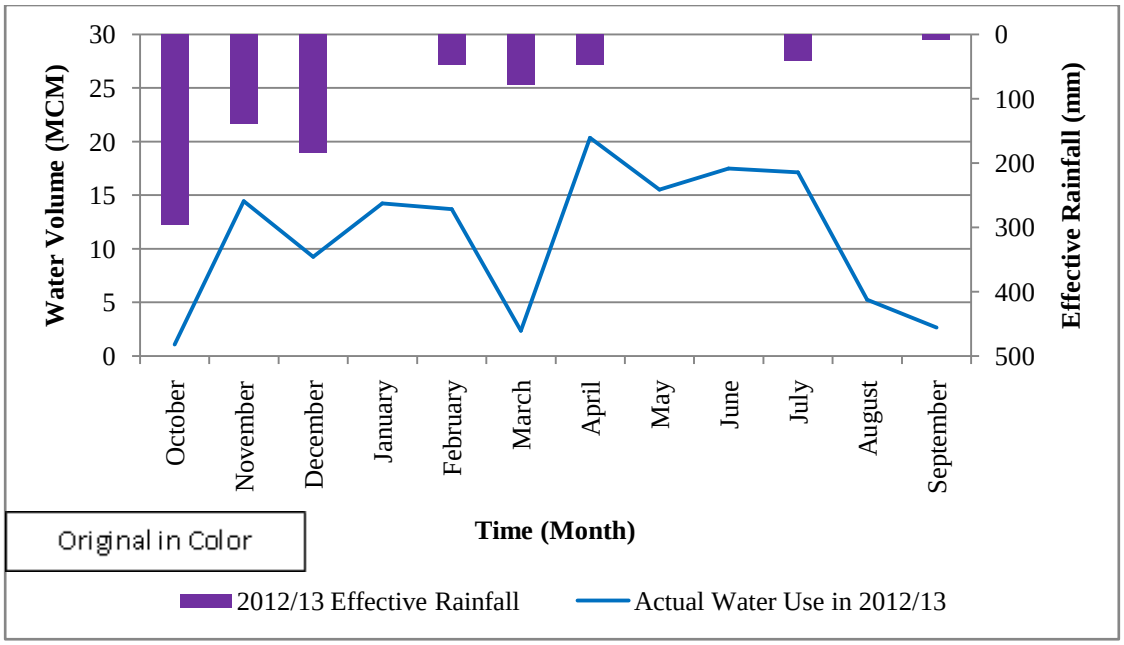

Figure 6.44: Monthly Actual Water Use in 2012/13

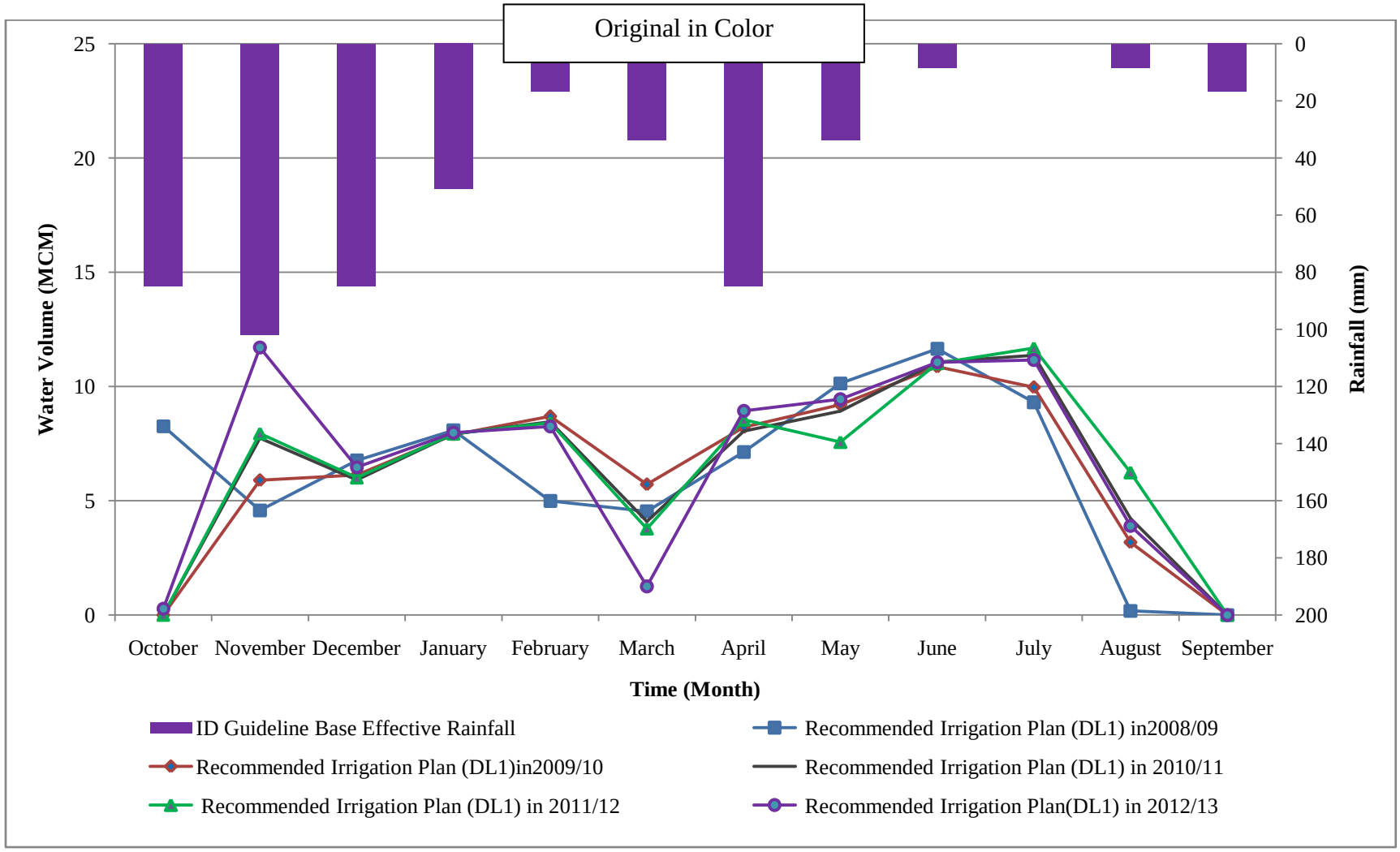

Figure 6.45: Monthly Recommended Irrigation Plan (DL1) of 2008/09- 2012/13

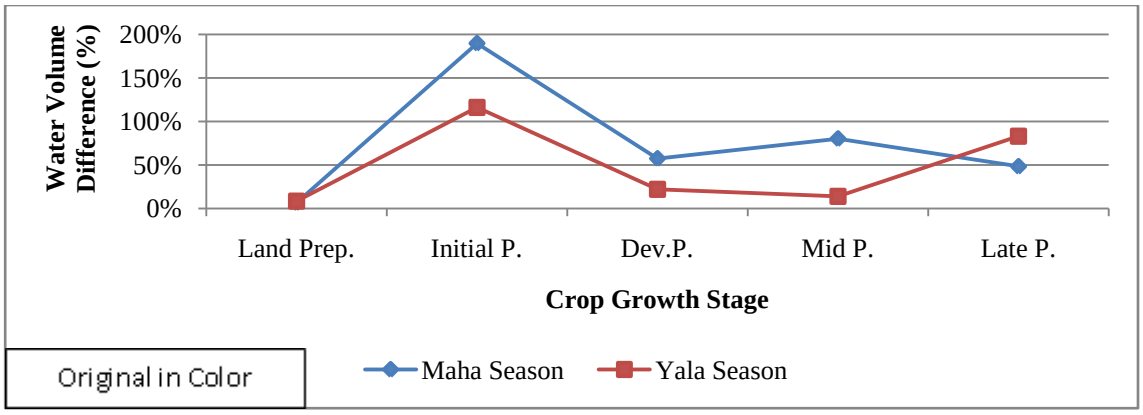

Figure 6.46: Water Volume Difference between Actual Water Use and ID Recommended Plan in Maha and Yala Season

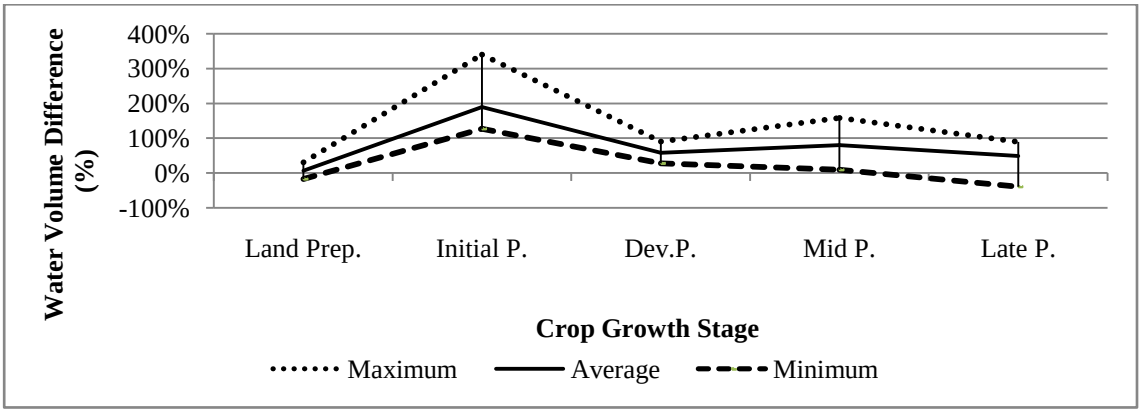

Figure 6.47: Difference of Actual Water Use Compared to Recommended Irrigation Plan in Maha Season

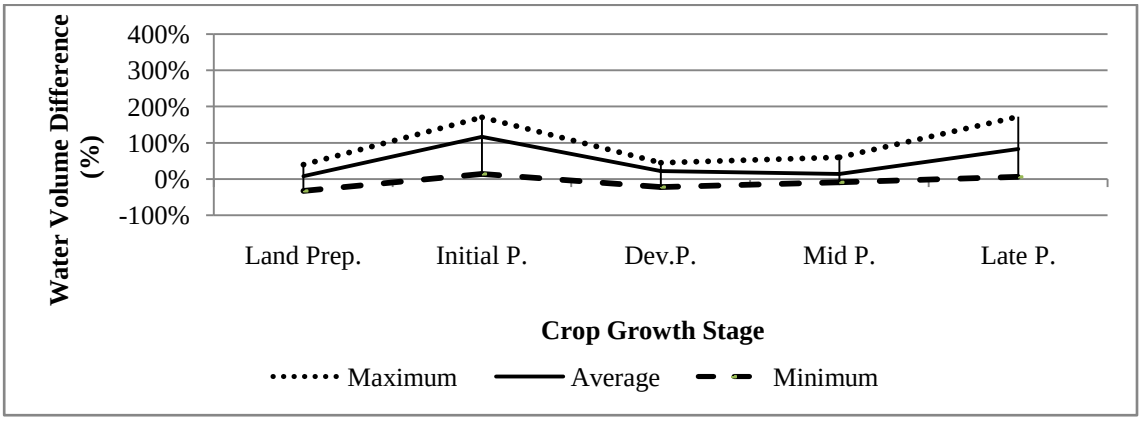

Figure 6.48: Difference of Actual Water Use Compared to Recommended Irrigation Plan in Yala Season

Seasonal Variation of Water Use Quantities are shown in the Figure 6-52 and Figure 6-53.

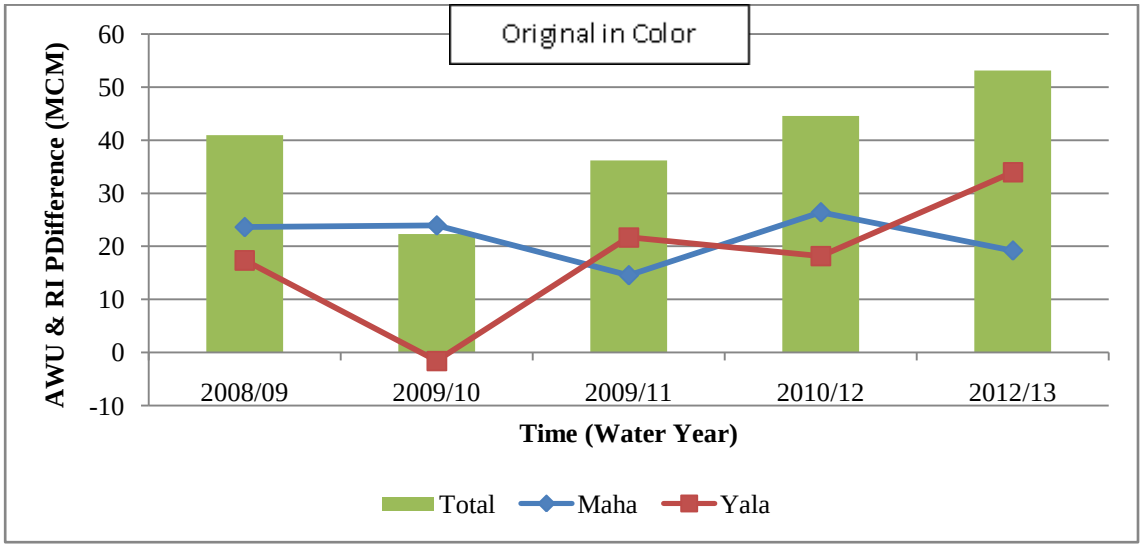

Figure 6.49: Percentage Seasonal Difference in Actual Water Use (AWU) Compared to Recommended Irrigation Plan (RIP).

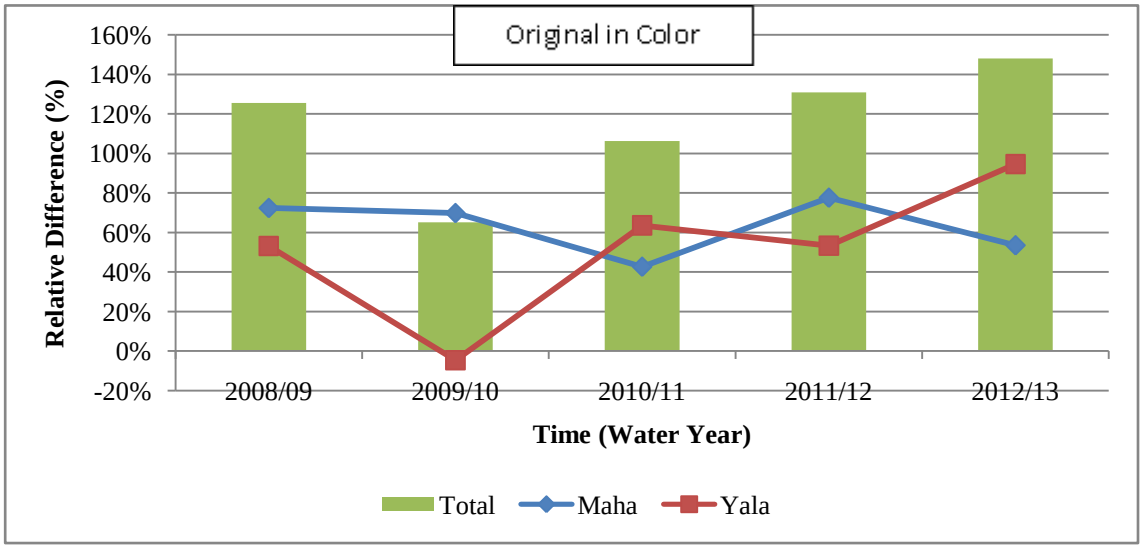

Figure 6.50: Percentage Seasonal Difference in Actual Water Use (AWU) Compared to Recommended Irrigation Plan (RIP).

These relative percentage Differences were computed using the following relationship

$$\frac{Actual\ \ Water\ \ Use - RIP}{RIP} \times 100\% \text{.....} \quad \text{Equation (6.1)}$$

Difference of Actual Water Use and the Recommended Irrigation Plan (DL1) when compared with the Rajangana Effective Rainfall are in Figure 6.51 and Figure A 6-6.

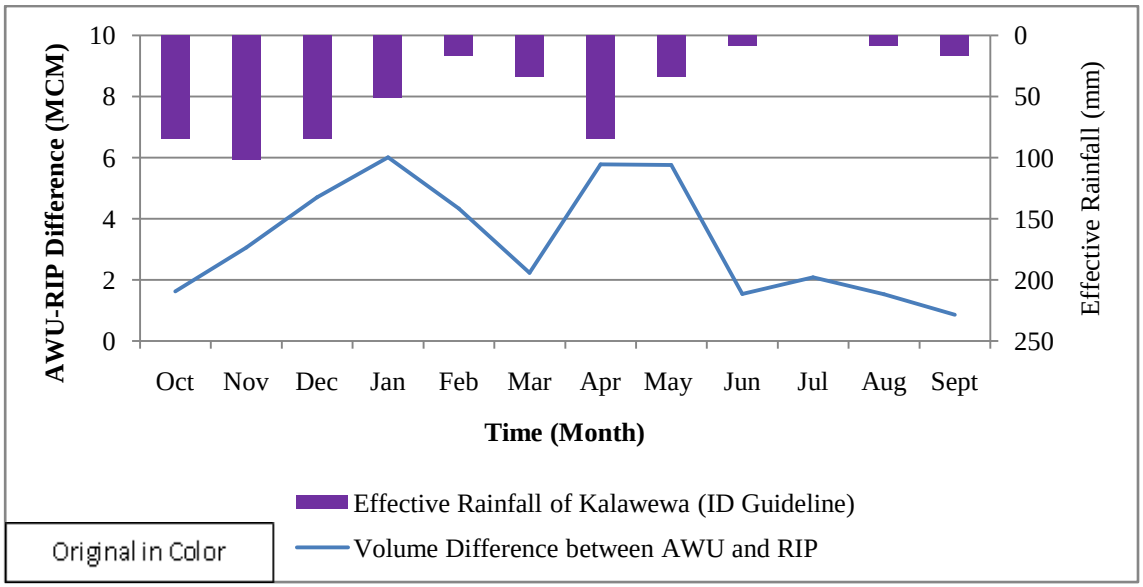

Figure 6.51: Average Difference between Actual Water Use and Recommended Irrigation Plan (DL1)

Variation of seasonal water duty with the Actual Water Use and the Recommended Irrigation Plan (DL1) are compared in Figure 6.52 - Figure 6.54. Values are in Table A6-10.

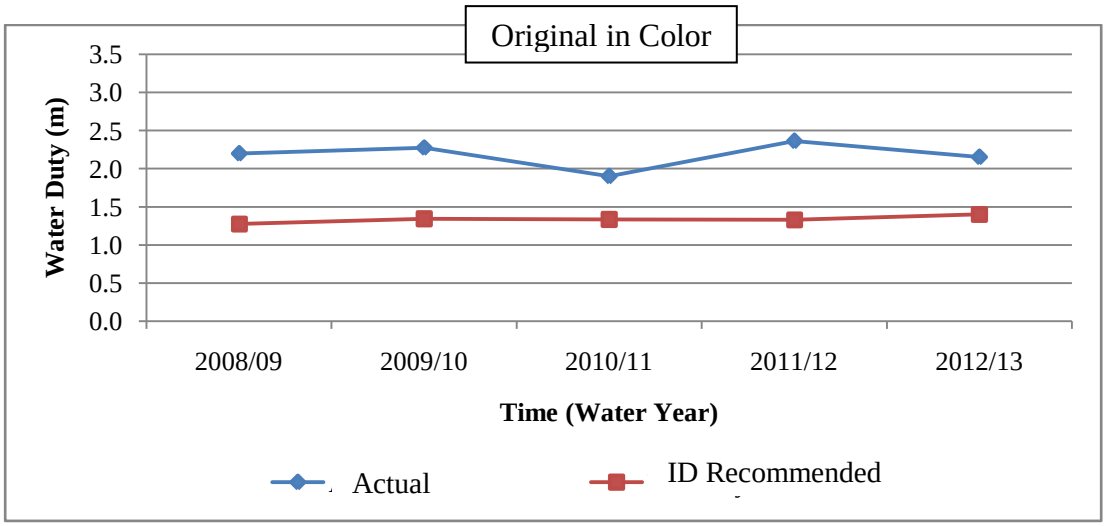

Figure 6.52: Comparison of Actual and ID Recommended Water Duty - Maha Season.

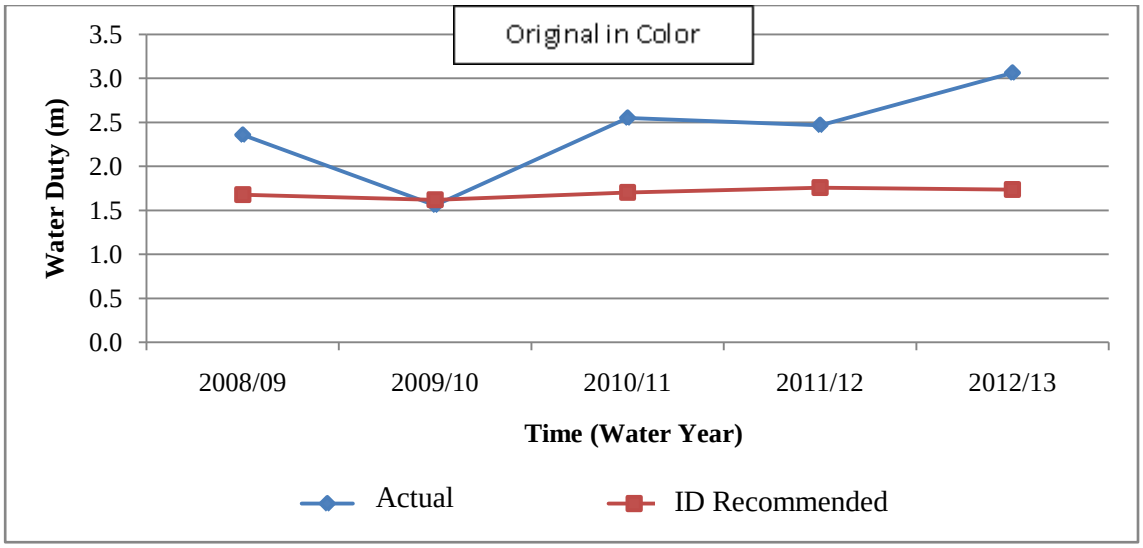

Figure 6.53: Comparison of Actual and ID Recommended Water Duty -Yala Season

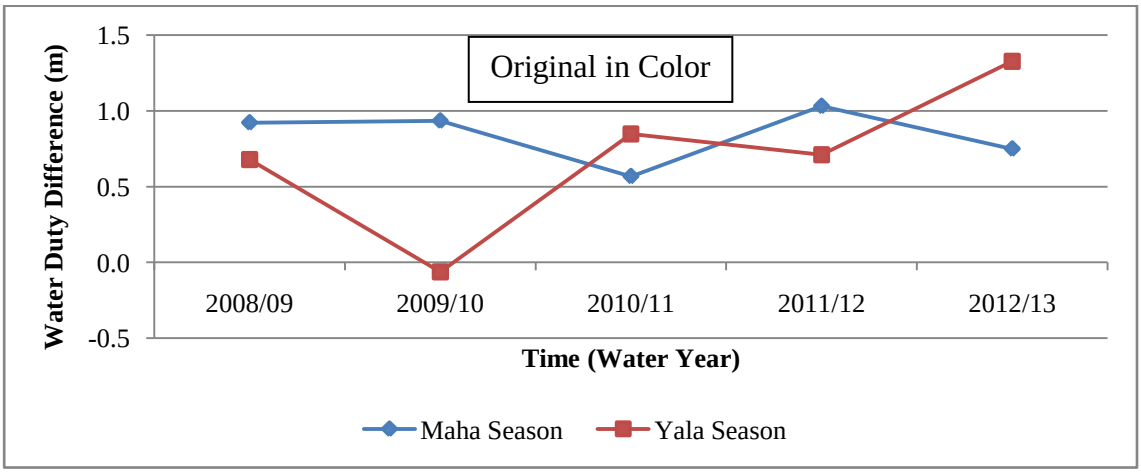

Figure 6.54: Maha and Yala Season Difference of Water Duty between Actual Water Use and Recommended Irrigation Plan (DL1)

6.1.10 Comparison of actual water use and anticipated water use

Anticipated water use computed considering effective rainfall experienced at Rajangana was compared with the actual water released to L.B. Gravity Irrigation System of Rajangana. Weekly variation of Actual Water Use (AWU) and the Anticipated Water Use (ANWU) together with the effective rainfall of Rajangana are shown in Figure 6.55

- Figure 6.59. This detailed comparison summarized as monthly and seasonal data were compared for a quantitative evaluation.

In Figure 6.60 - Figure 6.64, monthly actual and anticipated water uses are plotted with monthly effective rainfall received at Rajangana. Monthly Seasonal and differences are shown in Table A7.1 - Table A7.3. 45% -100% Annual differences could be seen within the study period.

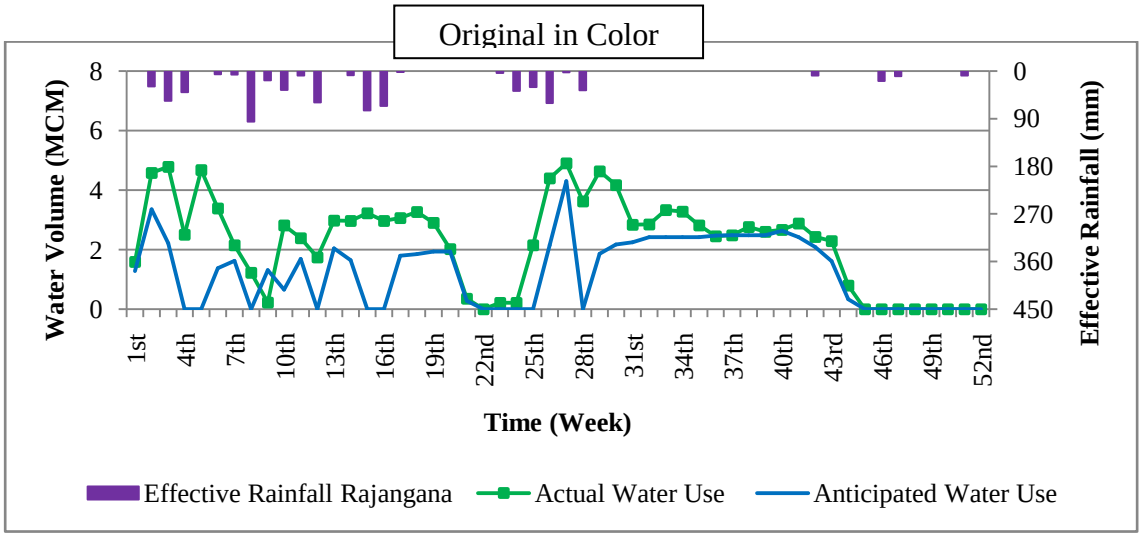

Figure 6.55: Actual Water Use, Anticipated Water Use and Effective Rainfall in

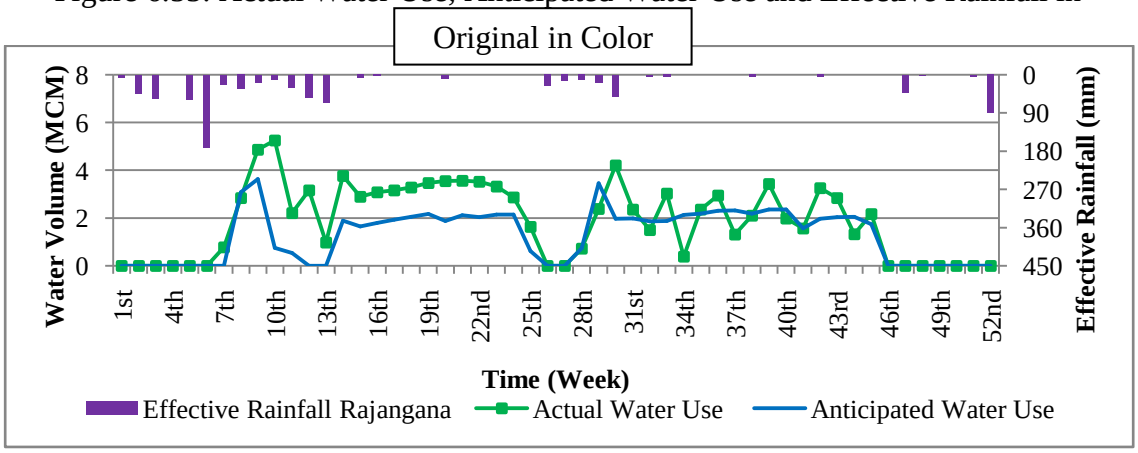

Figure 6.56: Actual Water Use, Anticipated Water Use and Effective Rainfall in 2009/10

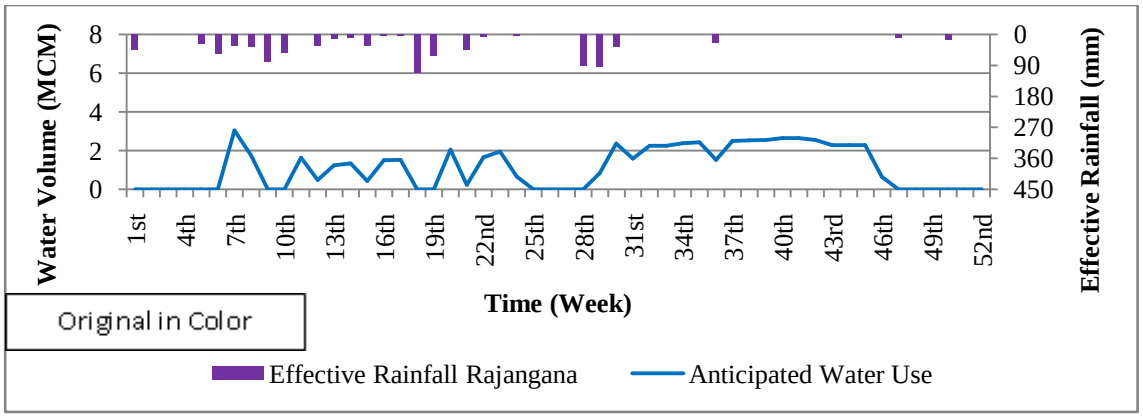

Figure 6.57: Actual Water Use, Anticipated Water Use and Effective Rainfall in 2010/11

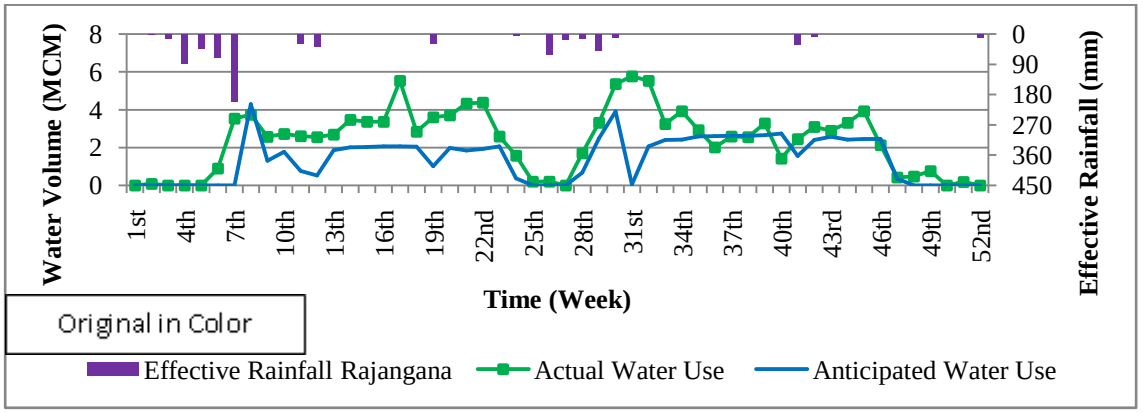

Figure 6.58: Actual Water Use, Anticipated Water Use and Effective Rainfall in 2011/12

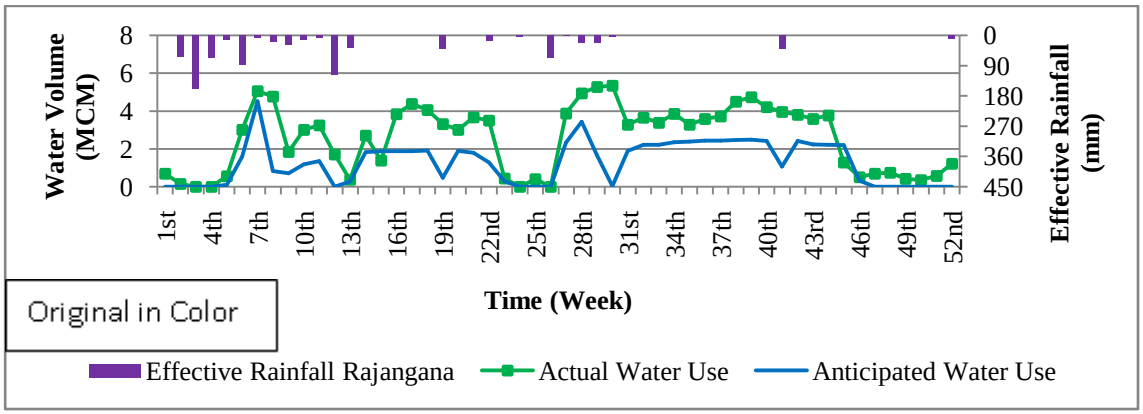

Figure 6.59: Actual Water Use, Anticipated Water Use and Effective Rainfall in 2012/13

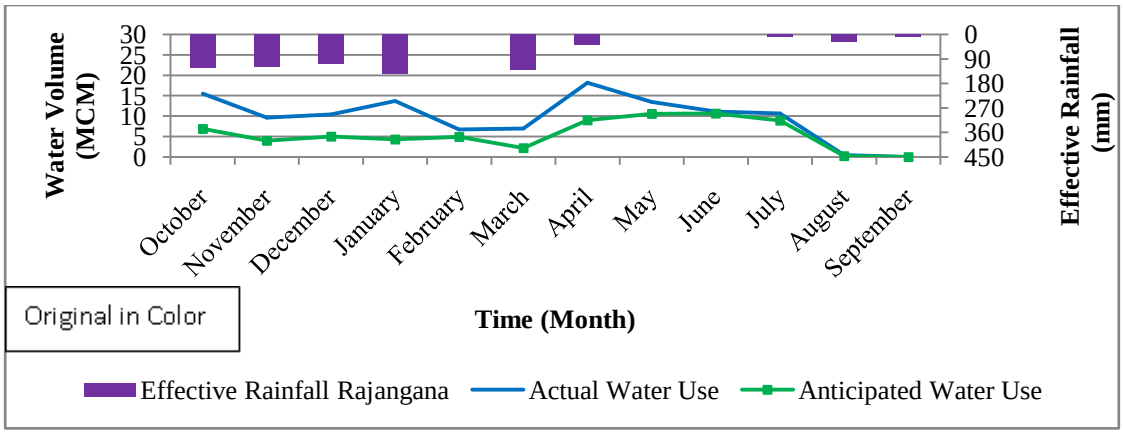

Figure 6.60: Comparison of Anticipated Water Use and Actual Water Use in 2008/09

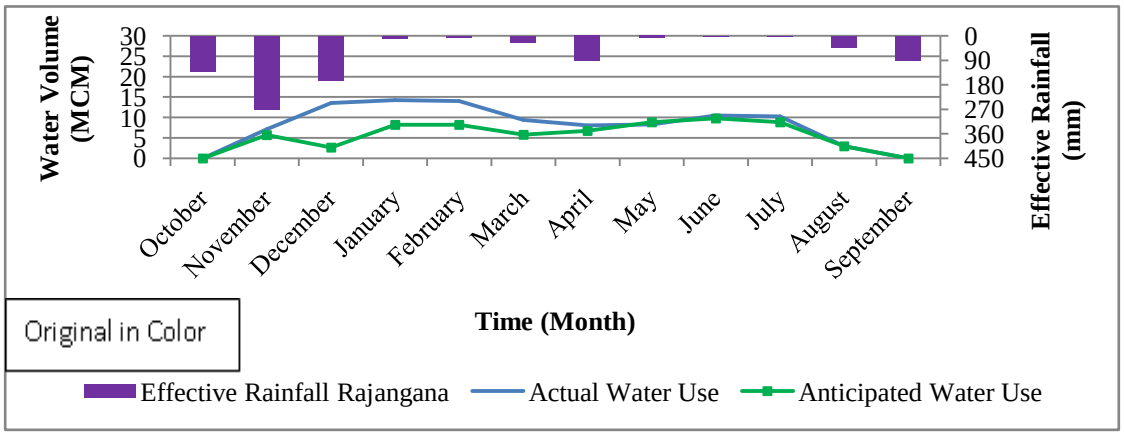

Figure 6.61: Comparison of Anticipated Water Use and Actual Water Use in 2009/10

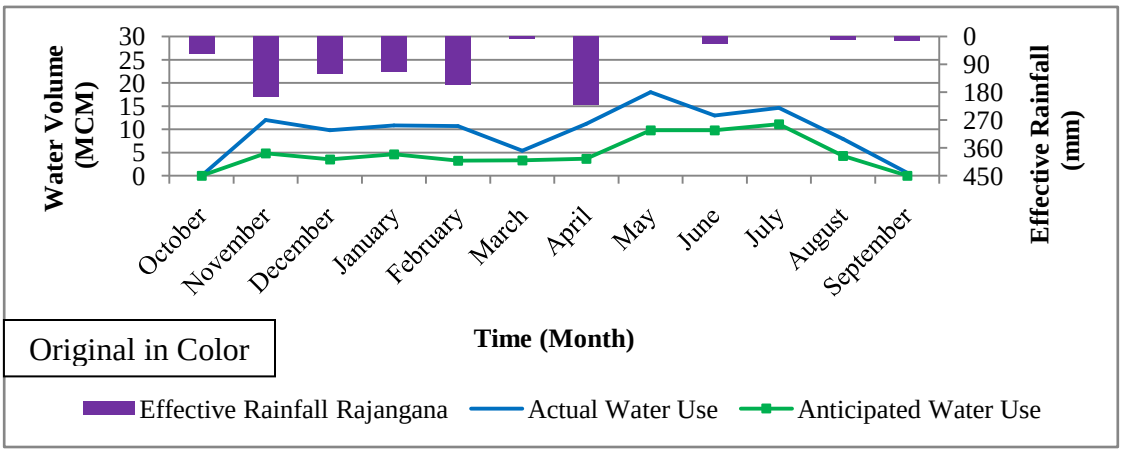

Figure 6.62: Comparison of Anticipated Water Use and Actual Water Use in 2010/11

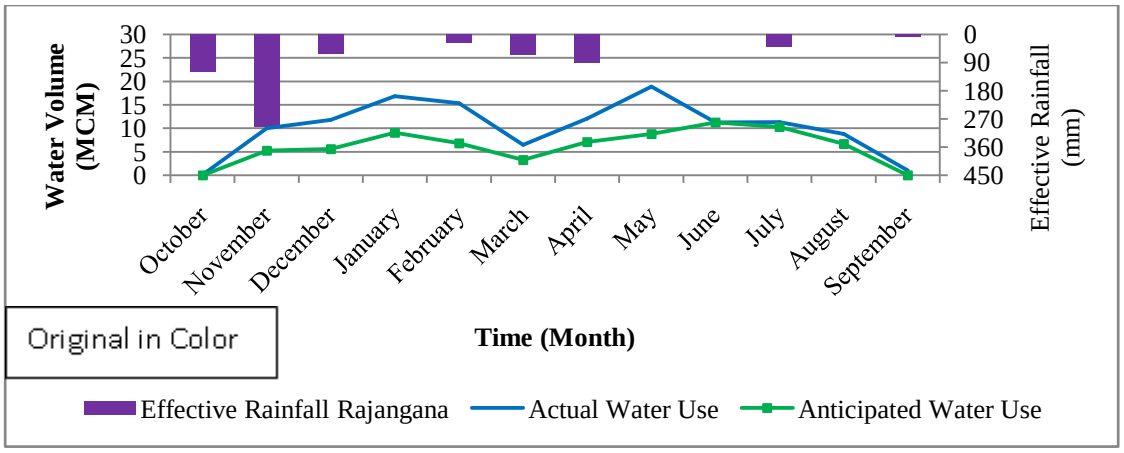

Figure 6.63: Comparison of Anticipated Water Use and Actual Water Use in 2011/12

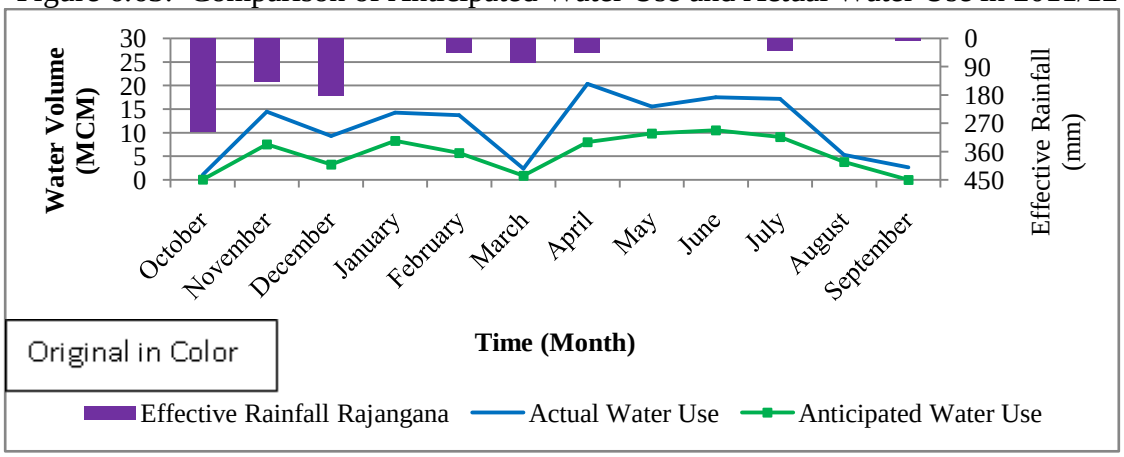

Figure 6.64: Comparison of Anticipated Water Use and Actual Water Use in 2012/13

Percentage of seasonal water volume differences between the Actual Water Use (AWU) and Anticipated Water Use (ANWU) are shown in the Figure 6.65 - Figure 6.69 for Maha Season and Yala Season separately. In the Yala Season, the percentage difference is lower than that of Maha Season. In both seasons high differences were noted during the initial period. The average differences in Yala and Maha Seasons were 51% and 117% respectively. In Maha season, the average percentage difference is about 55% in land preparation and it is high in initial stage period which is 372% (Figure 6.65 and Tables A 7-4 to A 7-6).

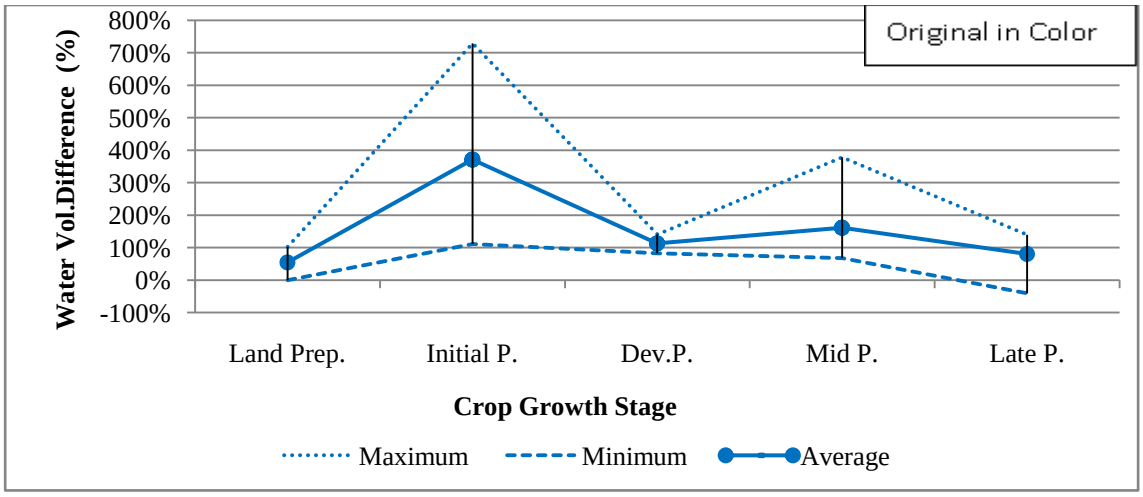

Figure 6.65: Variation of Differences between Actual Water Use and Anticipated Water Use in Maha Season-Crop Growth Stages

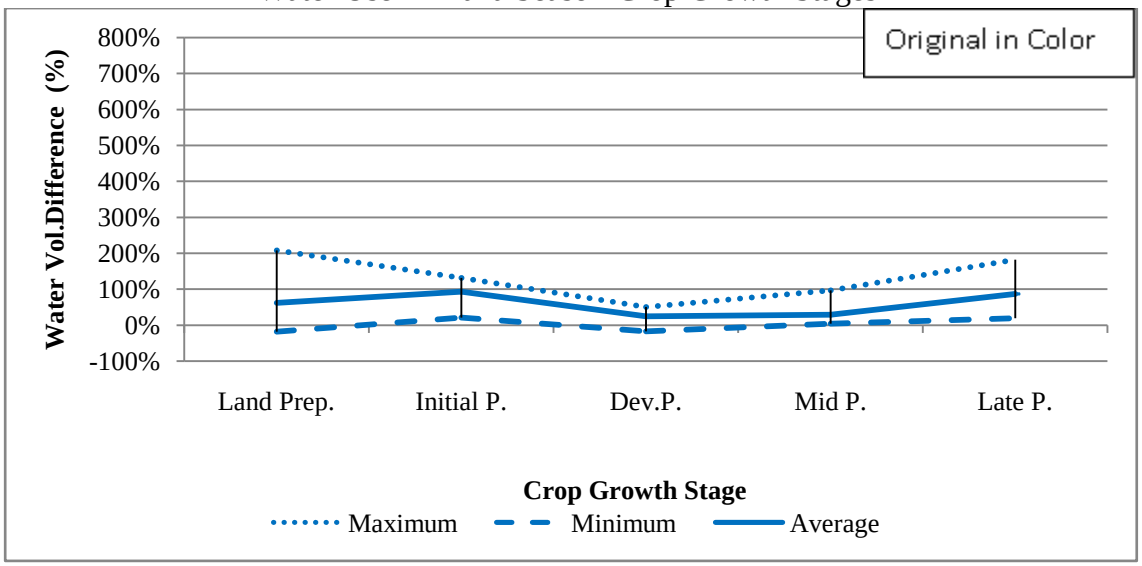

Figure 6.66: Variation of Difference between Actual Water Use and Anticipated Water Use in Yala Season-Crop Growth Stages

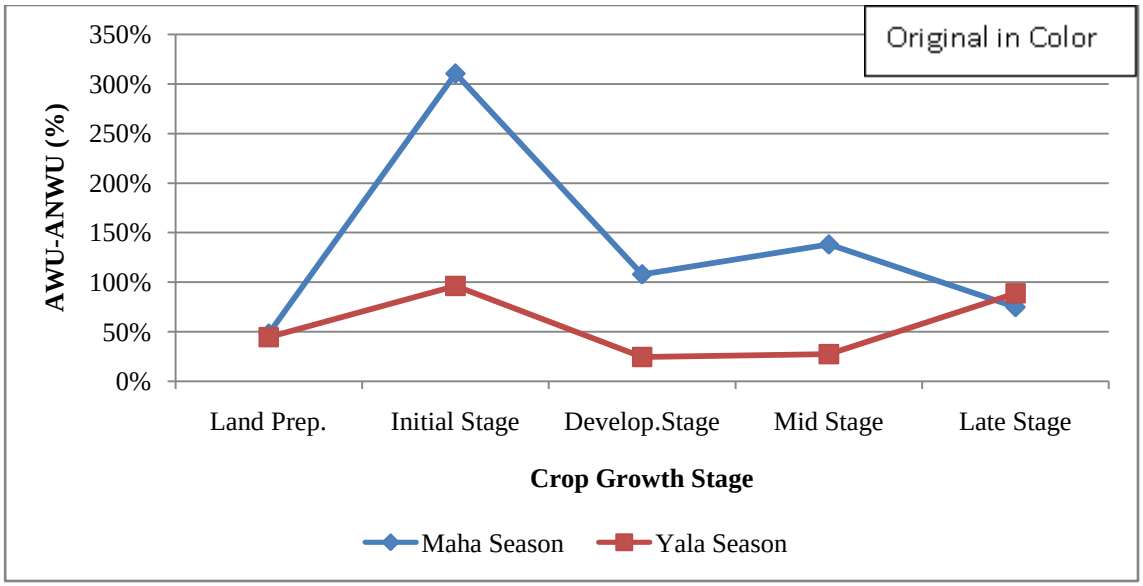

Figure 6.67: Variation of Difference between Actual Water Use and Anticipated Water Use in Maha and Yala Seasons–Crop Growth Stages

Seasonal Variation of water use quantity between the Actual Water Use and Anticipated Water Use is in Figure 6.68 and Figure 6.69.

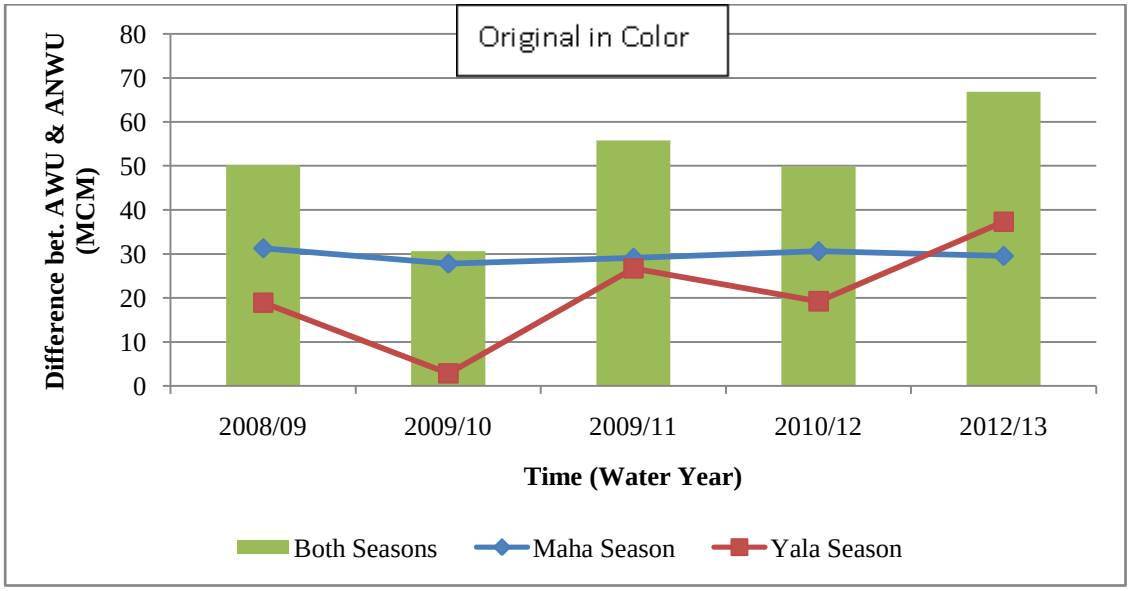

Figure 6.68: Variation of Difference between Actual Water Use and Anticipated Water Use from 2008/09 to 2012/13

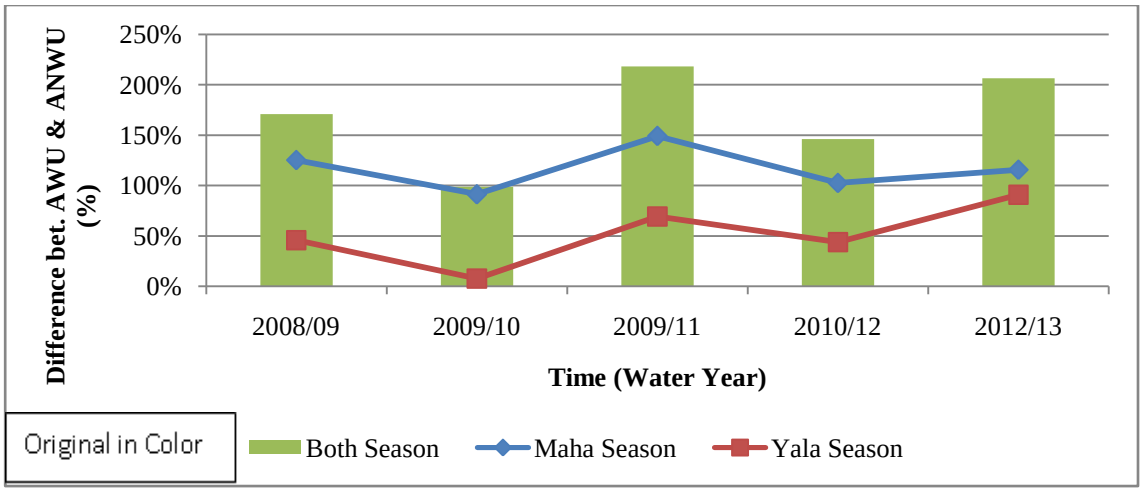

Figure 6.69: Percentage Difference between Actual Water Use and Anticipated Water Use from 2008/09 to 2012/13

Duty of Actual Water Use (AWU) and Anticipated Water Use (ANWU) are in the Figure 6.70 and Figure 6.71 and its difference of water duty between AWU and ANWU are in Figure 6.72. Its values are mentioned in the Table A7-8 of Appendix 7. This water duty difference is 1.16 m (117% of the water duty of Anticipated Water Use) in Maha season and 0.82 m in Yala which is 51% of Anticipated Water Use.

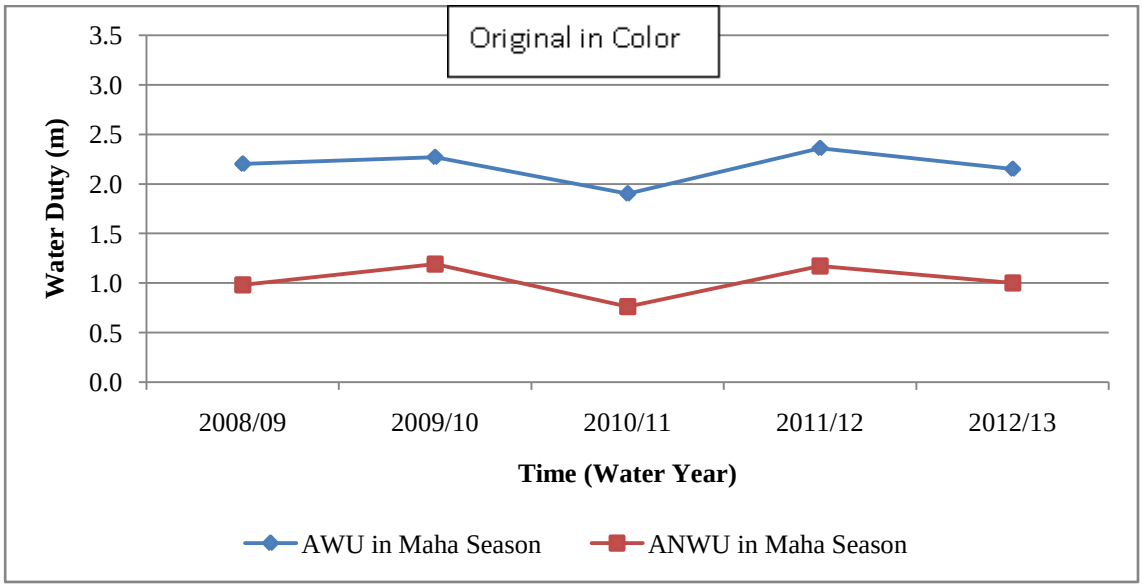

Figure 6.70: Maha Season Water Duty Corresponding to Actual Water Use and Anticipated Water Use

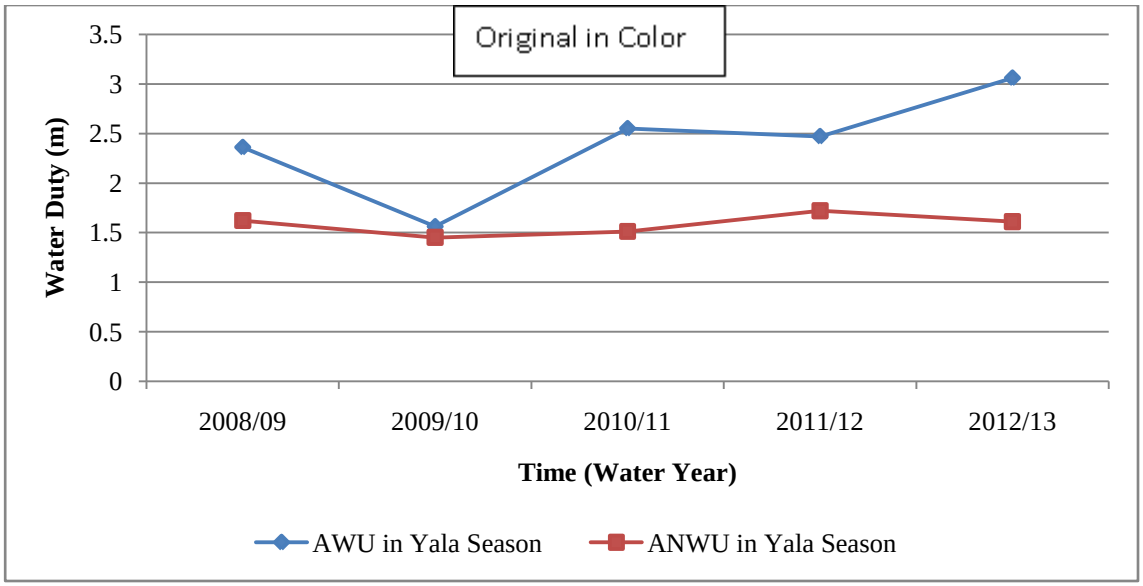

Figure 6.71: Yala Season Water Duty Corresponding to Actual Water Use and Anticipated Water Use

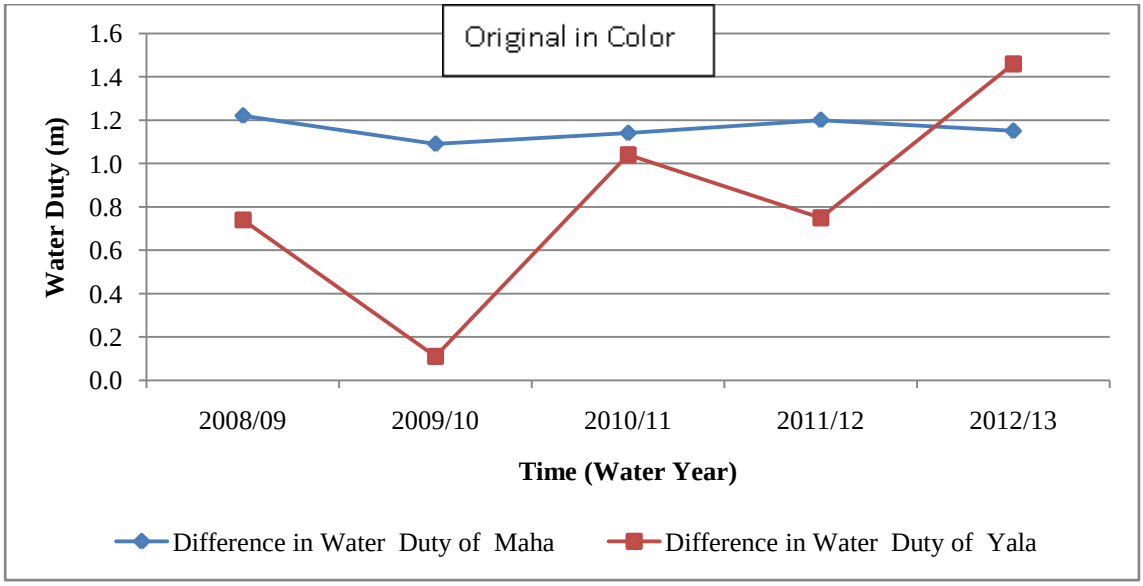

Figure 6.72: Water Duty Difference between Actual Water Use and Anticipated Water Use

6.1.11 Comparison of Recommended Irrigation Plan (DL1) and Anticipated Water Use

Recommended Irrigation Plan (RIP) was calculated with effective rainfall of DL1 Agro Ecological Region and Evaporation of Kalawewa given in ID Guideline (Figure 6.45). The Anticipated Water Use was computed with rainfall of Rajangana and pan evaporation of Maha Illupallama for the selected study period (Figure 6.19, Figure 6.22, Figure 6.25, Figure 6.28, Figure 6.31 and Figure 5.12). These were compared with each other and the monthly and seasonal comparison of Recommended Irrigation Plan and Anticipated Water Use (ANWU) are summarized in Appendix 8 and a quantitative evaluation of the difference is shown in the Figure 6.74 - Figure 6.77 corresponding values and comparison are shown in Table A8-1to Table A8-7 of Appendix 8.

Percentage difference was computed using the following equation.

$$\frac{RIP-ANWU}{ANWU} * 100 \ldots\ldots\ldots\ldots\ldots\ldots \quad \text{(Eq. 2)}$$

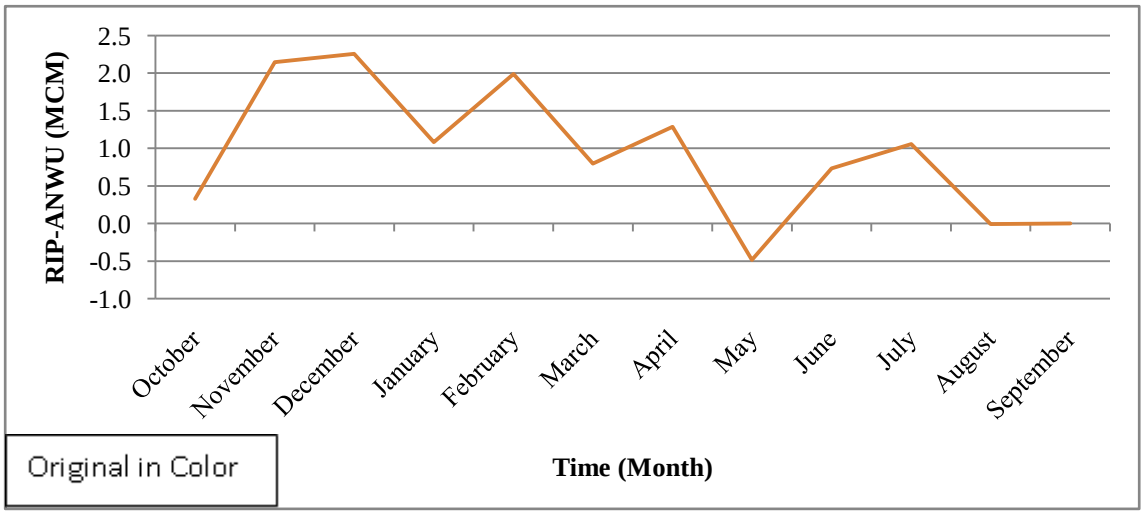

Figure 6.73: Monthly Water Volume Difference between Recommended Irrigation Plan (DL1) and Anticipated Water Use

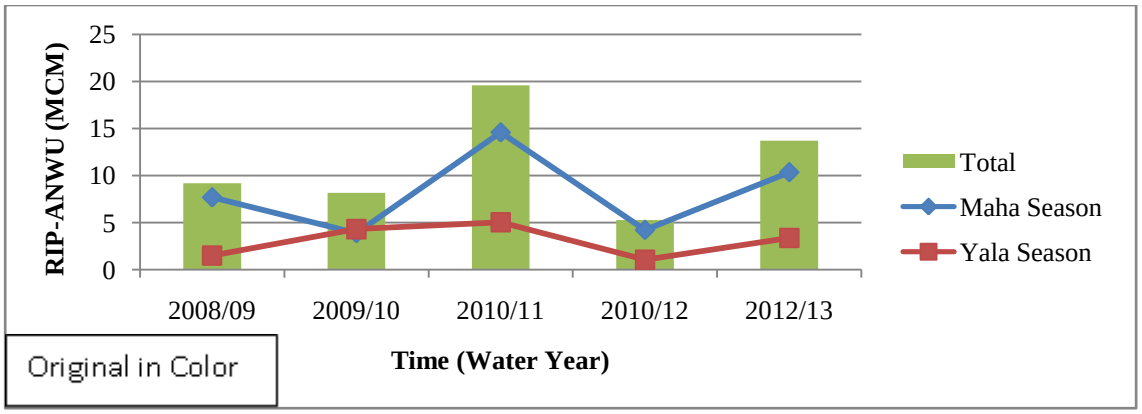

Figure 6.74: Seasonal Water Use Difference between Recommended Irrigation Plan (DL1) and Anticipated Water Use (2008/09 to 2012/13)

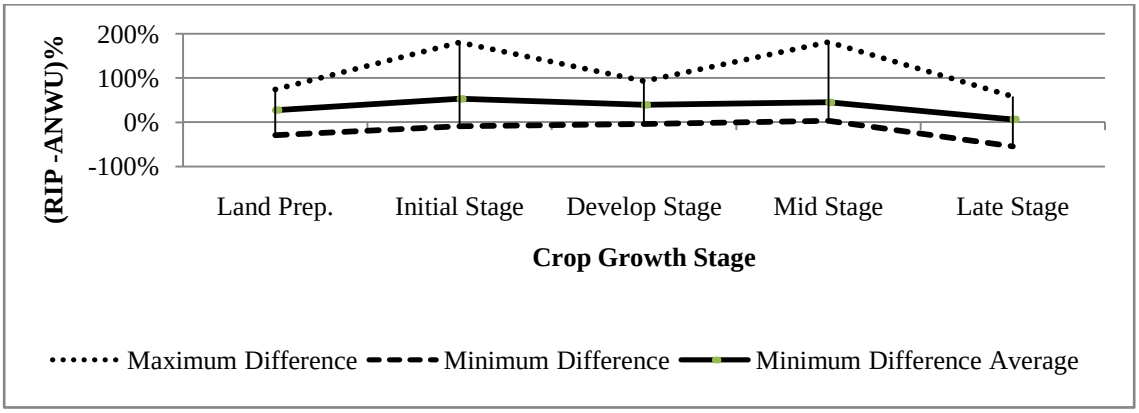

Figure 6.75: Water Volume Percentage Difference between Recommended Irrigation Plan (DL1) and Anticipated Water Use in Maha Season-Crop Growth Stages

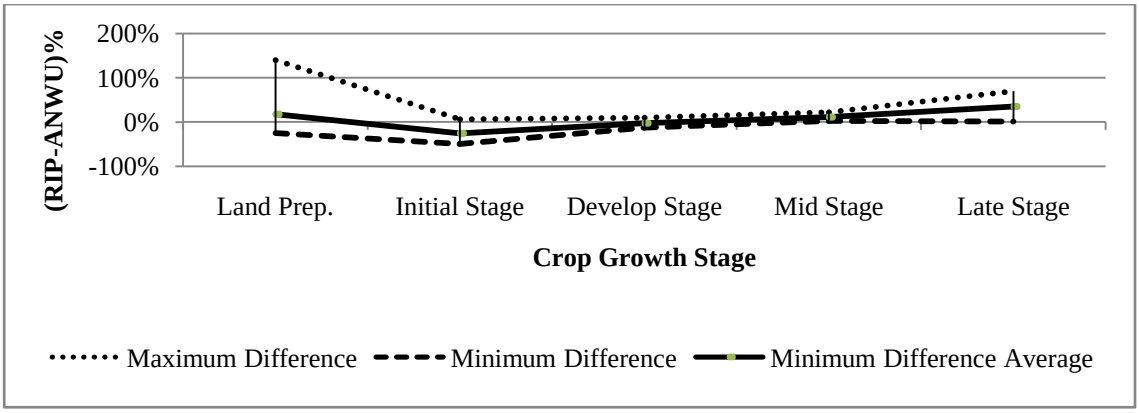

Figure 6.76: Water Volume Percentage Difference between Recommended Irrigation Plan (DL1) and Anticipated Water Use in Yala Season-Crop Growth Stages

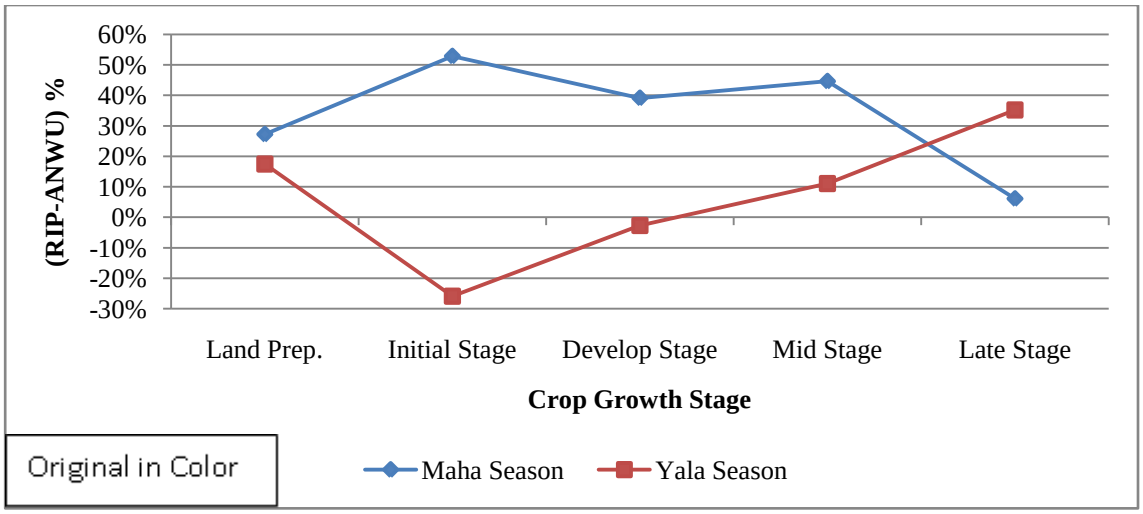

Figure 6.77: Percentage Water Volume Difference between Recommended Irrigation Plan (DL1) and Anticipated Water Use (Maha and Yala Season)

Water duty comparison for Maha and Yala seasons for these two cases are shown in Figure 6.78 - Figure 6.80. Corresponding values are shown in Table A8-8 of Appendix 8. During the study period, average differences in the water duty for Maha and Yala season are 35% and 8% respectively.

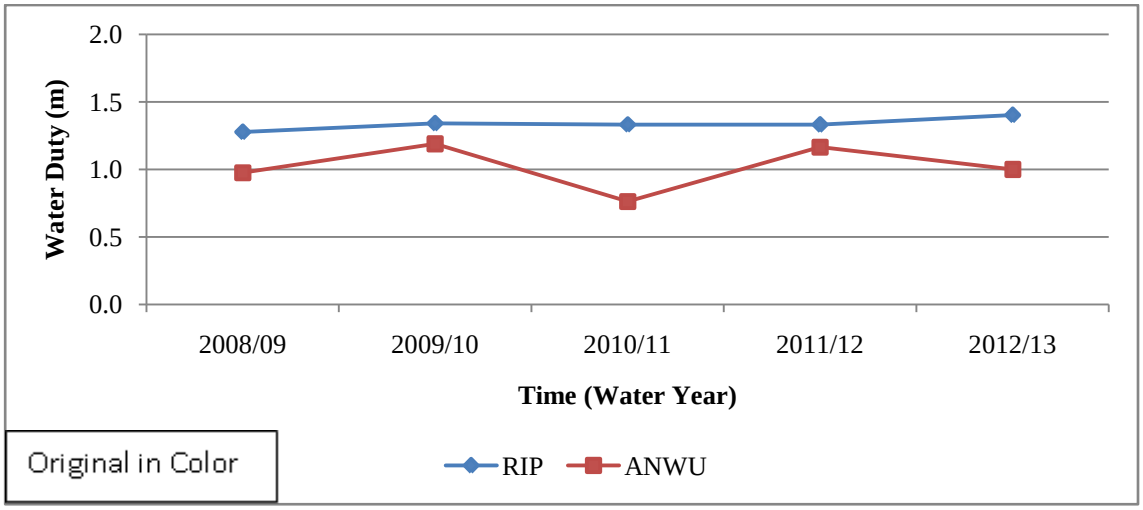

Figure 6.78: Comparison of Water Duty in Recommended Irrigation Plan (DL1) and in Anticipated Water Use (Maha Season)

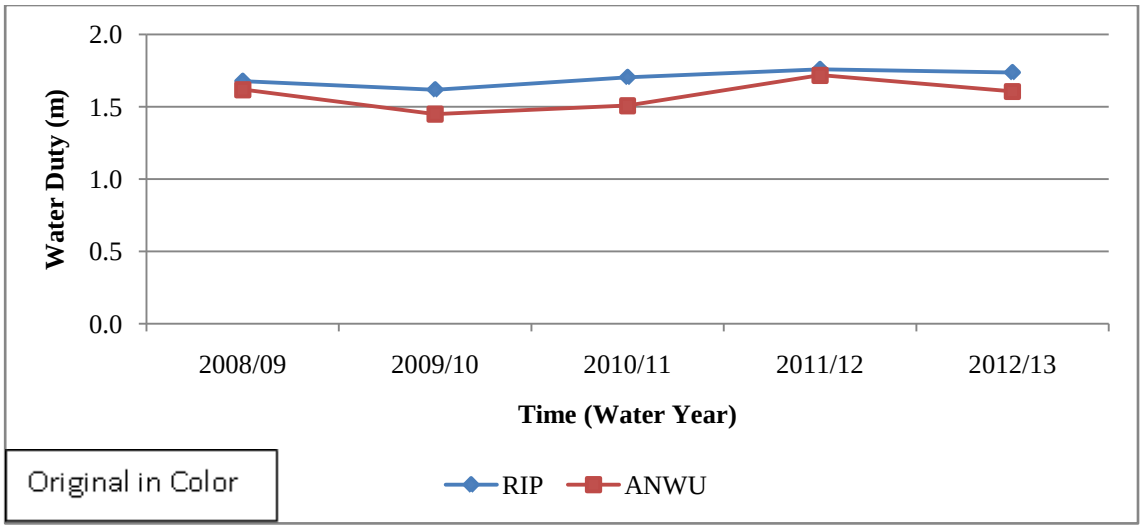

Figure 6.79: Comparison of Water Duty in Recommended Irrigation Plan (DL1) and in Anticipated Water Use (Yala Season)

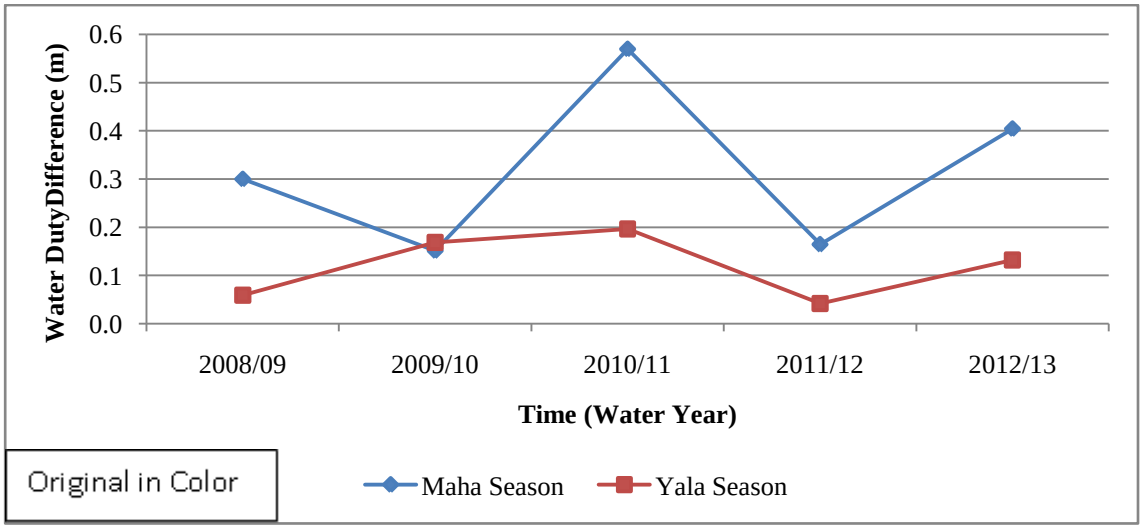

Figure 6.80: Water Duty Difference between Recommended Irrigation Plan (DL1) and Anticipated Water Use (Maha and Yala Seasons)

6.1.12 Water use, crop yield and rainfall

A seasonal comparison Paddy yield, water use and effective rainfall from 2008/09 to 2012/13 are given in Table 6-14. In Maha Season, average effective rainfall at Rajangana is 0.64 m and the same in Yala season is 0.16m.

Table 6-14: Seasonal Rainfall, Water Use and Paddy Yield at Rajangana L.B. from 2008/09 to 2012/13

Season	Effective Rainfall (m)	Actual Water Use (m/Ha)	Recommended Water Use (m/Ha)	Difference (m/Ha)	Paddy Yield MT/Ha
Maha 2008/09	0.60	2.20	1.28	0.93	6.91
Maha 2009/10	0.60	2.27	1.34	0.93	7.22
Maha 2010/11	0.70	1.90	1.33	0.57	5.02
Maha 2011/12	0.60	2.36	1.33	1.03	6.28
Maha2012/13	0.70	2.15	1.40	0.75	6.91
Maha Average	0.64	2.18	1.34	0.84	6.47
Yala 2008/09	0.10	2.36	1.68	0.68	6.91
Yala 2009/10	0.20	1.56	1.62	-0.06	5.65
Yala 2010/11	0.30	2.55	1.70	0.85	8.16
Yala 2011/12	0.10	2.47	1.76	0.71	6.28
Yala 2012/13	0.10	3.06	1.74	1.33	7.22
Yala Average	0.16	2.40	1.70	0.70	6.84

Average Actual water duty and recommended ID water duty for Maha season are 2.18 m and 1.34 m respectively. The same respective values for Yala season are 2.4 m and 1.7 m. Average paddy yield in Maha season is 6.67 Mt/Ha while the same in Yala season is almost 6.85 MT/Ha. Seasonal variation of these values are shown in Figure 6.81 to Figure 6.86.

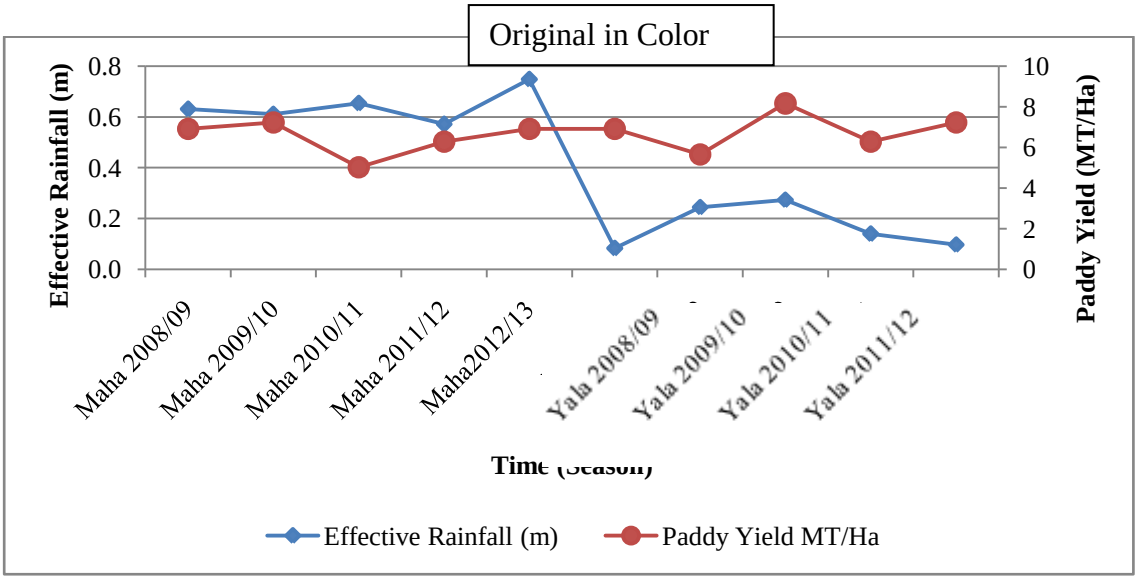

Figure 6.81: Seasonal Variation of Effective Rainfall and Paddy Yield from 2008/09 to 2012/13

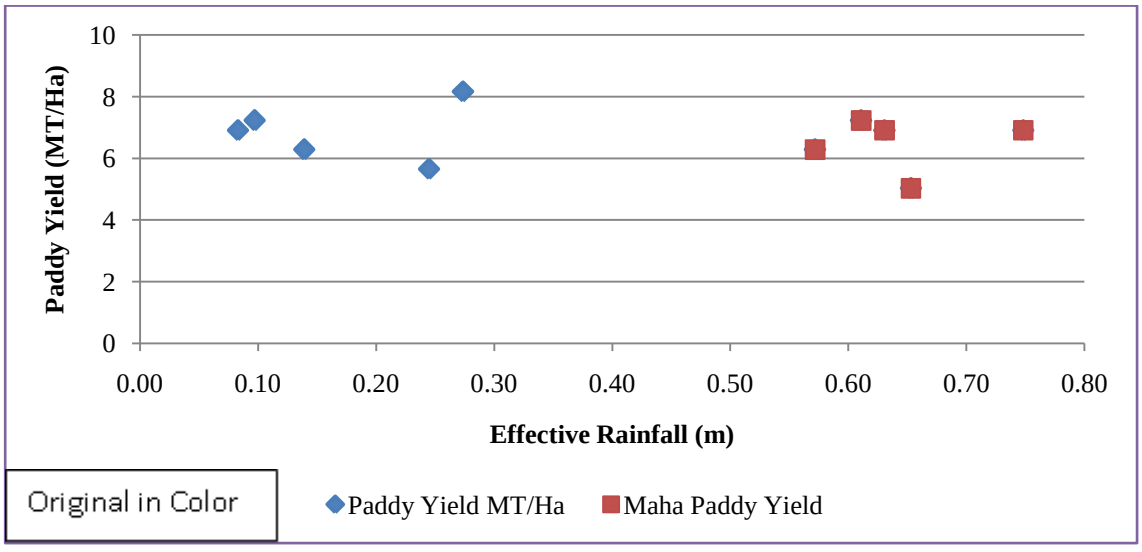

Figure 6.82: Seasonal Variation of Effective Rainfall and Paddy Yield from 2008/09 to 2012/13

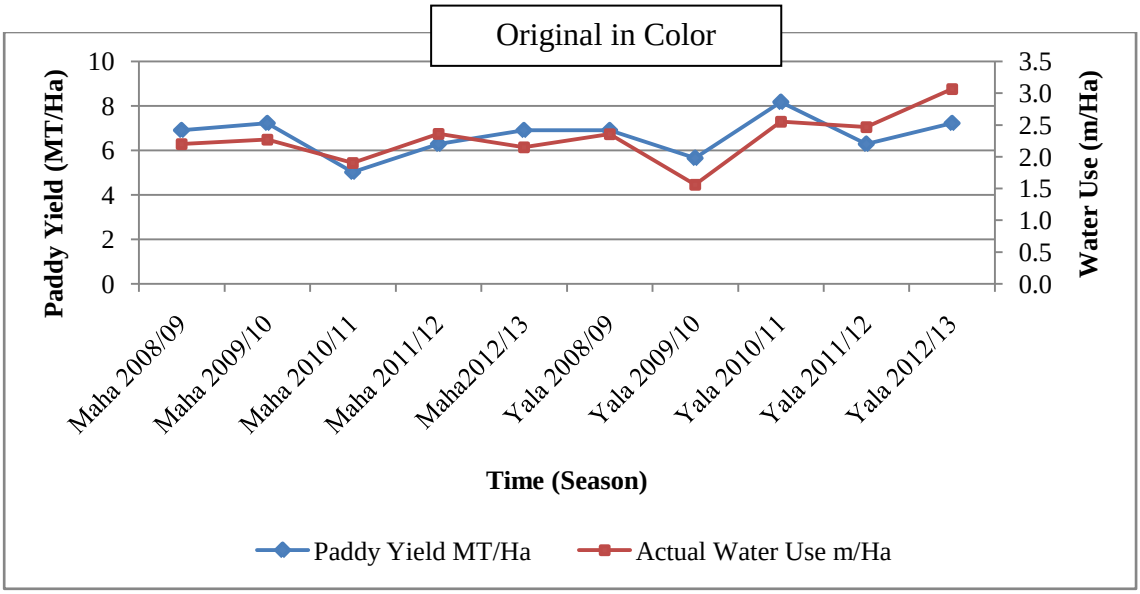

Figure 6.83: Seasonal Variation of Paddy Yield and Actual Water Use from 2008/09 to 2012/13

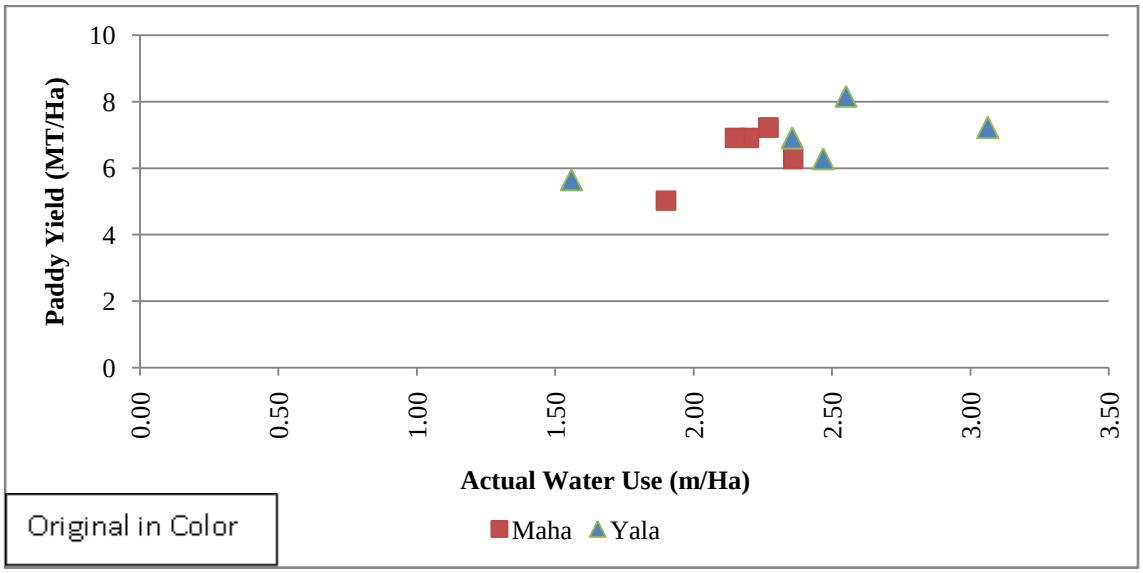

Figure 6.84: Relationship between Paddy Yield and Actual Water Use (2008/09 to 2012/13)

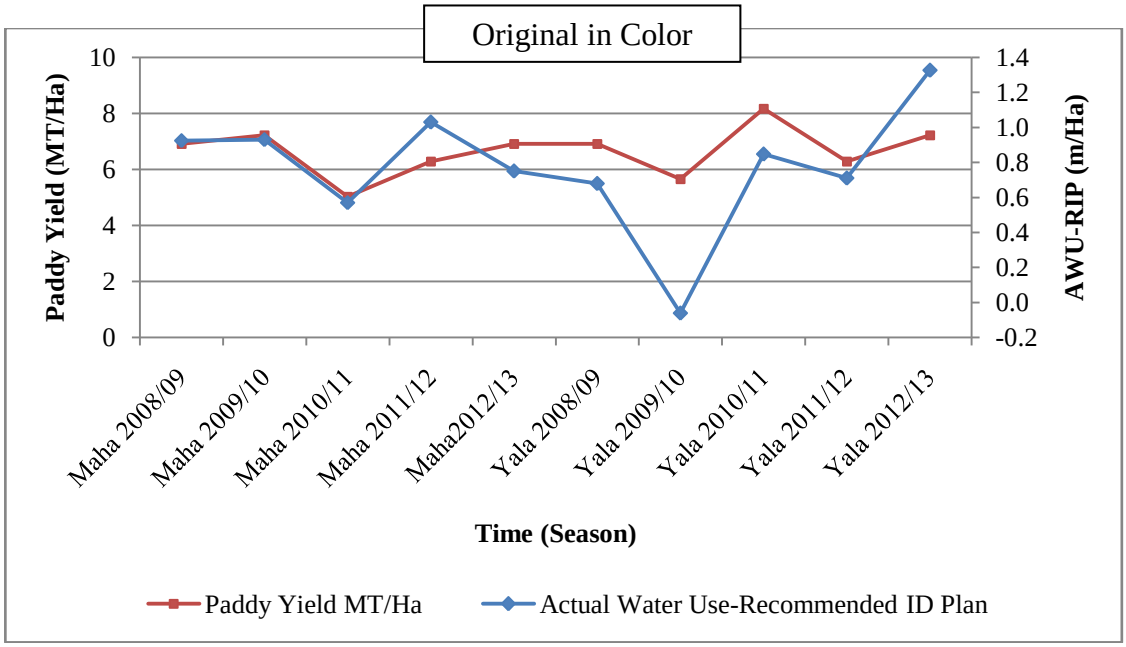

Figure 6.85: Relationship between of Paddy Yield and Difference in Water Duty Corresponding to Actual Water Use and Recommended Irrigation Plan (DL1) (2008/09 to 2012/13)

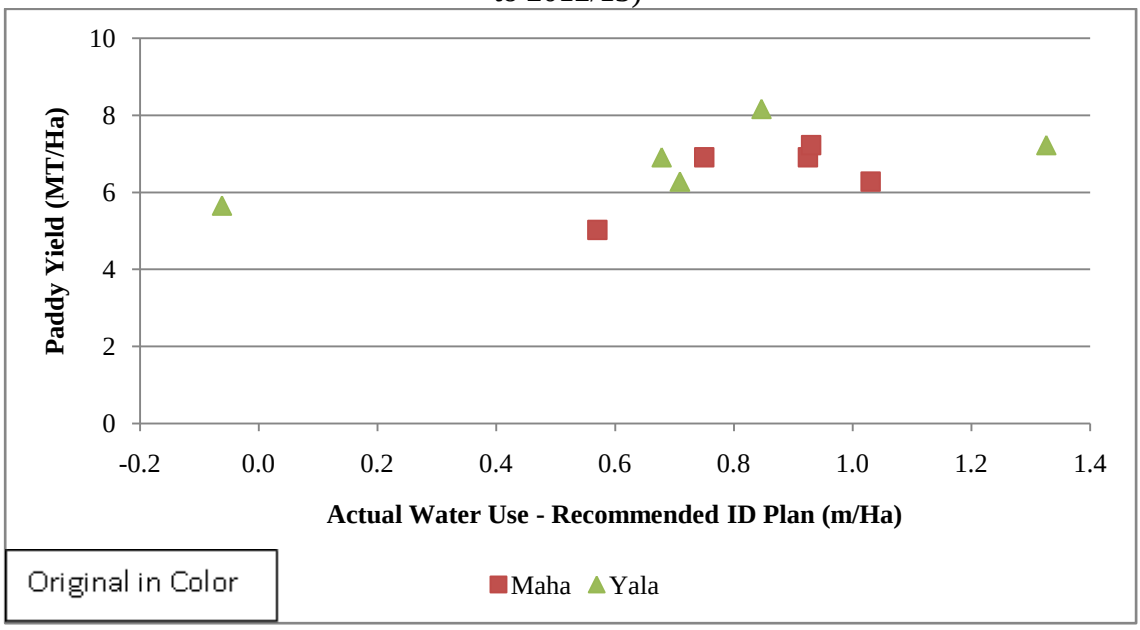

Figure 6.86: Relationship between Paddy Yield and Difference in Water Duty Corresponding to Actual Water Use and Recommended Irrigation Plan (DL1) (2008/09 to 2012/13)

These Figures (Figure 6.81 to Figure 6.86) show that the effective rainfall between seasons is significantly different and that the paddy yield is in sensitive to effective rainfall. This gives an indication that a significant quantity of water for crop growth is made available by irrigation. Paddy yield variation reflects a pattern that closely matches with that of actual water use (Figure 6.83). Figure 6.84 shows that with the increase of water use, the yield has shown an increase in the Yala season, but it is not so in the Maha season. In the Maha season, paddy yield appears to reach a limit that indicates a necessity to recognize the other reasons for increasing yield in Yala season.

This behavior is prominently shown by Figure 6.85 and Figure 6.86 where seasonal paddy yields are compared with the excess water utilization (i.e. Actual Water Use (AWU) - Recommended Irrigation Plan (DL1) (RIP).

7 DISCUSSION AND RECOMMENDATION

7.1 Effective Rainfall

ID Guidelines (Ponrajah, 1988) recommends the preparation of water issue plans using the 75% probable rainfall. In case of the Rajangana Irrigation Scheme, these values correspond to the DL1 agro ecological region of Sri Lanka. Actual rainfall shows that the rainfall experienced at Rajangana is low when compared with the 75% probable values. It may be necessary to use recent records and then evaluate the suitability of ID guideline values for the preparation of water issue plans. The monthly Effective Rainfall for computations was based on the empirical equations recommended in the ID guidelines. There is no evidence that these values have been verified for applicability. Hence it is necessary to evaluate effects of effective rainfall on the water issues computed using the rainfall values based on ID recommendations.

7.2 Observed Water Issue

Water issues of LB canal included water for the gravity and lift irrigation systems and a component for the environmental flows. In the present study, these were separated using various methods. Observed Quantities of water through the LB canal and other sub canals for different purposes were computed by dividing the total issue according to the command area. These were used for evaluations since there were no separate recorded quantifications. Extractions for the lift irrigation system were done on pump specifications and the number of working hours recorded by the pump operators. Age of pumps and the reliability of the pump operator recordings were not considered during computations. Environmental flow that had been taken for consideration is those quantities that had been released after or before the cropping periods. Since the effects of the entire LB canal area gets aggregated at the entire sluice water release, it is difficult to state whether these flows were released due to an environmental consideration or due to releases to some lands which were late in cultivations.

7.3 Water Issue of L.B Canal

According to the averaged observed water issue data of the LB canal during the study period, the Maha season water use has 11% lower value when compared with that of Yala season (Table 7-1). In 2009/10, Actual water use in Yala is 31% lower than Maha season and for the rest of the period, Yala season had consumed more water than the Maha season. Highest difference in water issue was noted in 2012/13 where there had been a 42% higher usage in the Yala which is the highest value within the study period. Out of the two components of the actual water release from the LB Main Sluice, the Gravity system component is approximately 98.6 % (Figure 7.2).

Table 7-1: Issue Water of L.B Canal from 2008 to 2013

Actual Water Use	**Water Use Quantity MCM**		**Difference**	
	Maha	Yala	(MCM)	Percentage
2008/09	59.0	61.2	2.2	4%
2009/10	58.7	40.7	-18.0	-31%
2010/11	49.0	66.2	17.2	35%
2011/12	60.8	63.8	3.0	5%
2012/13	55.4	78.8	23.4	42%
Average	56.6	62.1	5.6	11%

Table 7-2: Issued Water of L.B. Canal Use Detail

Water Year	**Total Water Release**	**Gravity Flow**		**Total Pump Flow**	
	Quantity	Quantity	Percentage	Quantity	Percentage
2008/09	118.1	116.6	98.74%	1.49	1.26%
2009/10	99.5	98.1	98.62%	1.37	1.38%
2010/11	115.2	113.9	98.83%	1.35	1.17%
2011/12	124.5	123.6	99.27%	0.91	0.73%
2012/13	134.2	133.5	99.41%	0.79	0.59%
Maximum	134.24	133.45	99.4%	1.49	1.38%
Minimum	99.46	98.09	98.6%	0.79	0.59%
Average	118.30	117.12	99.0%	1.18	1.0%

7.4 Water Use in Lifting Irrigation

Lift irrigation system with the use of 44 pumps carryout water extraction from the LB main canal. Annual water use shows a decreasing trend (Figure 7.1 and Figure 7.2). In

the lift irrigation system, Maha and Yala season, average flow rates are 0.44MCM and 0.74 MCM respectively. In Maha season the highest volume showed a value of 0.59 MCM in 2008/09. The lowest volume of 0.32 MCM had been in 2011/12. In Yala season the highest volume showed a value of 0.93 MCM in 2010/11 and the lowest volume of 0.44 MCM was in 2012/13. During the study period from 2008/09 to 2012/13 the water use volume has decreased by approximately 46% in total water use in the lift irrigation system. Its detail information are shown in Figure 7.1, Figure 7.2 and Table 7-3.

Table 7-3: Pumped Water Volume in the L.B. Canal System

Water Year	**Volume of Water Pumped for Lift Irrigation System**						
	Maha Season		Yala Season		Total	Difference (Yala-Maha)	
	Quantity (MCM)	Percentage	Quantity (MCM)	Percentage		Quantity	Percentage
2008/09	0.59	39%	0.90	61%	1.49	0.32	21%
2009/10	0.55	40%	0.82	60%	1.37	0.26	19%
2010/11	0.41	31%	0.93	69%	1.35	0.52	38%
2011/12	0.32	35%	0.59	65%	0.91	0.27	30%
2012/13	0.35	45%	0.44	55%	0.79	0.08	10%
Maximum	0.59	45%	0.93	69%	1.49	0.35	24%
Minimum	0.32	31%	0.44	55%	0.79	0.12	24%
Average	0.44	38%	0.74	62%	1.18	0.29	24%

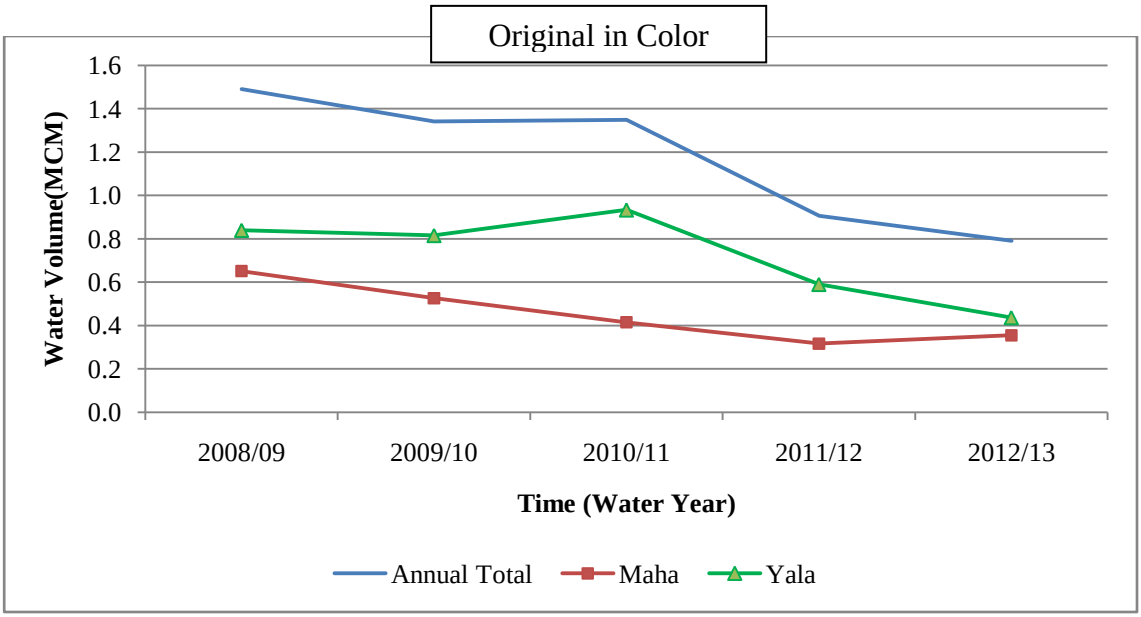

Figure 7.1: Water Volume Pumped for Lift Irrigation System (2008/09 to 2012/13)

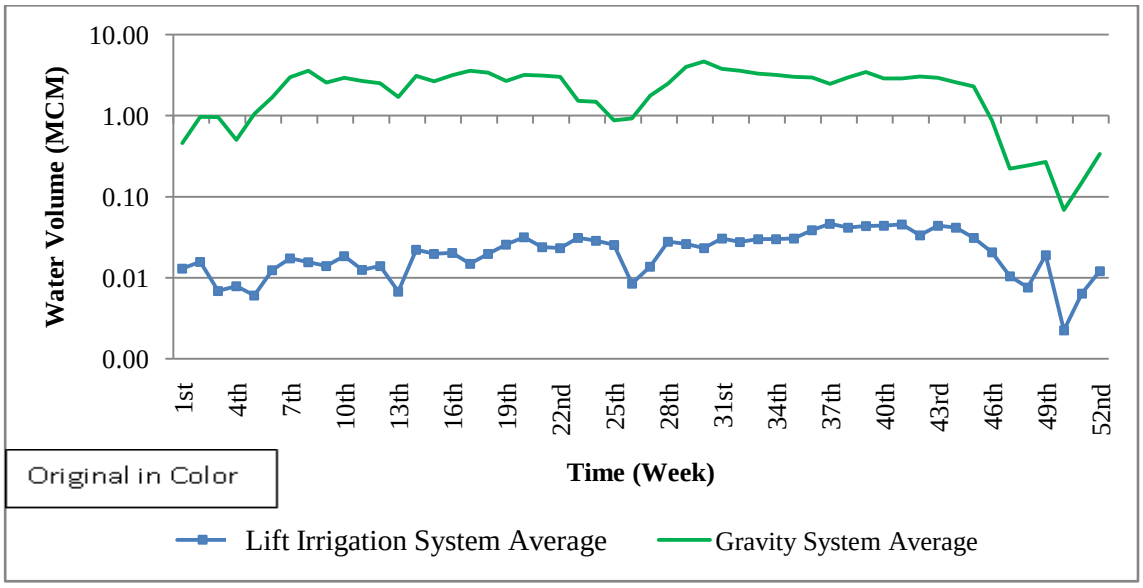

Figure 7.2: Average Quantity of Water Used by the Lift Irrigation System (2008/09 to 2012/13)

7.5 Actual Water use in the Gravity Fed System

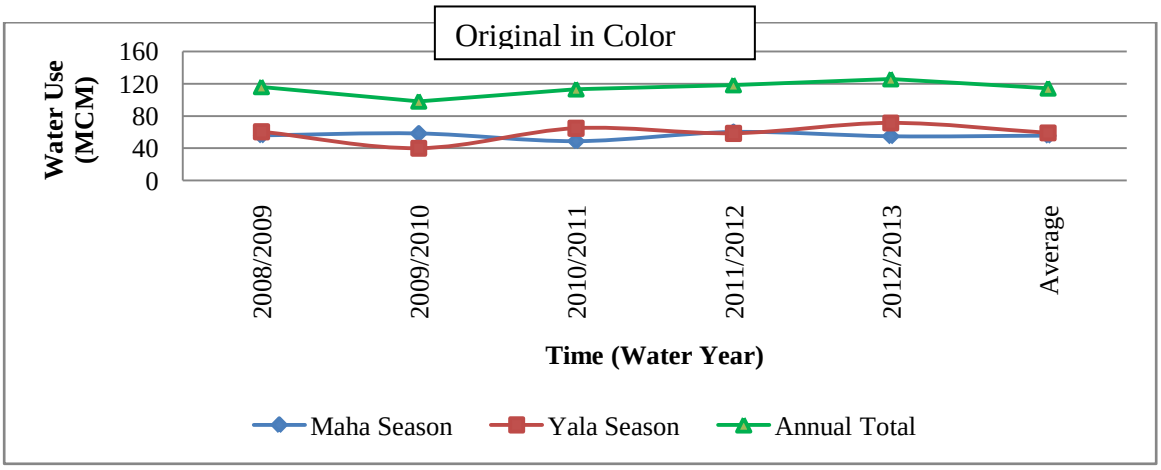

Figure 7.3: Actual Water Use in the L.B. Gravity Fed Irrigation System

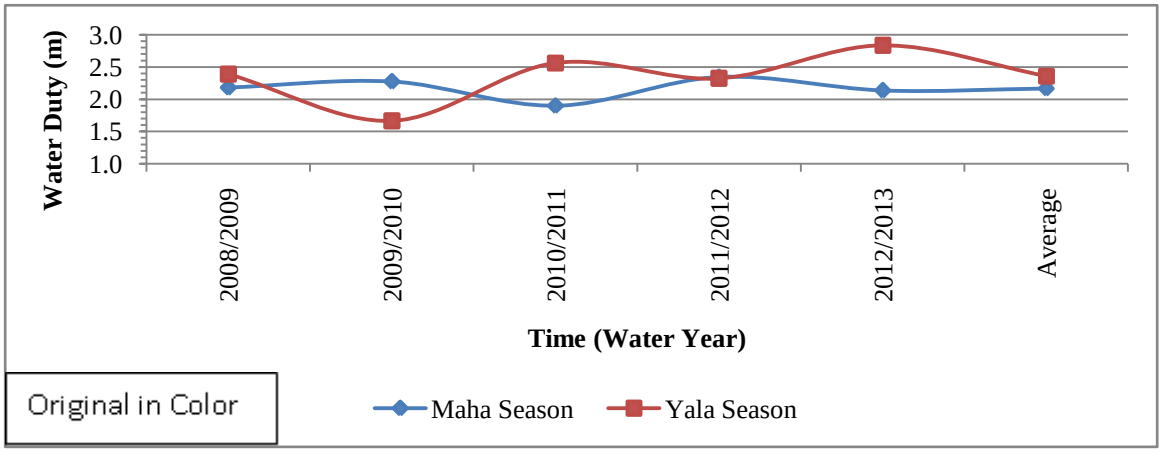

Figure 7.4: Actual Water Duty in L.B. Gravity Fed Irrigation System

Table 7-4: Actual Water Use in L.B. Gravity Fed Irrigation System

Details of Water Use	Season	2008/09	2009/10	2010/11	2011/12	2012/13	Average
Actual Water Use (MCM)	Maha	56	58	49	60	55	56
	Yala	60	40	65	63	78	61
Paddy Cultivated Area(Acres)	Maha	6325	6325	6325	6325	6325	6325
	Yala	6241	5920	6231	6213	6206	6162
Actual Water Duty (m)	Maha	2.20	2.27	1.90	2.36	2.15	2.18
	Yala	2.36	1.56	2.55	2.47	3.06	2.40

Irrigation under the Gravity flow system is the main component of water flow through the Rajangana LB canal system. Except the 2009/2010 water year, other years had similar values of water issue quantities for the gravity irrigation system. During the study period, minimum Maha season water issue volume of 49 MCM had been in the year 2010/11 while the highest Maha season volume was about 60 MCM in 2011/12. In the Yala season, minimum water delivery was about 40 MCM in 2009/10 while highest delivery volume was about 78 MCM in 2012/13 (

Table 7-4). Average actual water duty during Maha and Yala seasons was 2.18 m and 2.40 m respectively. In case of Maha Seasons, a minimum duty of 1.90m was noted in 2010/2011 while maximum duty was 2.36m in 2011/12. Yala season's minimum and maximum water duty values were 1.56m in 2009/2010 and 3.06 m in 2012/2013 respectively.

7.6 Recommended Irrigation Plan (DL1)

According to Irrigation Guideline Recommended Water Plans, the average Maha and Yala season water consumption during the study period had been approximately 34.19 and 43.51 MCM respectively. The annual variation of the same had been between 75.60 MCM and 80.34 MCM respectively from 2008/09 to 2012/13. Comparison of Yala and Maha water requirements noted that, Yala requirement on average is 9.28 MCM (27%) and it is higher than the Maha Season (Table 7-5). Water Duty variation showed that on average, the ID recommended values for the Maha and Yala seasons were 1.34 m and 1.70 m, respectively (Table 7-6**).** Average water duty in the Maha Season demonstrated a 27 % lower value when compared with that of Yala Season.

Table 7-5: Water Use in Recommended Irrigation Plan (DL1) between 2008/09 to 2012/13

Water Year	Water Volume in Plan(MCM)			Difference (Yala-Maha)	
	Maha	Yala	Total	Quantity(MCM)	Percentage
2008/09	32.64	42.92	75.56	10.28	31%
2009/10	34.29	41.39	75.68	7.1	21%
2010/11	34.08	43.61	77.69	9.53	28%
2009/12	34.05	45.02	79.07	10.94	32%
2008/13	35.88	44.46	80.34	8.56	24%
Maximum	35.88	45.02	80.34	10.94	32%
Minimum	32.64	41.39	75.56	7.10	21%
Average	34.19	43.48	77.67	9.28	27%

Table 7-6: Water Duty Corresponding to Recommended Irrigation Plan (DL1) (2008/09 to 2012/13)

Water Year	Water Duty of Recommended Irrigation Plan (DL1)			
	Maha (m)	Yala (m)	Yala - Maha (m)	Percentage
2008/09	1.28	1.68	0.40	31%
2009/10	1.34	1.62	0.28	21%
2010/11	1.33	1.70	0.37	28%
2011/12	1.33	1.76	0.43	32%
2012/13	1.40	1.74	0.34	24%
Maximum	1.40	1.76	0.43	32%
Minimum	1.28	1.62	0.28	21%
Average	1.34	1.70	0.36	27%

7.7 Anticipated Water Use

Seasonal variation of Anticipated Water Use is in the Table 7-7 and Figure 7.5. Table 7-8 shows the comparison of anticipated water duty. If Rajangana farmers and water managers could make full use of the effective rainfall experienced, then for the average study period, the water use in Maha and Yala Seasons would have been only 26.06 and 40.43 MCM respectively. Due to low actual rainfall values experienced during the Yala seasons of entire study period, Yala season anticipated water use was much higher values than those of Maha Season. According to this comparison, average Yala season water use was 14.36 MCM (59%) higher when compared with Maha. Average anticipated water duty in Maha and Yala seasons were 1.02 m and 1.58 m respectively (Table 7-8). The average water duty in the Maha Season demonstrated a 59 % reduction when compared with that of Yala Season.

Table 7-7: Anticipated Water Use for Maha and Yala (2008/09 to 2012/13)

Water Year	**Anticipated Water Use (MCM)**		**Differences(Yala- Maha)**	
			Maha Season	
	Maha	Yala	Quantity (MCM)	Percent
2008/09	24.98	41.41	16.43	66%
2009/10	30.43	37.09	6.66	22%
2010/11	19.52	38.58	19.06	98%
2011/12	29.85	43.96	14.11	47%
2012/13	25.54	41.09	15.55	61%
Maximum	30.43	43.96	19.06	98%
Minimum	19.52	37.09	6.66	22%
Average	26.06	40.43	14.36	59%

Table 7-8: Water Duty of Anticipated Water Use from 2008/09 to 2012/13

Water Year	Water Duty (m)		Water Duty Difference	
	Maha	Yala	(Yala-Maha) m	Percentage Difference
2008/09	0.98	1.62	0.64	65%
2009/10	1.19	1.45	0.26	22%
2010/11	0.76	1.51	0.75	99%
2011/12	1.17	1.72	0.55	47%
2012/13	1.00	1.61	0.61	61%
Maximum	1.19	1.72	0.75	99%
Minimum	0.76	1.45	0.26	22%
Average	1.02	1.58	0.56	59%

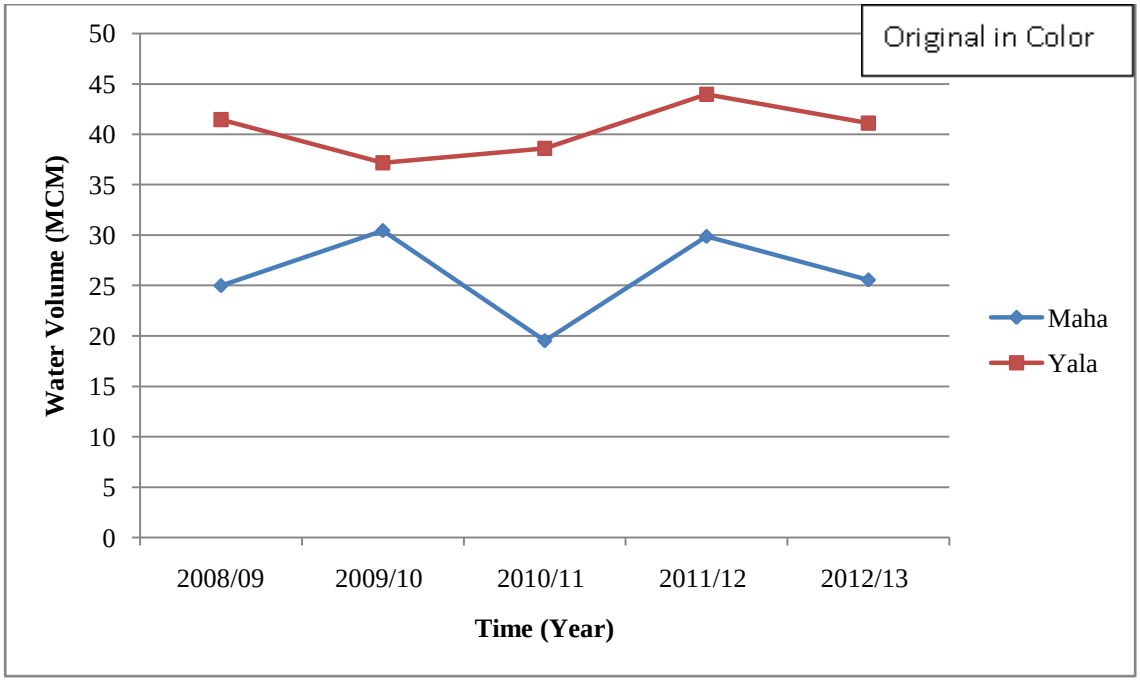

Figure 7.5: Anticipated Water Use in Maha and Yala (2008/09 to 2012/13)

7.8 Comparison of Rajangana ID Plan and Recommended Irrigation Plan (DL1)

Seasonal water use quantity and water duty comparisons are shown in Table 6-11 to Table 6-13, Figure 6.37, Figure 6.38. Figure 7.6 shows the variation in the difference. Values are also given in Table 7-9 and in Appendix 5.

The comparisons clearly indicates that the Rajangana ID Plan has a higher water duty throughout the study period than the Recommended Irrigation Plan (DL1). In Maha season, water duty is 37% higher in the Rajangana ID Plan when compared with the Recommended Irrigation Plan (RIP). In Yala season water duty is 25% higher than the ID Recommendation (Table 6-13). The differences in the water volume on average are approximately 12.59 MCM and 42.09 MCM respectively for Maha and Yala seasons.

Table 7-9: Annual Water Use Difference between the Rajangana ID Plan and Recommended Irrigation Plan (DL1)

Water Year	**Rajangana ID Plan and Recommend Irrigation Plan Difference**				
	Annual Difference (MCM)	Rajangana ID- RIP in Maha		Rajangana ID- RIP in Yala	
		Quantity (MCM)	%	Quantity (MCM)	%
2008/09	45.68	18.55	41%	27.13	59%
2009/10	36.47	11.26	31%	25.21	69%
2009/11	59.99	10.11	17%	49.89	83%
2010/12	58.88	13.79	23%	45.09	77%
2012/13	72.42	9.27	13%	63.15	87%
Maximum	72.42	18.55	41%	63.15	87%
Minimum	36.47	9.27	13%	25.21	59%
Average	54.69	12.59	25%	42.09	75%

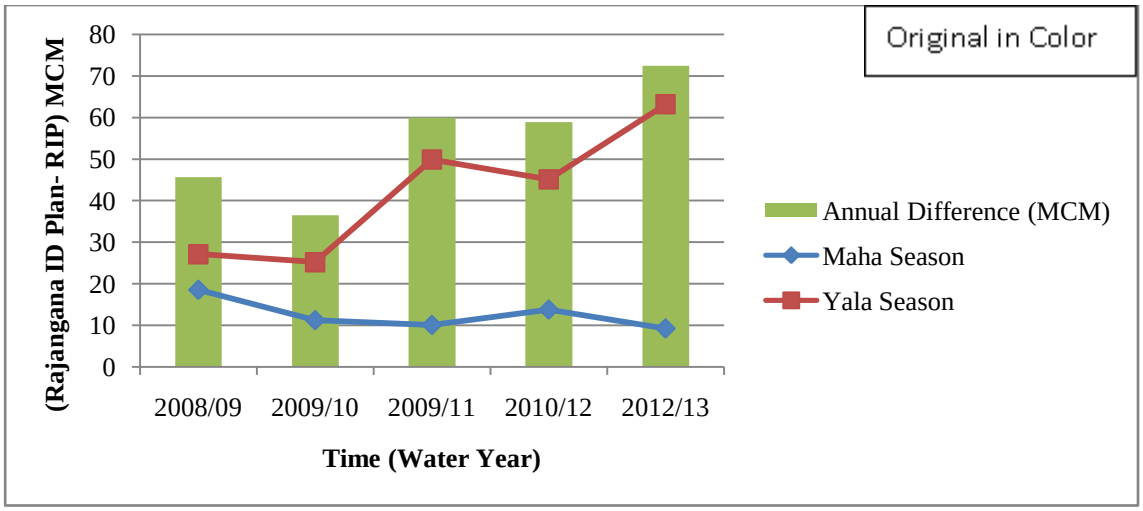

Figure 7.6: Comparison of Seasonal Water Use Differences with Annual Total Difference between Rajangana ID Plan and Recommended Irrigation Plan (DL1)

Maha Season average of the difference in respective plans is 25% while Yala difference is 75% of water volume when compared with Ponrajah (1988). In the present work, when computing the values for Recommended ID Plan, the ID Guideline was followed with the same basedata used by Rajangana Irrigation Engineer's Division. Due to availability limitations, these plans could be evaluated only at a monthly scale. It is probable that the temporal aggregation would have had an impact on the results. However the comparison done for this study shows that there is a requirement to evaluate the assumptions, basedata, and practices incorporated, when interpreting the ID guidelines for water issue planning and scheduling.

7.9 Comparison of Actual Water Use and Recommended Irrigation Plan (DL1)

Comparison of water volume and water duty during Maha and Yala seasons from various points of view are shown in Figure 6.46, Figure 6.50, Figure 6.51, Figure 6.52, Figure 6.54, Figure 7.7 and Figure 7.8. The annual and seasonal water quantity differences are shown in the Table 7-10 and in Table A6-8 and A6-9 of Appendix 6. Differences are shown in Figure 6.52 to Figure 6.54 and Figure 7.9 and in Appendix 6.

Table 7-10: Water Use Difference between Actual Water Use and Recommended Irrigation Plan (DL1)

Water Year	Difference between Actual Water Use and Recommend Irrigation Plan				
	Annual Difference (MCM)	Maha		AWU- RIP in Yala	
		AWU- RIP (MCM)	(AWU- RIP)/RIP	AWU- RIP (MCM)	(AWU- RIP)/RIP %
2008/09	40.96	23.60	58%	17.36	42%
2009/10	22.33	23.91	107%	-1.58	-7%
2010/11	36.19	14.52	40%	21.67	60%
2011/12	44.54	26.39	59%	18.15	41%
2012/13	53.11	19.18	36%	33.93	64%
Maximum	53.11	26.39	107%	33.93	64%
Minimum	22.33	14.52	36%	-1.58	-7%
Average	39.43	21.52	60%	17.91	40%

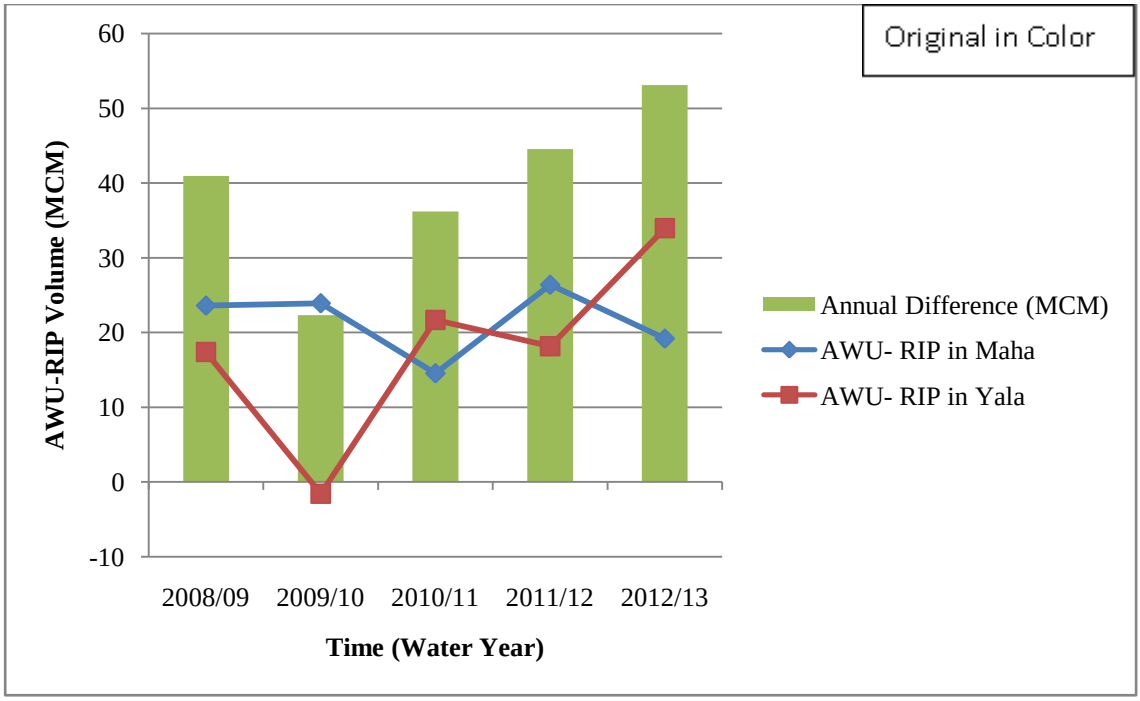

Figure 7.7: Water Quantity Difference between Actual Water Use and Recommended Irrigation Plan (DL1)

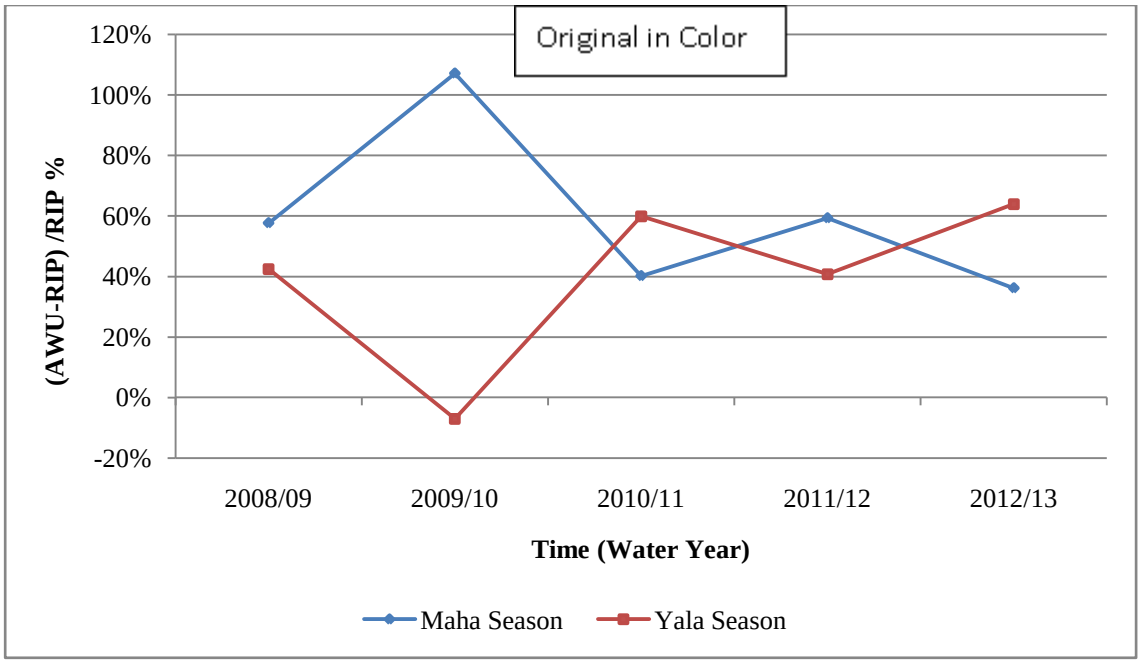

Figure 7.8: Percentage of Water Use Difference in Maha and Yala season separately (2008/09 to 2012/13)

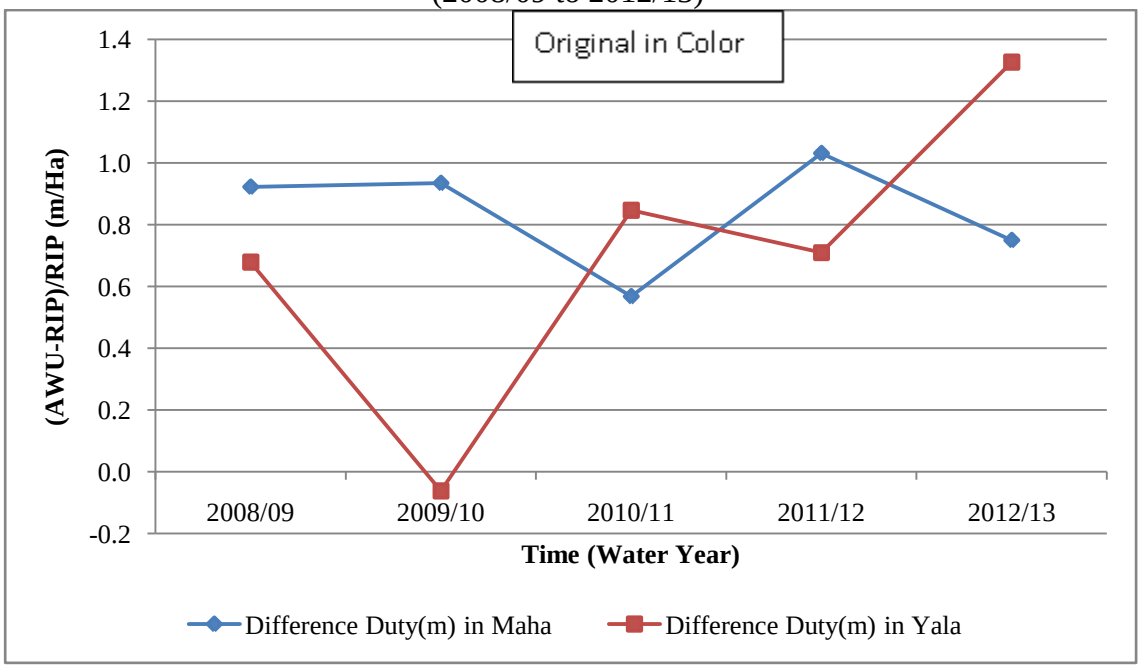

Figure 7.9: Seasonal Water Use Difference per Unit Area.

The following are the key factors noted during the evaluation.

- Average water use in the Maha and Yala seasons indicated that the overuse quantities are 21.52 and 17.91 MCM respectively. Accordingly these values were 63% and 52% higher than the respective quantities planned for Maha and Yala seasons. This difference could be noted throughout the study period. In the present study computation of weekly values, the timing of seasons, base data etc., were carefully checked and matched to avoid unrealistic situations. Since the pumped water quantities are very low when compared with gravity system, any minor inaccuracies in the lift irrigation extractions would not lead to such a significant effect when comparing the quantities. Therefore the large difference is most likely due to practices in the gravity fed system. In reality, water demands are adjusted to suit field conditions and to farmer requests thereby leading to large differences. Another reason could be that the planned water quantities are issued without considering the contribution made by the actual rainfall within the cultivation period. The recommended ID plan computations assumed a single stagger as quoted in the field data. However it appears that there is a requirement for staggers since the area to be cultivated is large and machine power is limited in the irrigation scheme. Due to Lack of flow data in secondary and tertiary canals, it was not possible to check the changes that would occur due to shifts in growing seasons, farmer delays in land preparation etc. However it is important to note that the difference is quite significant. Even if 25% of the water quantity difference is attributed to the effects of assumptions made for data deficiencies, still the overuse values point to need of early attention.
- In the year 2010/11, Maha season had used a water quantity which is lower than the other four years. The difference in this year is 14.52 MCM which is equal to 40% of Recommended Irrigation Plan (DL1) volume indicating that the over use in the best match year is 43% of the Recommended ID Plan. Highest actual Maha Season water volume difference of 26.39 MCM is in 2011/12. This reflects that the water

over use is approximately 78% higher when compared with the Recommended Irrigation Plan (DL1). In the Maha season, average over use relative to Irrigation Department Guideline is 21.52 MCM which shows that the average over use is at a 63% high value (Table 7-10 and Table A6-8).

- 2009/10 Yala season demonstrated that the Recommended ID Plan computed value is 5% higher than the actual use (Table A6-8). This shows a possible water scarce situation in this particular year in which farmers resorted to stringent water management techniques as recommended in the ID Guidelines. The rainfall variation (Figure 5.13 - Figure 5.17) shows that in this year and in the previous year, the annual rainfall had dropped. The behavior is not consistent though there had been a very dry Yala season in the 2008/09. There had been overuse in the same year. 2009/10 Maha season overuse demonstrates the worst during study period. A close look at the comparison of Figure 6.61 shows that the actual water use not only matches with the Yala season but also coincide adequately with the land preparation period. Both these have contributed to the minimum overuse value.
- The maximum seasonal difference in water volume is 33.93 MCM in 2012/13 and it reflects that the actual water use has jumped to 176% of the Recommended Irrigation Plan (DL1) when compared with the 140% of the previous year (Table A6-6). It appears that presence of water in the reservoir prompts managers to extend the quantities to higher values than those stated in the Guidelines. Yala season's average difference between the Actual and ID Recommended Plan is 17.91 MCM reflecting that the 'Actual Water Use' in this season is at a value of 141% of the Recommended Plan (Table 7-10 and Table A6-6).
- Comparisons show (Table A6-9) that an annual average water volume of about 39.43 MCM is released exceeding the estimates done according to the Irrigation Department Guidelines. This 51% is more than the volume recommended by irrigation guidelines
- The differences in the seasonal water quantities are well reflected in water duty values and also in the weekly comparisons. Water duty of actual water use is 2.18m

and 2.40m in Maha and Yala respectively whereas, in the Recommended Irrigation Plan (DL1), the respective values are 1.34m and 1.70m. According to these values the average actual water duty is 63% and 41% higher than Recommended Irrigation Plan (DL1) for Maha and Yala seasons respectively.

- It appears that either farmers or the controlling agencies responsible for water management in the Rajangana Irrigation Scheme had over used water since water is in abundance. In case this assumption is not correct, the other possible reason could be that the ID guideline recommendations differ widely when it comes to the application at the Rajangana Irrigation Scheme.
- Water use in the rainy Maha Season is higher than the dry Yala season. This reflects that there is a little effort to make maximum use of rainfall and also to save water for the Dry Season. Hence the values and comparisons indicate that there is no water shortage in the Rajangana Reservoir.

7.10 Comparison of Actual Water Use and Anticipated Water Use

Comparison of 'Actual Water Use' and 'Anticipated Water' Use enables capturing the level of actual rainfall utilization during water issues. Results indicate that throughout the study period the Actual Water Use is higher than the Anticipated Water Use, thus indicating a lack of efforts to make good use of rainfall received at the paddy fields. On average, Maha season indicated that Actual Water Use is more than twice the amount of Anticipated Water Use while in the Yala season it is approximately 1.5 times. In an annual basis, the difference indicates that the Actual Water Use is approximately 1.77 times more than the Anticipated. The following details could be noted during the evaluation. Comparative statistics for the study period are shown in Table A7-3, A7-6 and A7-7 of Appendix 7.

- In Maha season, average volume of actual water use is 55.71 MCM which is 114% more than the value of the anticipated water use. The minimum difference of 27.78 MCM had been in 2009/10 while the maximum difference of 31.26 MCM had been

in 2008/09. In these two years the Actual Water Use in the respective years had been 91% and 125% more than the Anticipated Water Use.

- In Yala season, the average Actual Water Use is higher by 20.99 MCM and in comparative terms, this over issue is 51% of the average Anticipated Water Volume in Yala season. The minimum difference between the two is in the year 2009/10 (2.82 MCM, 8%) while the maximum is in the year 2010/11 (37.30 MCM, 91%).
- Table A7-8 shows Maha and Yala season water duty behavior throughout the study period reflecting the same behavior shown in the volumes of water released at the LB sluice. When compared with the anticipated irrigation water duty in Maha and Yala seasons, the additional water issues in the respective seasons amount 117% and 51% of the anticipated water use. It is important to note that in other years these values are approximately between 44% and 91% high, in the Yala season of 2009/10 this value had dropped to 8%.
- Comparison of the difference between actual and anticipated water use during the crop growth stages showed that the percentage of water use differences in Maha Season are higher than the Yala season differences and its details are shown in Table 7-11 - Table 7-13 and in Table A7-4 and A7-5 of Appendix 7. On average land preparation has the lowest difference (48%) and initial growth stage has the highest percentage difference in Maha Season (310%). In the Yala season, Development stage had the lowest (25%) water use difference between Crop Growth Stages. The initial stage of Yala season had 96% as the highest difference between the Actual Water Use and Anticipated Water Use (Figure 7.11 - Figure 7.13). These averages for the study period showed that the initial crop growth stage reflects the highest actual and anticipated difference.

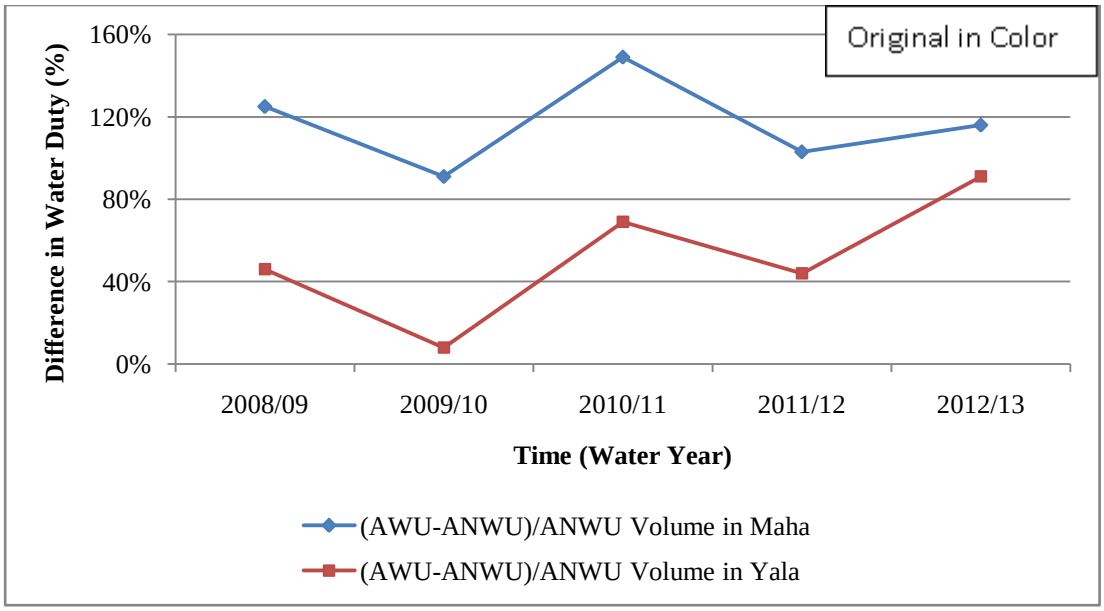

Figure 7.10: Seasonal Difference between Actual Water Use and Anticipated Water Use (2008/09 to 2012/13)

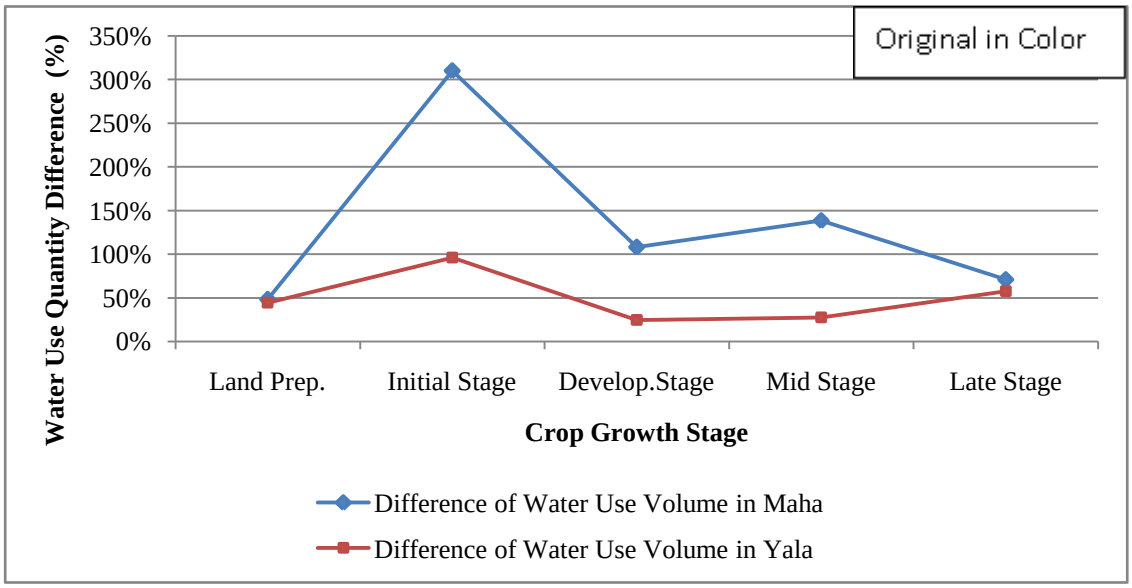

Figure 7.11: Comparison of Crop Growth Stage Water Use Volume Difference (2008/09 to 2012/13)

Table 7-11: Water Volume Differences between the Actual Water Use and Anticipated Water Use according to Crop Growth Stage from 2008/09-2010/11

Season	Crop Growth Stage	2008/2009			2009/2010			2010/2011		
		ANWU (MCM)	AWU (MCM)	(AWU - ANWU / ANWU)%	ANWU (MCM)	AWU (MCM)	(AWU - ANWU / ANWU)%	ANWU (MCM)	AWU (MCM)	(AWU - ANWU / ANWU)%
Maha Season	Land Preparation	6.84	6.84	0%	6.72	8.49	26%	4.80	9.74	103%
	Initial Stage	3.00	15.61	420%	1.30	10.76	729%	1.78	7.85	342%
	Developing Stage	4.26	10.03	135%	6.16	11.93	94%	4.21	10.14	141%
	Mid Stage	4.12	19.71	378%	8.70	14.63	68%	3.93	9.39	139%
	Late Stage	6.76	4.05	-40%	7.55	12.39	64%	4.79	11.48	140%
Maha Season Total		24.98	56.24	125%	30.43	58.20	91%	19.52	48.60	149%
Yala Season	Land Preparation	6.45	11.44	77%	5.89	6.73	14%	3.20	9.84	208%
	Initial Stage	6.28	12.82	104%	5.45	6.59	21%	6.44	13.00	102%
	Developing Stage	10.39	13.10	26%	9.48	7.89	-17%	9.60	14.42	50%
	Mid Stage	10.70	11.14	4%	9.03	10.04	11%	11.10	14.09	27%
	Late Stage	7.59	11.82	56%	7.23	8.64	20%	8.25	13.92	69%
Yala Season Total		41.41	60.32	46%	37.09	39.90	8%	38.58	65.27	69%
Annual Total		66.39	116.56	171%	67.52	98.11	99%	58.10	113.87	218%

Table 7-12: Water Volume Differences between the Actual Water Use and Anticipated Water Use according to Crop Growth Stage from 2011/12 to 2012/13

Season	Crop Growth Stage	2011/2012			2012/2013			Annual Average	
		ANWU (MCM)	AWU (MCM)	(AWU - ANWU / ANWU)%	ANWU (MCM)	AWU (MCM)	(AWU - ANWU / ANWU)%	(AWU – ANWU) (MCM)	(AWU - ANWU / ANWU)%
Maha Season	Land Preparation	4.29	8.24	92%	6.21	9.45	52%	2.78	55%
	Initial Stage	3.90	8.23	111%	2.71	9.62	255%	7.88	372%
	Developing Stage	7.21	13.14	82%	3.96	8.42	113%	5.57	113%
	Mid Stage	7.68	16.51	115%	7.24	15.14	109%	8.74	162%
	Late Stage	6.76	14.32	112%	5.42	12.43	129%	4.68	81%
Maha Season Total		29.85	60.44	103%	25.54	55.06	116%	29.65	117%
Yala Season	Land Preparation	7.05	5.76	-18%	7.40	9.54	29%	2.67	62%
	Initial Stage	6.87	15.89	131%	6.31	13.13	108%	6.02	93%
	Developing Stage	11.19	12.85	15%	10.29	15.18	48%	2.50	24%
	Mid Stage	10.04	10.47	4%	9.08	17.89	97%	2.73	29%
	Late Stage	8.81	18.21	107%	8.02	22.64	182%	7.07	87%
Yala Season Total		43.96	63.17	44%	41.09	78.39	91%	20.99	51%
Annual Total		73.80	123.61	147%	66.63	133.45	207%	50.63	168%

Table 7-13: Percentage Differences of Water Volume between Actual Water Use and Anticipated Water Use within the Crop Growth Stage Period.

Percentage Water Use Difference (Actual-Anticipated)/Anticipated						
Maha Season		Land Prep.	Initial Stage	Development Stage	Mid Stage	Late Stage
	Maximum	103%	729%	141%	378%	140%
	Minimum	0%	111%	82%	68%	-40%
	Average	48%	310%	108%	138%	71%
Yala Season		Land Prep.	Initial Stage	Development Stage	Mid Stage	Late Stage
	Maximum	208%	131%	50%	97%	182%
	Minimum	-18%	21%	-17%	4%	20%
	Average	44%	96%	25%	27%	57%

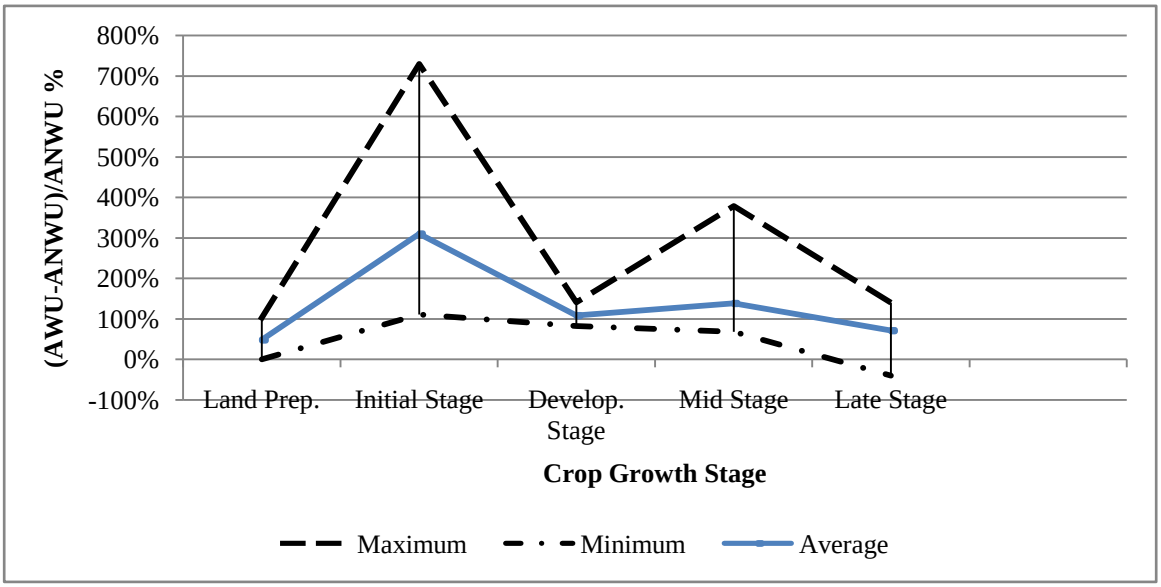

Figure 7.12: Average Difference in Actual Water Use and Anticipated Water Use at Each Crop Growth Stage (Maha Season)

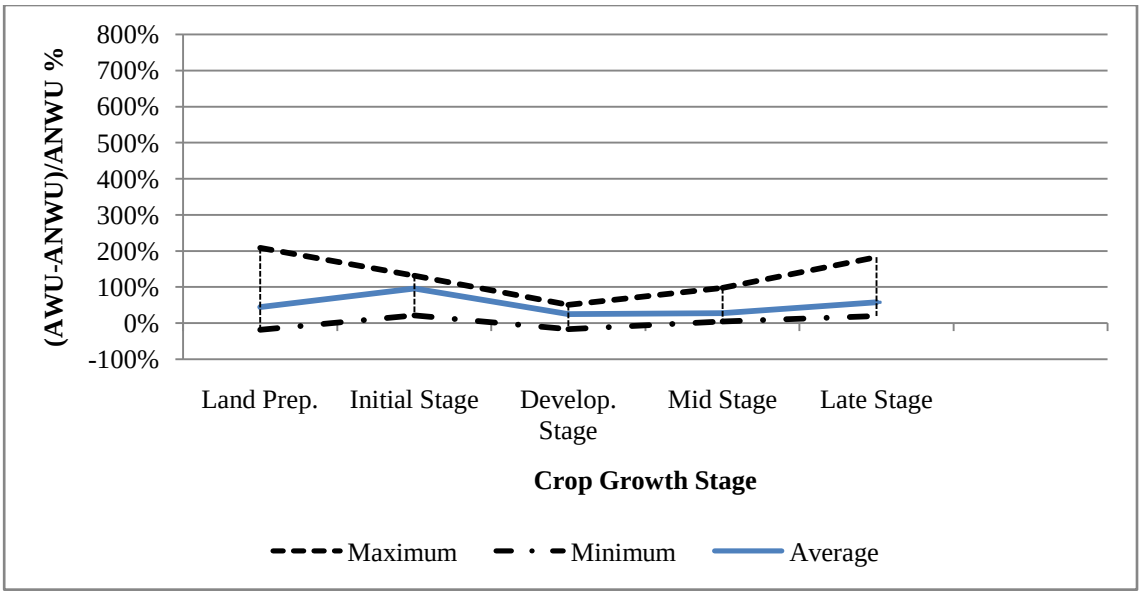

Figure 7.13: Average Difference in Actual Water Use and Anticipated Water Use at Each Crop Growth Stage (Yala Season)

A comparison of Actual Water Use and the Anticipated Water Use was done to capture the differences in the crop growth stages. Though the differences were relatively small in the Yala season, a significantly high "Actual Use" value could be seen in all crop growth stages for both seasons.

Low values of water use difference in the Maha season could be seen in the Land Preparation and in the Late Season crop growth stages. In the Yala season the low differences were in the Crop Development and Maturity Stages. The highest deviation in the Maha Season is during Initial Crop Growth Stage while the highest in the Yala Season is during Land Preparation Stage.

Significant over use which demonstrated a spreading across all crop development stages shows that there is a short coming in the full use of effective rainfall during cultivations. The overuse needs careful investigation of farmer practices. It is important to ascertain whether farmers are mismanaging the system or whether the system is in a poor status leading to significant water losses. It is also worthy to investigate whether the determination of effective rainfall, crop factors, and other recommendations in the

Irrigation Department Guidelines are causing this disparity. Another reason for the considerable differences could be the notion of water abundance in the Rajangana Reservoir and utilizing the precious water resource even without a need.

7.11 Comparison between Recommended Irrigation Plan (DL1) and Anticipated Water Use

Maha season average value comparison for all crop growth stages showed that the Recommended Irrigation Plan estimates were higher than the Anticipated Water Use (Table A8-4). This indicated that on average, contributions made by rainfall received at Rajangana during Maha season was higher than the 75% probable rainfall of Kala Wewa as reported in the ID Guidelines. In case all other parameters remained constant and rainfall received at Rajangana was accounted during water releases, then there would have been average water saving of approximately 8 MCM in the Maha Season (Table A8-6).

In the Yala season, for two crop growth seasons the rainfall contribution had been lesser than that assumed at the planning stage. Average anticipated water use shows that in total there would have been a water saving of 3.05 MCM per Yala season if actual rainfall was accounted for during water issues (Table 7-14).

Comparison of annual water volumes shows that on average, proper accounting of actual rainfall could reduce approximately 11.18 MCM of water usage. Out of this, the larger quantity would be the possible reduction corresponding to the Maha Season. Though the Yala season showed a possible improvement, on average, the amount is 3.05 MCM which is approximately 8% of the estimations done with the 75% probable rainfall. Annual totals of possible water savings during the study period varied between 5.27 MCM and 19.59 MCM (Table A8-7). Water duty comparisons for the entire study period showed that accounting of actual rainfall at Rajangana would have resulted in a 1.02m water duty for Maha season, instead of 1.34m estimated according to ID guideline. Yala season water duty in the study period would have reduced to 1.58 m from the ID estimation of 1.70m (Table A8-8). Average values of water quantity and

water duty reflect that during the study period, Maha season rainfall at Rajangana had been well above the 75% probable rainfall while the Yala rainfall had matched the 75% probable rainfalls assumed at the pre-season planning.

Average deviation of the Anticipated Water Use from the Recommended ID Plan (DL1) at each crop growth stage was quantified and averaged for the study period (Table 7-14, Table 7-15). These values show that advantages during the Maha season appear lowest in the late season while for the Yala season advantages arrive in the land preparation, maturity and late season growth periods. Computation of percentage deviations (Table 7-15, Figure 7.15 and Figure 7.16) also shows that Maha season advantages during all crop growth stages significantly vary between years. Yala season percentage deviations show only a little deviation in the Crop Development, Mid-Season and Late-Season crop growth stages.

Table 7-14: Average Difference between Anticipated Water Use and Recommended Irrigation Plan for Each Crop Growth Stage

Season		**Average Value for 2008/09 - 2012/13**		
	Growth Stage	Anticipated Water Use (AWU) MCM	Recommended ID Plan (RIP) MCM	(RIP-ANWU) MCM
Maha	Land Prep	5.77	7.34	1.57
	Initial	2.54	3.88	1.34
	Crop Dev.	5.16	7.18	2.02
	Maturity	6.33	9.16	2.82
	Late Season	6.26	6.63	0.38
	Total	26.06	34.19	8.13
Yala	Land Prep	6.00	7.04	1.05
	Initial	6.27	4.64	-1.63
	Crop Dev.	10.19	9.92	-0.27
	Maturity	9.99	11.09	1.10
	Late Season	7.98	10.79	2.81
	Total	40.43	43.48	3.05
Annual Total		66.49	77.67	11.18

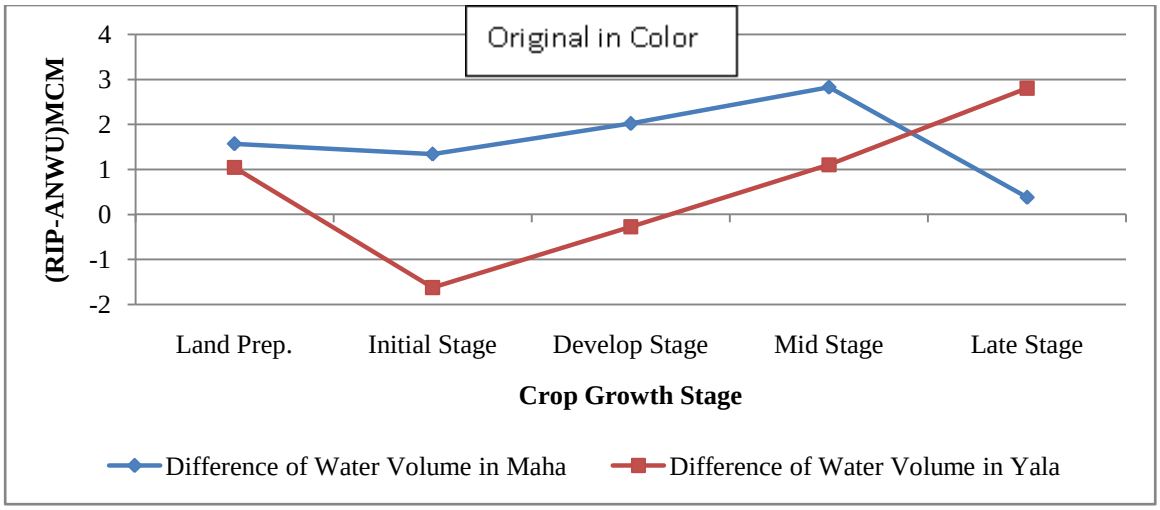

Figure 7.14: Water Use Difference between Recommended Irrigation Plan and Anticipated Water Use for each Crop Growth Stage

Table 7-15: Percentage Deviation of Anticipated Water Use from the Recommended Irrigation Plan (DL1) (2008/09-2012/13)

Percentage Deviation of Water Use in Crop Growth Stages (2008/09-2012/13)				
(Recommended - Anticipated)/Recommended				
Season	Growth Stage	Average	Maximum	Minimum
Maha	Land Prep.	27%	74%	-29%
	Initial Stage	53%	180%	-9%
	Develop Stage	39%	93%	-4%
	Mid Stage	45%	181%	3%
	Late Stage	6%	58%	-55%
Yala	Land Prep.	11%	58%	-34%
	Initial Stage	-44%	6%	-98%
	Develop Stage	-3%	9%	-14%
	Mid Stage	10%	18%	3%
	Late Stage	19%	31%	1%

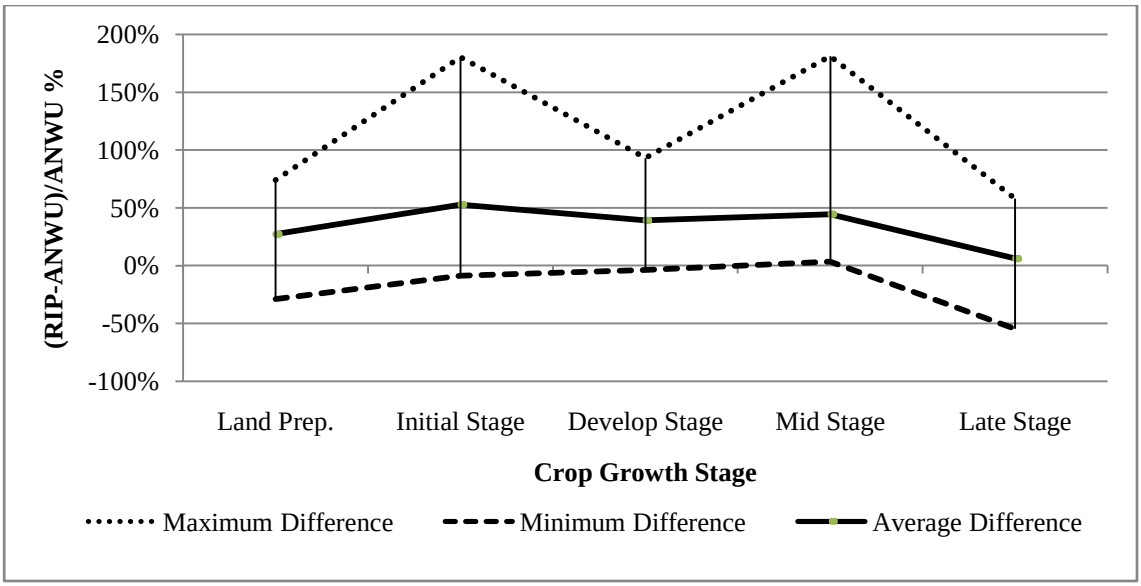

Figure 7.15Annual Variation of Anticipated Water Use from the Recommended ID Plan (DL1) in Maha Season (2008/09-2012/13)

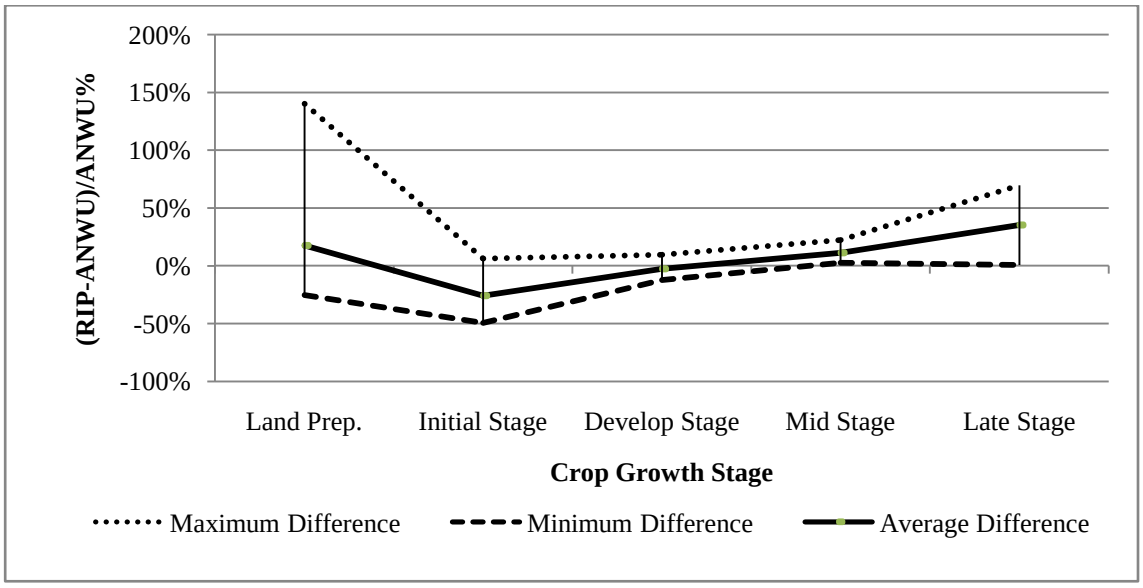

Figure 7.16: Average Variation of the Anticipated Water Use from the Recommended ID Plan (DL1) in Yala Season (2008/09-2012/13)

7.12 Relation of Actual Water Use and Crop yield

Variation of Actual Water Use and the Crop Yield per unit area (Figure 7.17) reflects that there may be a close link between the two. Most of the years showed that with the

rise of actual water use, there is a rise in the yield but it is important to find whether there is a direct correlation. Table 7-16 gives the corresponding values.

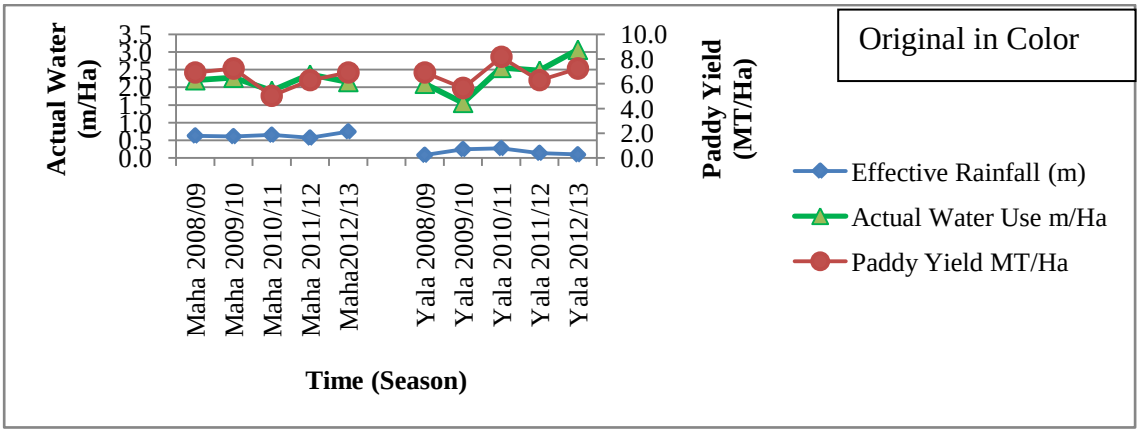

Figure 7.17: Seasonal Rainfall, Actual Water Use and Paddy Yield Per Unit Area (2008/09-2012/13)

Table 7-16: Paddy Yield Relation with Actual Water in Both Season (2008/09-2012/13)

Season	Water Year	Actual Water Use m/Ha	Yield/Actual water (MT/m)	Paddy Yield MT/Ha
Maha	2008/09	2.20	3.14	6.91
	2009/10	2.27	3.18	7.22
	2010/11	1.90	2.64	5.02
	2011/12	2.36	2.66	6.28
	2012/13	2.15	3.21	6.91
	Average	2.18	2.97	6.47
Yala	2008/09	2.10	3.29	6.91
	2009/10	1.56	3.62	5.65
	2010/11	2.55	3.20	8.16
	2011/12	2.47	2.54	6.28
	2012/13	3.06	2.36	7.22
	Average	2.35	3.00	6.85

Figure 7.18 shows that though there is a general tendency indicating an increase in the yield with an increase in the water use. However, a close look at the values demonstrate water use with very little change in yield. Yala season demonstrates a high

Figure7.19 shows the average "yield per actual water use" for both seasons of the study period. It is important to note the sharp decline of yield per actual water use in the Yala season of study period. Out of the 5 years in the study period, three had shown values closer to 3 MT/m. In the other two years, it had lowered to approximately 2.6 MT/m. These behaviors suggest the need of a critical evaluation by considering social, physical and cultural factors in order to arrival at optimum water utilization.

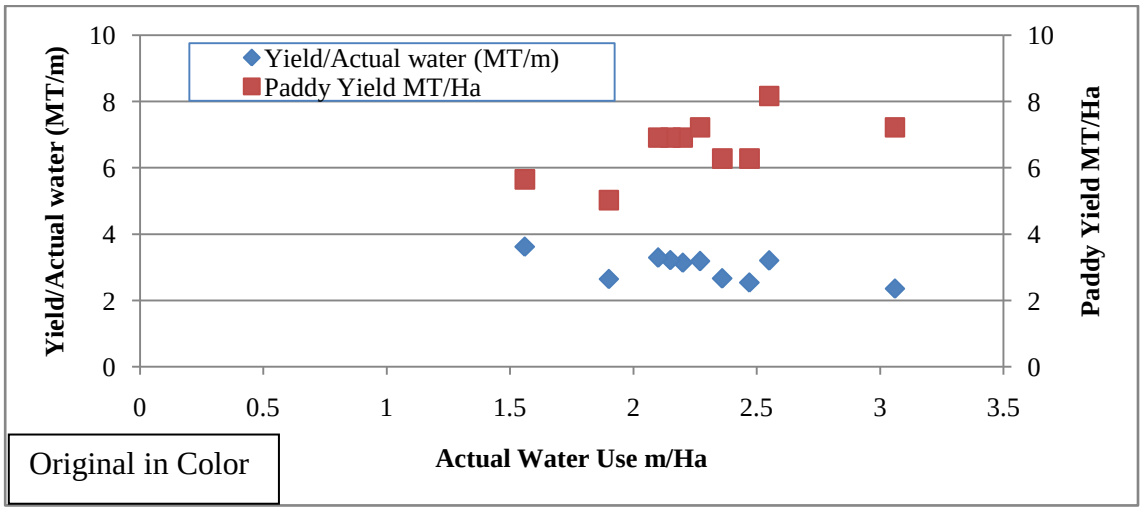

Figure 7.18: Seasonal Variation of Paddy Yield and Actual Water Use (2008/09 - 2012/13)

Figure7.19 is a clear demonstration of whether the water use is productive or not. During the study period, the Yala season had been the most productive with a maximum yield per unit of water amounting to 3.62 MT/m. The seasonal average 2.99 MT/m shows a sharp increase in the water use without receiving proportionate increase in yield. Study Results of present study show four less productive seasons in the last three

years.

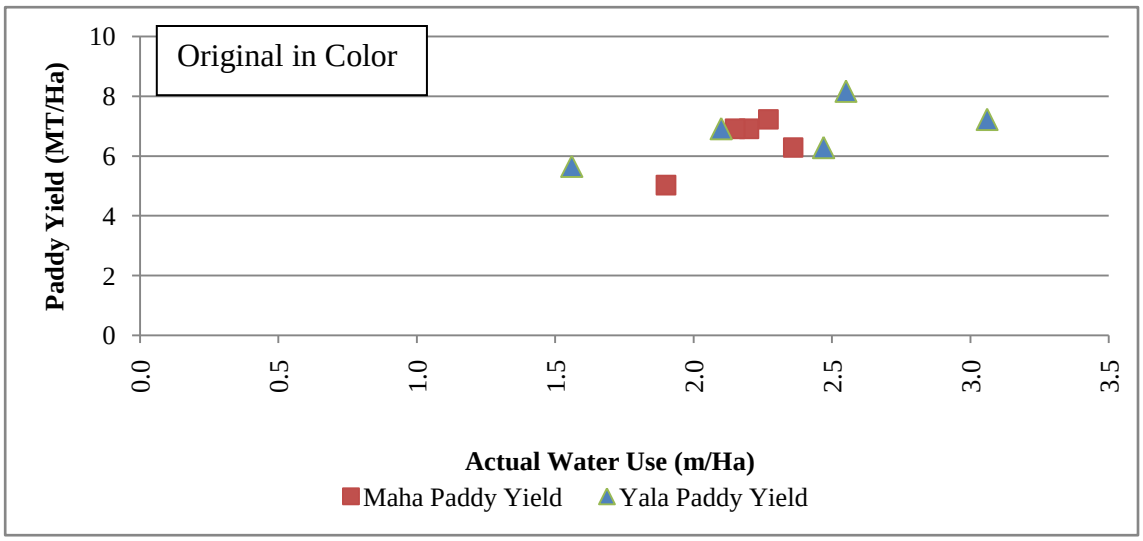

Figure7.19: Yield and Actual Water Duty in Maha Season (2008/09-2012/13)

7.13 Water Utilization

Comparison of the Recommended ID Plan (DL1) and the Rajangana ID plan showed a huge disparity in the water use volumes. Therefore it is important to carry out a careful evaluation of the present practices, computational assumptions and the accuracy of base data to ensure that water scheduling is done in a consistent manner. It could be noted that for reliable water planning the present ID guideline would require scientific determination of the experiences water use from the inception of Rajangana Scheme considering the up-to-date field practices.

Within the entire study period, Actual Water Use measured at the sluice outlet had been significantly higher than the Anticipated Water Use and the Recommended Irrigation Plan water volumes according to the ID guidelines. This excess water utilization could be either due to more water used in the farms for crop growth, or wasted by farmers as application losses, or due to water losses in the canals due to operation and maintenance deficiencies, or due to erroneous measurements as a result of sluice calibration requirements. However, data limitations in the present study clearly recognized a very high difference in the actual water use, when compared with the values computed

according to Irrigation Department Guidelines. Order of magnitude of the difference identified by this research reflects that there is a clear necessity to further investigate and perform appropriate management of scarce water resources. It is also important to note that this high difference could also occur due to an underestimated water requirement caused by the parameters and data recommended in the guidelines. Water overuse could also be due to a flexible practice of water issues in order to use excess water in the reservoir thus avoiding spillage.

Computations also revealed a practice that lacks making adjustments to irrigation plans in order to incorporate actual rainfall as and when received at the field. This could be seen in the large differences between the Actual Water Use and the Anticipated Water Use. The present study sheds light to the need of a careful monitoring system for the LB main canal water issues. To capture the cause for the overuse, it is very important to commence a 'canal flow gauging' arrangement covering primary, secondary and tertiary canals.

7.14 Methods of Cultivation, Water Scheduling and Water Issues

The present study identified that in the Rajangana LB Canal System, 100% of the Area in Maha season and approximately 98% of the area in Yala season is cultivated with paddy. The varieties of paddy cultivated during the both seasons are short duration of 105 day variety. This is a deviation from the anticipated crop for Maha season which is 135 day paddy variety (Ponrajah 1988). During discussions with water experts and at field level stakeholder consultations, it was indicated that the reason for selection of 105 day paddy for Maha Season was the restrictions in the water availability. This contradicts the finding from the present study which revealed that there is a significant over issue of water in the LB canal system when compared with that recommended in the ID Guidelines. Hence it is important to carry out a more focused investigation to understand the underlying reasons for the change. The study also identified that Rajangana water planners had not considered a stagger in the water scheduling. Practice of a stagger could not be captured during the field work too. However it was

noted that in many instances the canal free board is encroached for enhanced water delivery. A hidden unstructured stagger according to the adjustments sought by individual farmers could also be a reason for the selection of a shorter paddy variety because it provides more room for manipulation. It is also important to note that the change in the paddy variety was first noted during the evaluation of actual water issue quantities on a weekly time scale. Though there should be a time saving of at least 30 days when using a shorter variety, the study could not understand whether the farmers had used this time saving for their advantage by at least growing OFC in between seasons. Especially where it appears that there is water in abundance.

It was recognized that there is a difference in the Rajangana ID plans and water issue requirements computed by this study. Commutations by the two parties used the same ID guidelines and field data but calculations were carried out separately. This reveals that there is room to improve the clarity of ID guidelines together with an updating of the data used for these recommendations.

The present study points to the need of updating the ID Guideline through a well structured research program. Up to now water managers and farmers had maintained only the water issue records at the two main sluices. Pump operation hours were the only available records to capture water extractions. This deprived a more detailed evaluation of water use efficiencies and other factors that could have led to a better understanding of water issue deviations from the ID guideline recommendations. Also the lack of a detailed measuring and recording system for the canal system prevents the evaluation of spatial differences, issues and strengths that could show the way to better water use. Data scarce situations were overcome by incorporating educated extrapolation techniques. Hence it is important to appreciate the order of magnitude of the results highlighted in the present research. Though the study recognized that the farmers and water managers adjust the water issue schedules to suit the availability of rains, there is a need to introduce, an appropriate number of gauges and a dynamic management information systems to make necessary adjustments with short lead-times

and then to document such changes for periodic evaluations. Comparisons carried out by the present study pointed to the need to consider the actual rainfall for better accounting for water savings.

Evaluation of the present gravity fed irrigation system at the LB main canal of the Rajangana irrigation scheme over five recent years showed that farmers cultivate paddy in 100% and 99% of the command area during Maha and Yala seasons respectively while cultivating the 105 day paddy variety in both seasons. The system urgently requires a dynamic spatially distributed canal water measurement and a performance evaluation system. It is also important to

(i) Establish rain gauges in a spatially distributed manner,
(ii) Enable accounting of rainfall to adjust water schedules for water savings,
(iii) Initiate research to update the Irrigation Guidelines and also to
(iv) Investigate the farmer and water manager capacity building requirements.

7.15 Water Management

The present study evaluated only the reservoir releases. A reservoir operation study to capture the availability of water in the Rajangana reservoir was not conducted. Study of the pattern and quantities of water issues at the LB Canal gravity fed system strongly suggest that Rajangana Irrigation Scheme is a water abundant scheme. This is also the common understanding of regional and national water planners because it is well known that apart from the associated catchment inflows, this reservoir receives return water from Mahaweli river diversions to Kala wewa basin. However this study is the first to clearly identify the level of abundance thus hinting the possibility of further downstream developments if water could be efficiently used in the presently irrigated areas.

As stated at many locations in this dissertation, it is important to carry out many parallel tasks to improve the water management in the Rajangana LB Canal system. A reservoir operation study should be performed, a study of canal status and sources of water losses

needs to be executed, a measurement system should be established, human resource development/ capacity building programs have to be in place and strengthening Guidelines need to be carried out.

8 CONCLUSIONS

1. Evaluation of the Rajangana Left Bank gravity fed irrigation system over the five year study period revealed the need of appropriate canal water measurement system and also the need to introduce a spatially distributed performance monitoring system for the identification of critical areas ensuring efficient water management.
2. Evaluations pointed to an over issue of water in the LB gravity fed irrigation system throughout the seasons which could result from many issues such as canal water losses, poor application, lack of a spatially distributed measurement system, availability of water in abundance and existence of a weak datasets which prevents systematic planning.
3. Irrigation Department guidelines should be critically evaluated and updated with the incorporation of structured research programs.
4. Comparison of actual water issues at the LB Sluice disclosed a significant over issues of water throughout both seasons showing that on-average, the released water volumes in Maha and Yala seasons respectively amounted to approximately 63% and 52% higher water requirements when compared with those computed according to ID guidelines.
5. Comparison of "Guideline Based" and "Actual" Water Duty values showed that in both seasons the actual utilizations are much more than estimated. On average, Maha Season actual water duty was 2.18 m while the guideline based value was 1.34 m. The respective values for Yala season were 2.40m and 1.70m.
6. Evaluation of Maha Season water issues during various crop growth stages indicated that on average the Initial Crop Growth Stage had used a water quantity amounting to 4 times that anticipated by ID guidelines. In other Growth Stages the increase in the actual use varied between 1.5 - 2.4 Times that of guidelines.

7. Evaluation of Yala Season water issues during crop growth stages indicated that on average the Initial Crop Growth Stage used a water quantity nearly twice of that anticipated by the ID guidelines. In other Growth Stages the increase varied between 1.25 -1.57 times.
8. Paddy Yield per unit of water indicates a highest value of 3.62 MT/m with an average value of 2.99. A tendency of growing water overuse could be noted in the Yala season while in two of the Maha seasons water overuse had not resulted a better yield.

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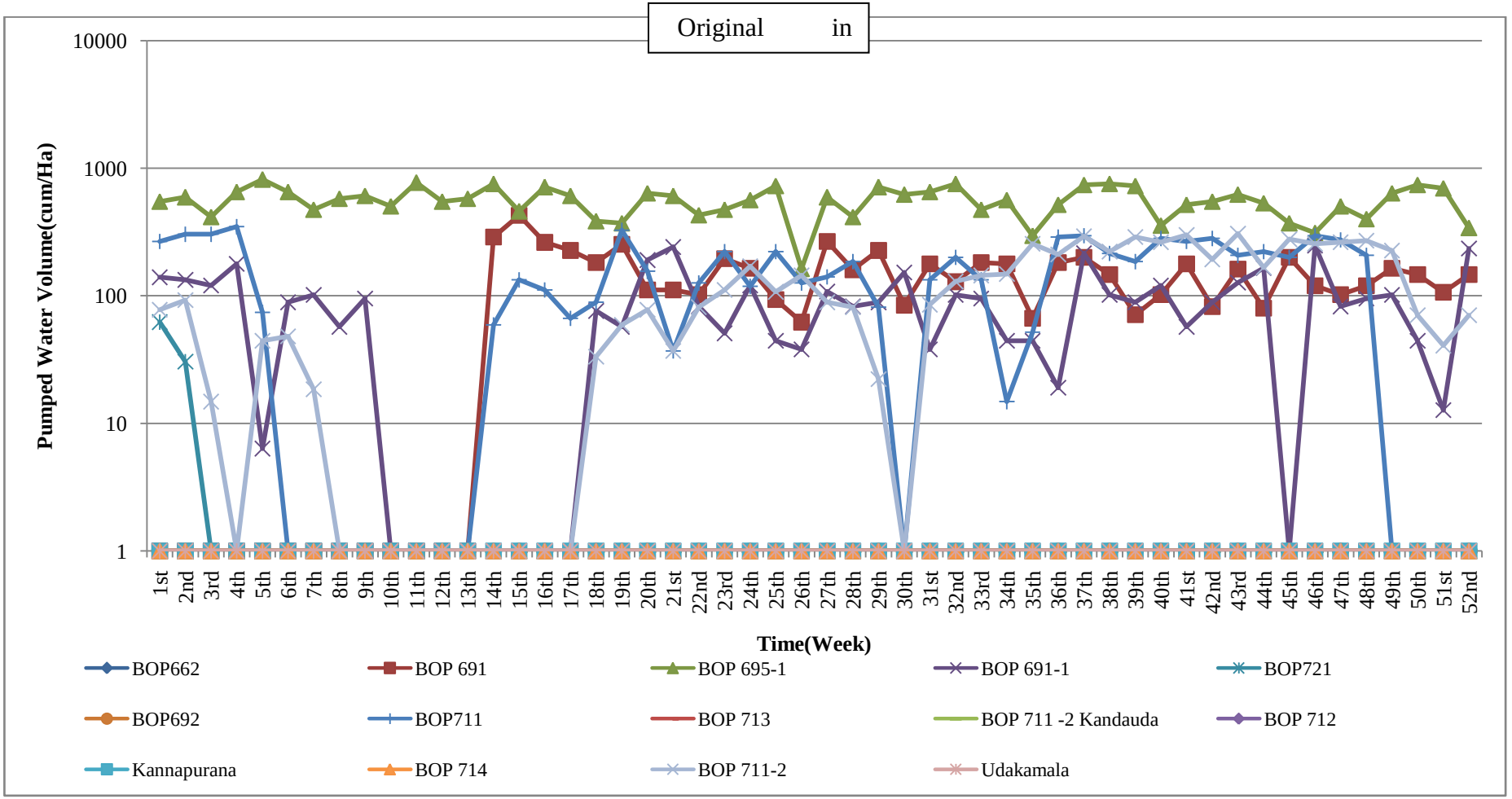
APPENDIXES

APPENDIX-1 Pumped Water for Lift Irrigation in LB Canal 2008/09-2012/13



Note: Pump Station Details are in Figure 1-1 and 1-2

Figure A1-1: Pumped Water Volume at Each Pumping Station Prior to Checking (2008/09)

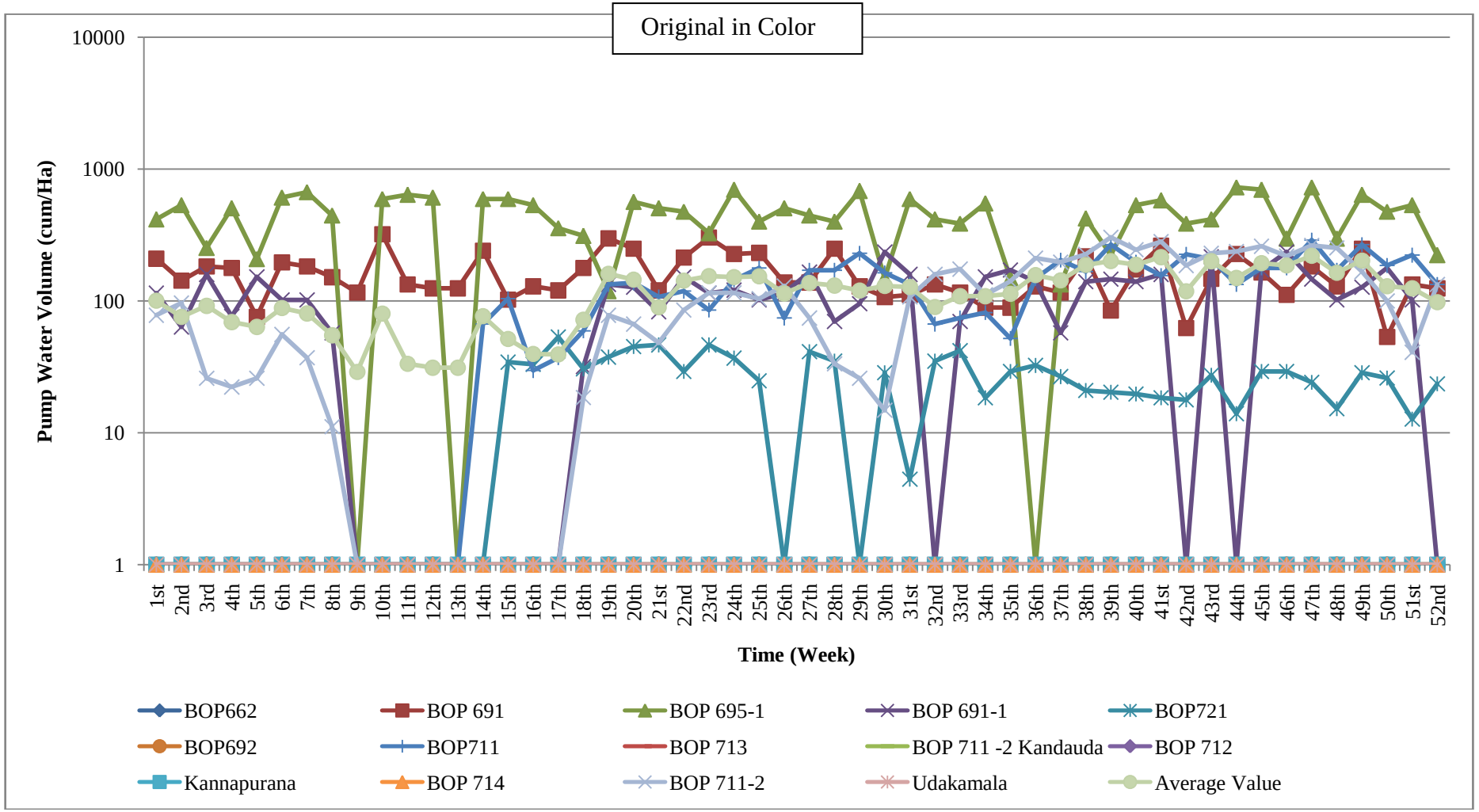
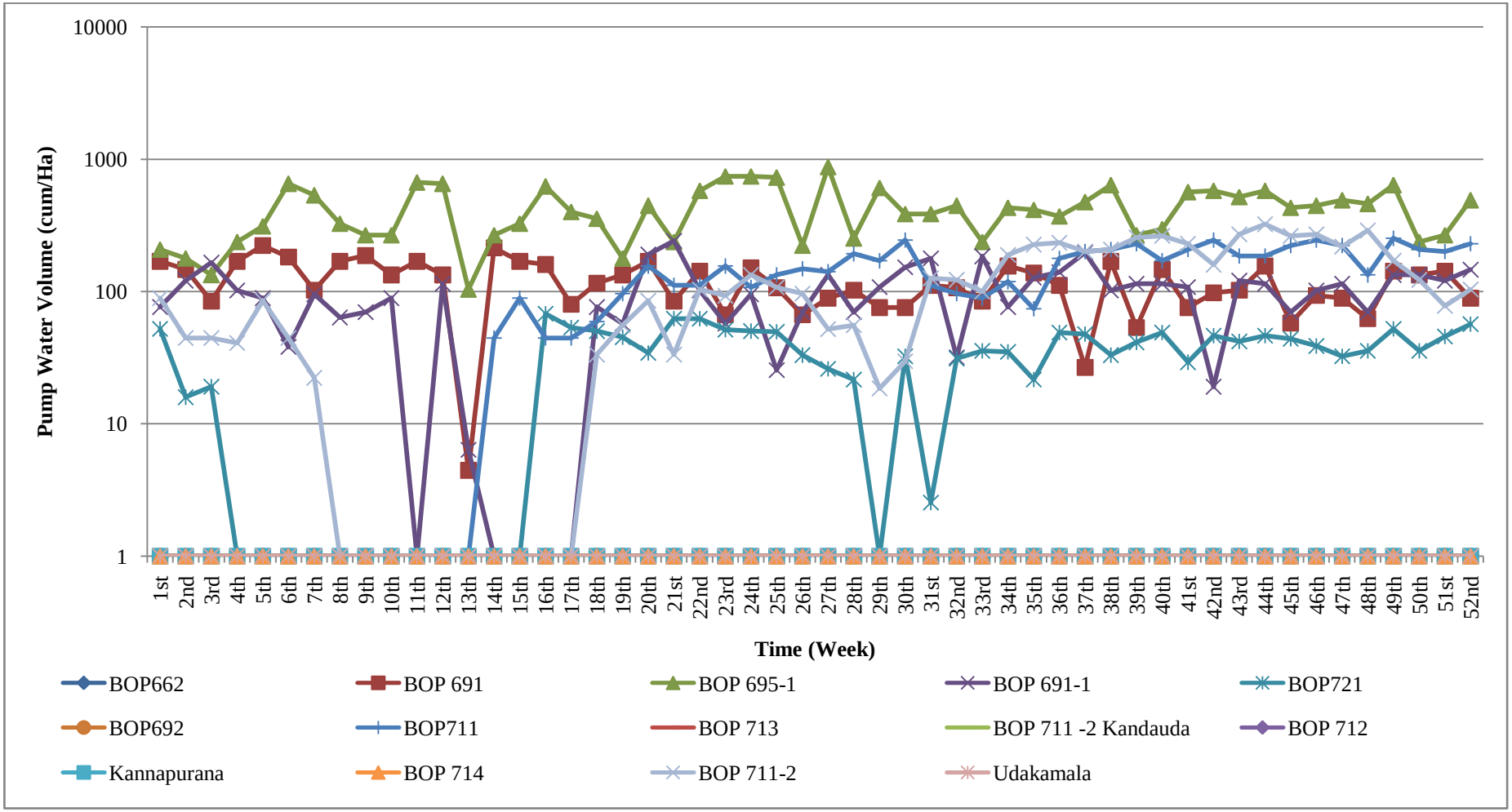


Figure 1-2: Pumped Water Volume at Each Pumping Station Prior t[illegible]

Note: Pump Station Details are in Figure 1-1 and 1-2

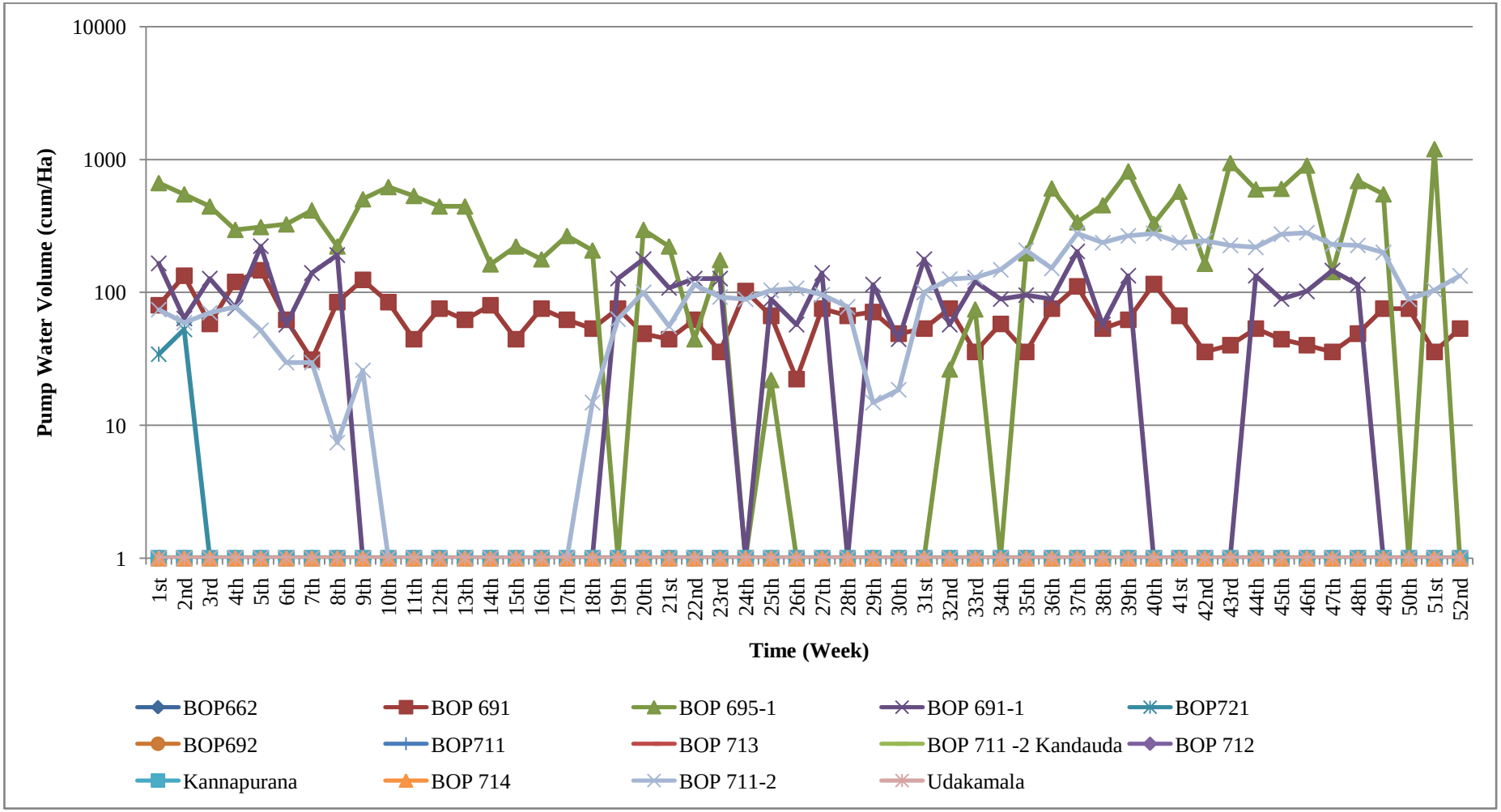
Original in



Note: Pump Station Details are in Figure 1-1 and 1-2

Figure 1-3: Pumped Water Volume at Each Pumping Station Prio[illegible]

Original in



Note: Pump Station Details are in Figure 1-1 and 1-2

Figure 1-4: Pumped Water Volume at Each Pumping Station Prio[illegible]

Original in Color

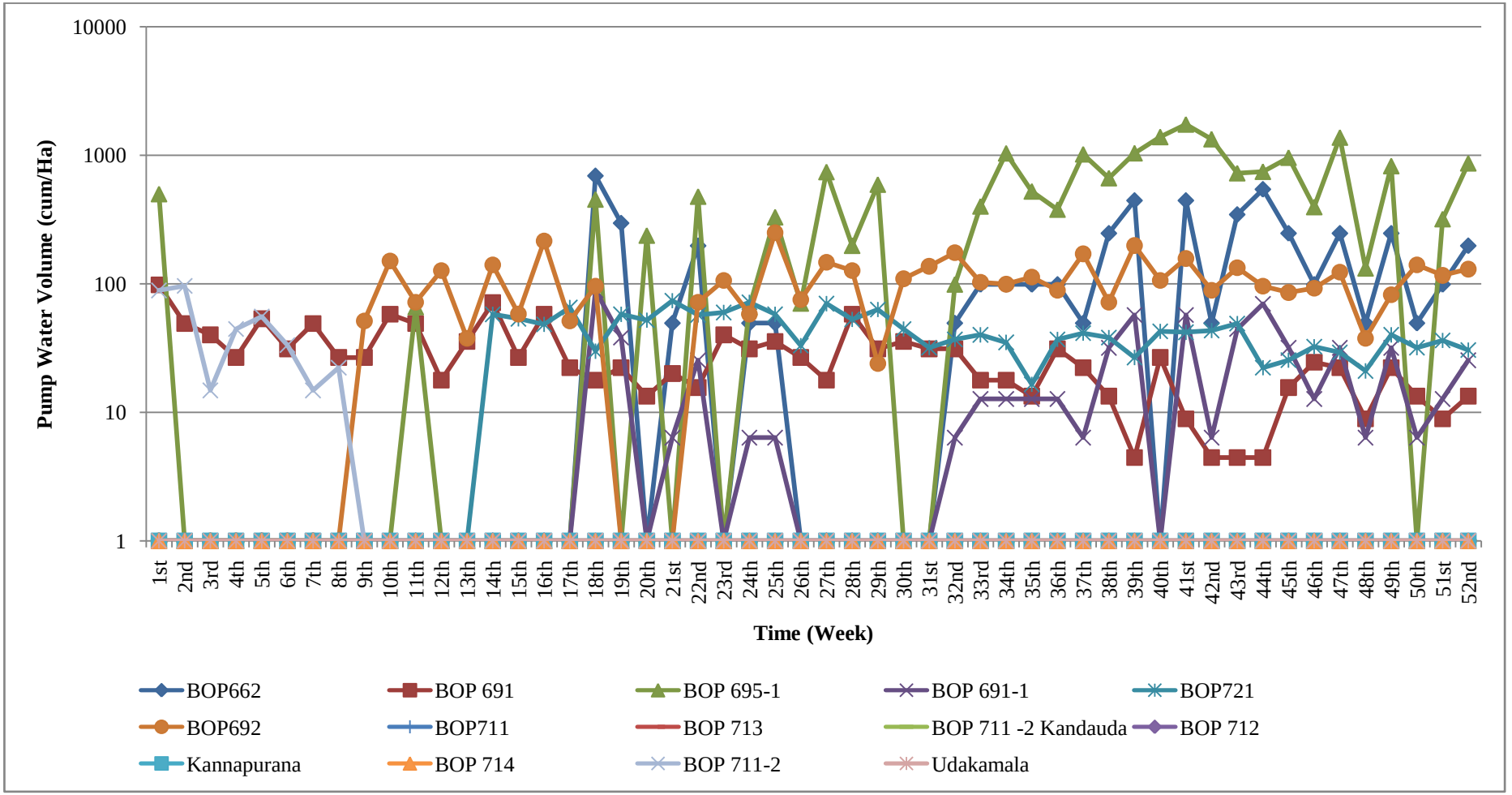
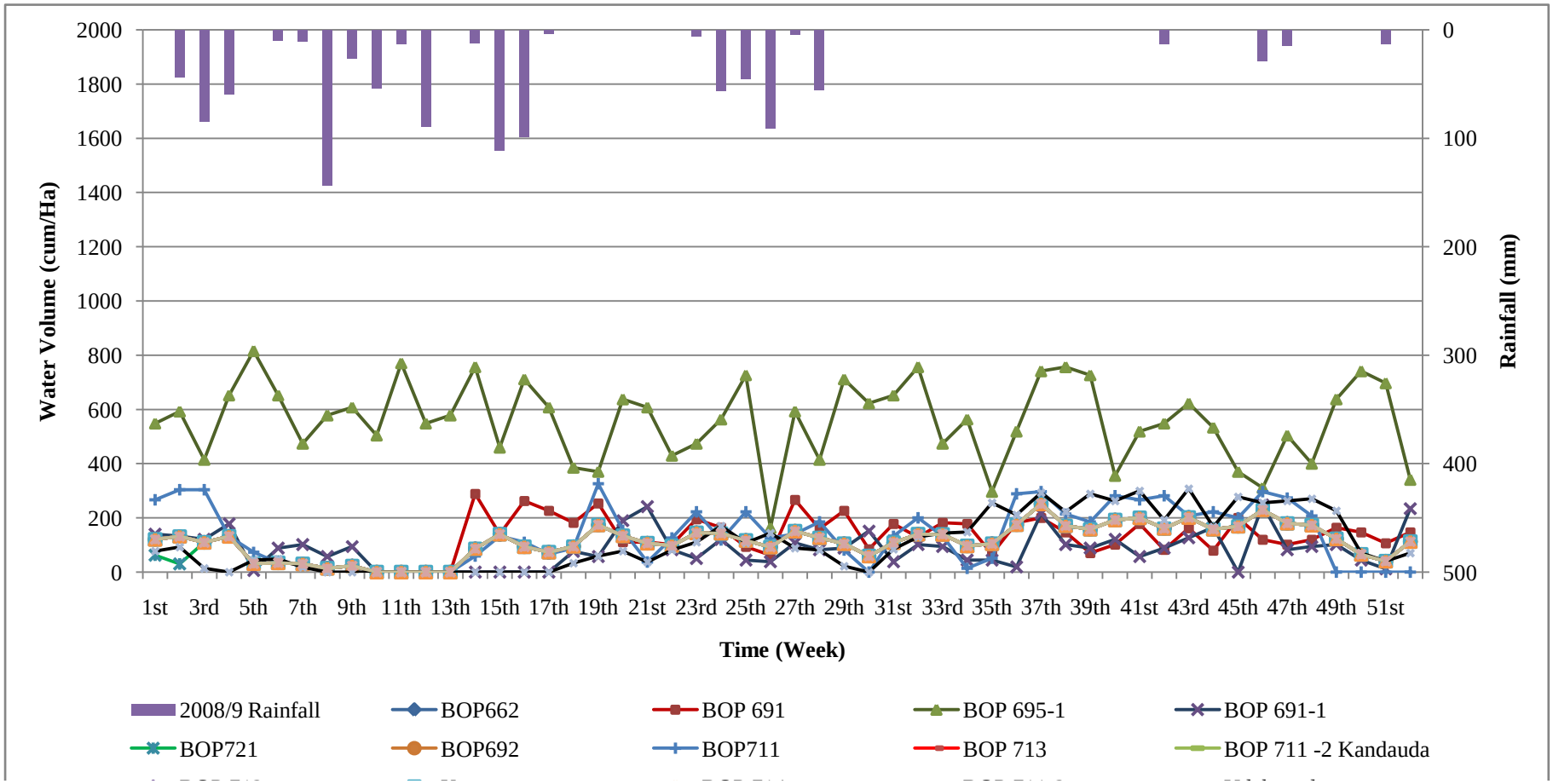


Figure 1-5: Pumped Water Volume at Each Pumping Station Prior

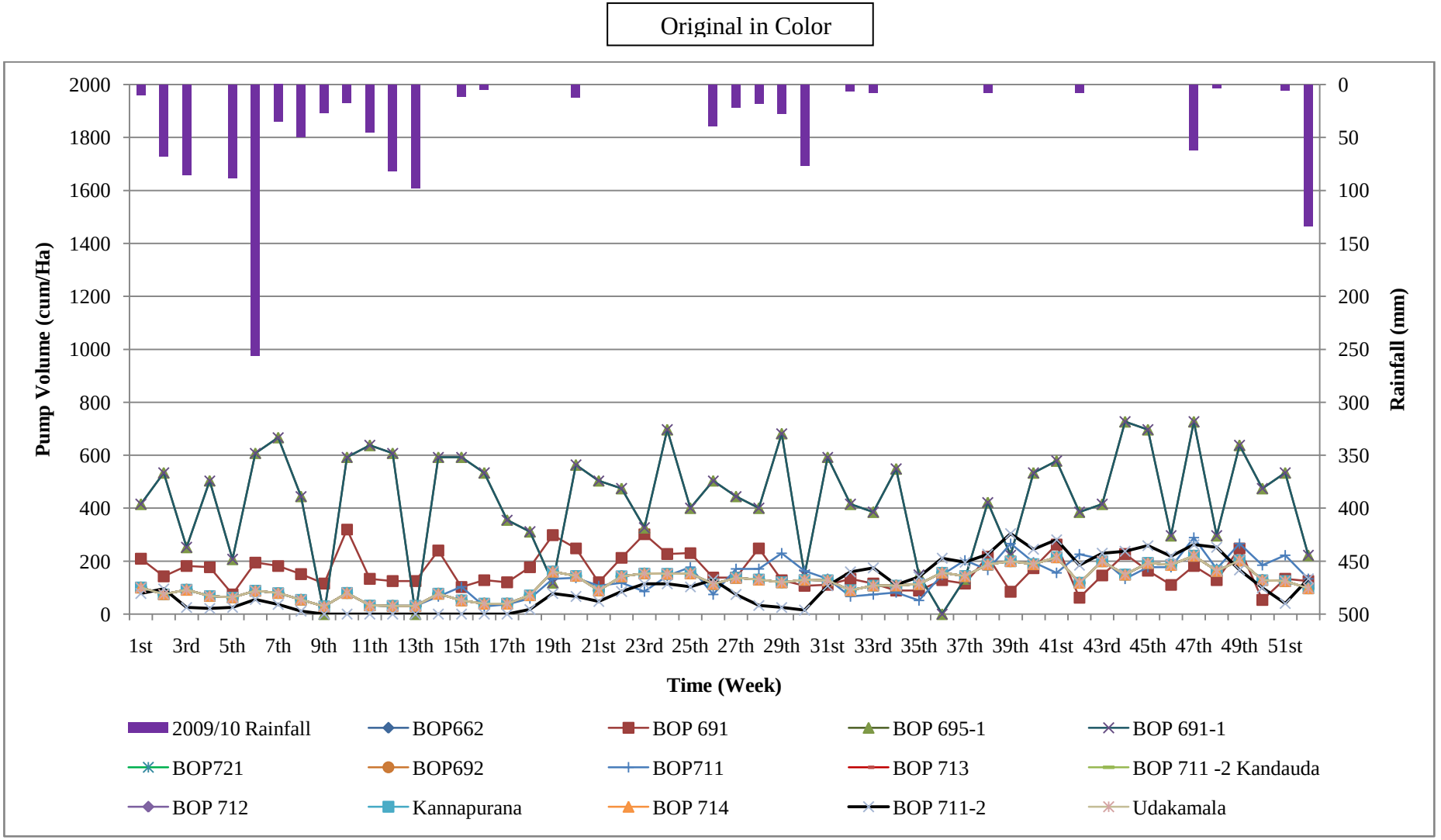
Note: Pump Station Details are in Figure 1-1 and 1-2

Original in Color



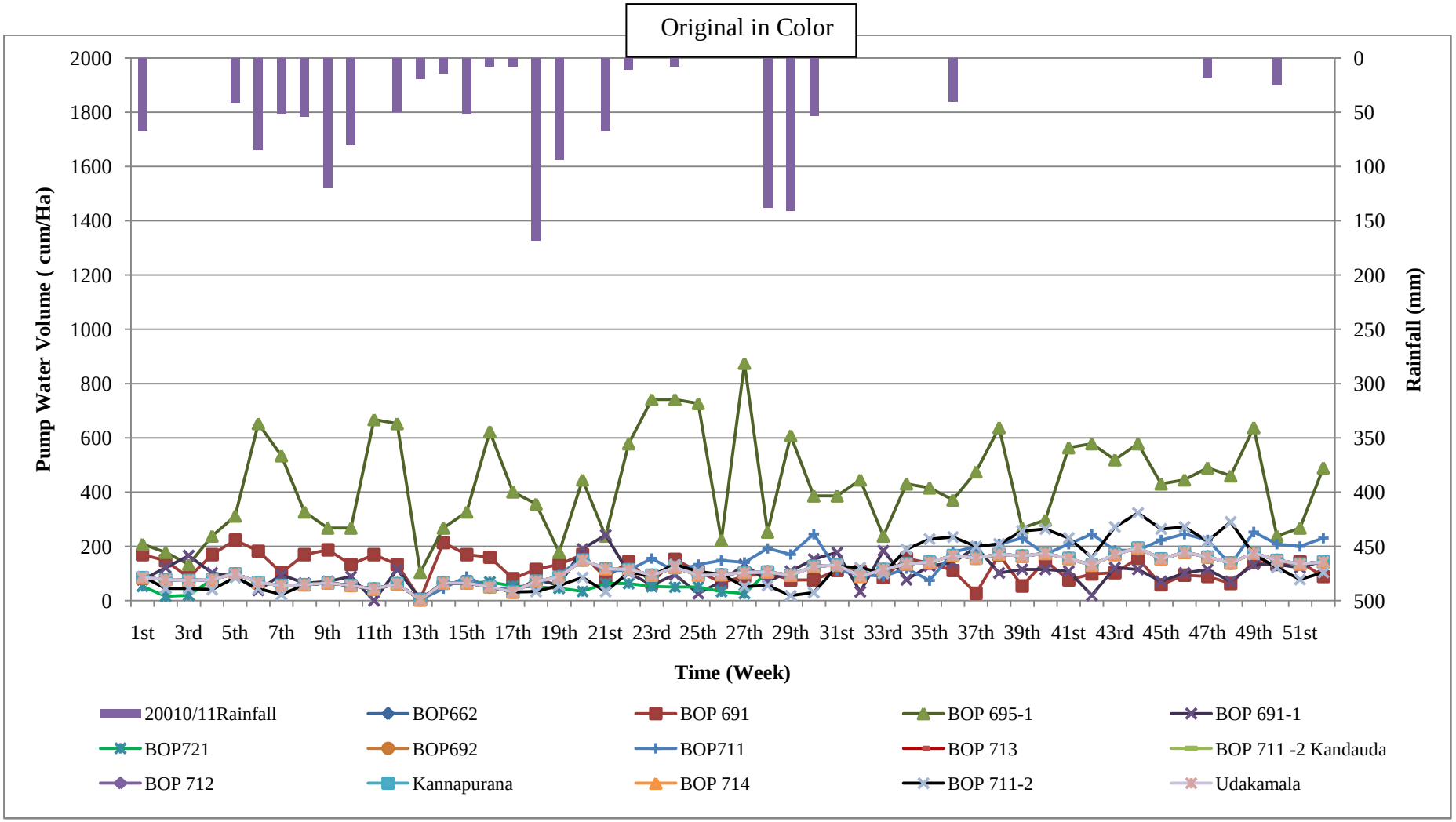
Note: Pump Station Details are in Figure 1-1 and 1-2

Figure 1-6: Corrected Pump Data of 2008/09



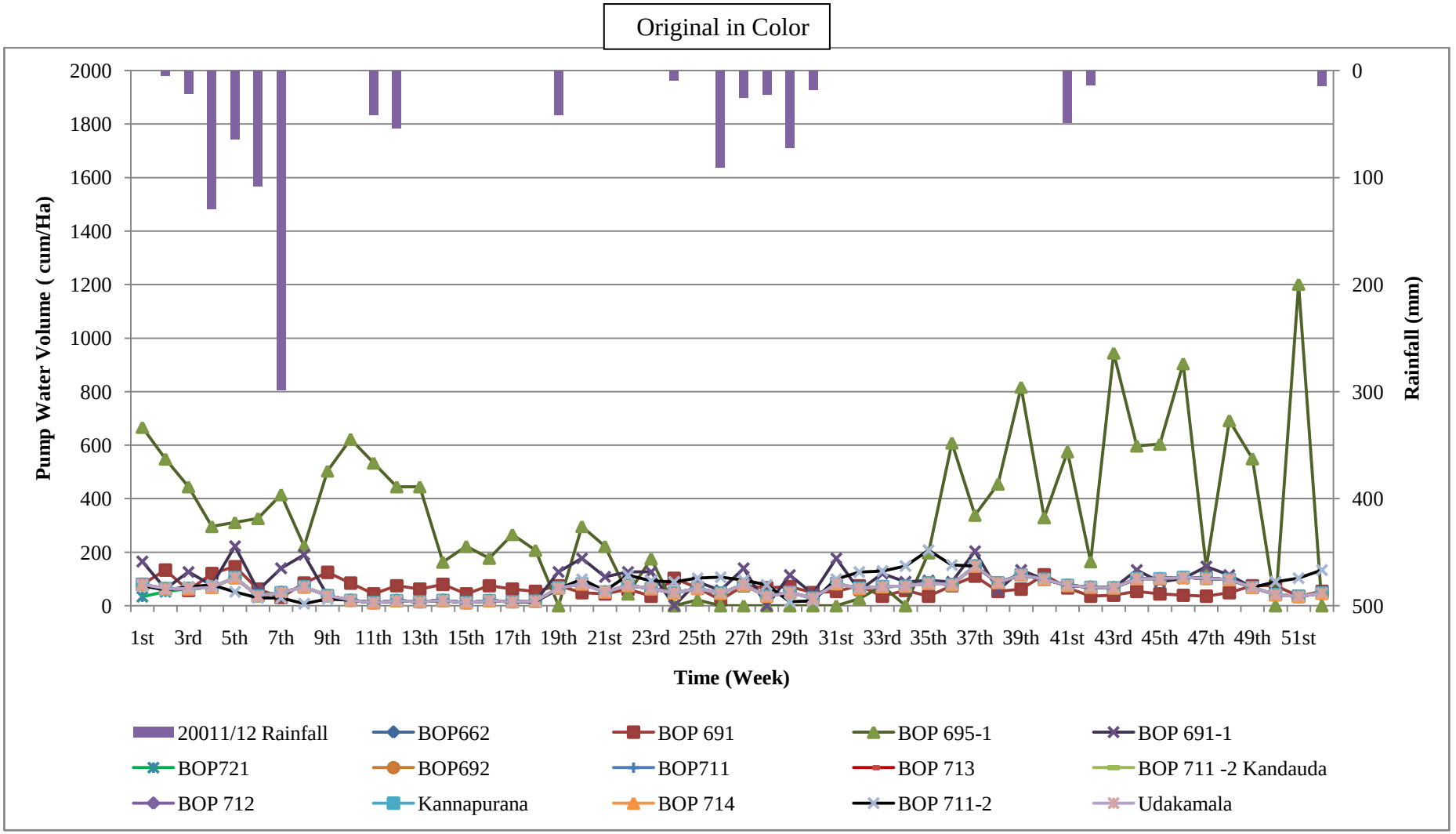
Note: Pump Station Details are in Figure 1-1 and 1-2

Figure 1-7: Corrected Pump Data of 2009/10



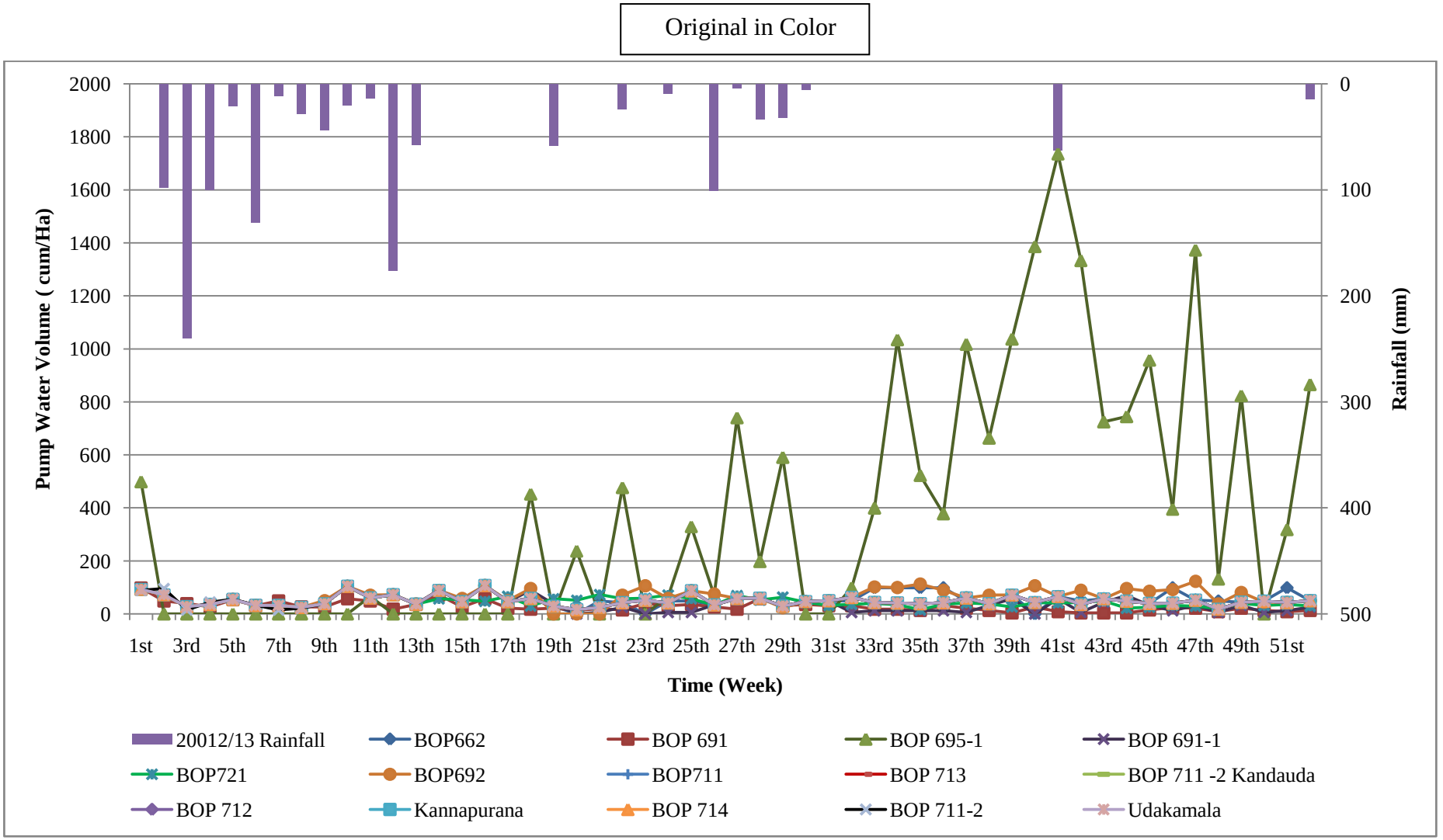
Note: Pump Station Details are in Figure 1-1 and 1-2

Figure 1-8: Corrected Pump Data of 2010/11



Note: Pump Station Details are in Figure 1-1 and 1-2

Figure 1-9: Corrected Pump Data of 2011/12



Note: Pump Station Details are in Figure 1-1 and 1-2

Figure 1-10: Corrected Pump Data of 2012/13

APPENDIX-2 Weekly Water Issues Data of L.B. Sluices (Maha and Yala Seasons)

1. **Total Water Release**
2. **Water Used in Gravity System**
3. **Pumped Water for Lift Irrigation**

Table 2-1 :Left Bank Sluice Water Issue (Maha SeasonMCM/Week)

Description	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	13th	14th	15th	16th	17th	18th	19th	20th	21st	22nd	23rd	24th	25th	26th
Total Water Release(2008/09)	1.62	4.61	4.82	2.55	4.69	3.40	2.16	1.23	0.24	2.82	2.39	1.74	2.99	3.00	3.26	3.00	3.09	3.30	2.95	2.06	0.39	0.00	0.26	0.26	2.18	4.42
Total Water Release(2009/10)	0.00	0.01	0.00	0.00	0.00	0.00	0.81	2.86	4.88	5.28	2.23	3.18	0.98	3.80	2.91	3.09	3.18	3.30	3.51	3.60	3.59	3.57	3.37	2.91	1.69	0.00
Total Water Release(2010/11)	0.00	0.00	0.00	0.00	0.00	1.10	3.34	5.36	3.22	0.85	2.86	3.40	1.44	2.54	2.38	2.54	1.79	3.52	0.00	3.57	3.62	3.63	1.09	2.77	0.00	0.00
Total Water Release(2011/12)	0.00	0.10	0.00	0.00	0.00	0.91	3.54	3.76	2.58	2.73	2.60	2.56	2.69	3.47	3.36	3.38	5.53	2.85	3.62	3.73	4.35	4.39	2.60	1.59	0.21	0.21
Total Water Release(2012/13)	0.73	0.17	0.00	0.00	0.57	3.01	5.05	4.78	1.85	3.04	3.27	1.72	0.38	2.72	1.40	3.86	4.39	4.07	3.32	3.01	3.67	3.52	0.46	0.00	0.42	0.00

Table 2-2: Left Bank Sluice Water Issue (Yala Season MCM/Week)

Description	27th	28th	29th	30th	31st	32nd	33rd	34th	35th	36th	37th	38th	39th	40th	41st	42nd	43rd	44th	45th	46th	47th	48th	49th	50th	51st	52nd
Total Water Release(2008/09)	4.95	3.66	4.66	4.19	2.87	2.89	3.38	3.31	2.85	2.50	2.56	2.81	2.65	2.73	2.94	2.47	2.36	0.85	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Water Release(2009/10)	0.00	0.76	2.42	4.25	2.40	1.52	3.06	0.43	2.39	3.00	1.35	2.17	3.49	2.04	1.64	3.29	2.90	1.38	2.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Water Release(2010/11)	0.00	1.50	4.27	4.17	4.64	4.31	3.54	4.41	3.61	3.74	2.23	2.91	3.25	4.09	3.48	2.57	3.11	3.75	4.16	1.77	0.00	0.00	0.21	0.00	0.00	0.50
Total Water Release(2011/12)	0.00	1.71	3.32	5.36	5.79	5.54	3.27	3.94	2.95	2.03	2.63	2.57	3.30	1.45	2.47	3.11	2.91	3.34	3.95	2.17	0.45	0.50	0.78	0.00	0.20	0.00
Total Water Release(2012/13)	3.89	4.95	5.28	5.34	3.28	3.66	3.39	3.86	3.30	3.60	3.74	4.51	4.76	4.22	3.97	3.82	3.59	3.78	1.29	0.51	0.71	0.75	0.44	0.35	0.58	1.23

Table 2-3: L.B. Canal Gravity System Water Issue(Maha Season MCM/Week)

Description	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	13th	14th	15th	16th	17th	18th	19th	20th	21st	22nd	23rd	24th	25th	26th
Gravity System(2008/09)	1.59	4.58	4.79	2.51	4.68	3.39	2.15	1.22	0.23	2.82	2.38	1.74	2.98	2.97	3.22	2.97	3.06	3.27	2.90	2.02	0.35	0.00	0.21	0.21	2.15	4.39
Gravity System(2009/10)	0.00	0.00	0.00	0.00	0.00	0.00	0.78	2.84	4.87	5.25	2.21	3.16	0.97	3.77	2.89	3.08	3.16	3.28	3.47	3.55	3.56	3.53	3.32	2.86	1.64	0.00
Gravity System(2010/11)	0.00	0.00	0.00	0.00	0.00	1.08	3.32	5.34	3.20	0.83	2.84	3.38	1.44	2.51	2.35	2.51	1.77	3.50	0.00	3.53	3.59	3.60	1.06	2.74	0.00	0.00
Gravity System(2011/12)	0.00	0.08	0.00	0.00	0.00	0.90	3.52	3.74	2.56	2.72	2.59	2.55	2.68	3.46	3.35	3.37	5.52	2.84	3.60	3.70	4.33	4.37	2.58	1.57	0.19	0.20
Gravity System(2012/13)	0.70	0.15	0.00	0.00	0.56	3.00	5.04	4.77	1.84	3.01	3.25	1.70	0.37	2.70	1.39	3.83	4.38	4.05	3.31	3.00	3.66	3.50	0.44	0.00	0.40	0.00

Table 2-4: L.B. Canal Gravity System Water Issue(Yala Season MCM/Week)

Description	27th	28th	29th	30th	31st	32nd	33rd	34th	35th	36th	37th	38th	39th	40th	41st	42nd	43rd	44th	45th	46th	47th	48th	49th	50th	51st	52nd
Gravity System(2008/09)	4.90	3.62	4.63	4.17	2.84	2.84	3.34	3.28	2.81	2.45	2.49	2.76	2.60	2.67	2.88	2.42	2.29	0.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gravity System(2009/10)	0.00	0.72	2.38	4.22	2.36	1.50	3.03	0.39	2.36	2.95	1.31	2.11	3.43	1.98	1.57	3.26	2.84	1.33	2.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gravity System(2010/11)	0.00	1.47	4.24	4.13	4.61	4.28	3.51	4.37	3.56	3.69	2.19	2.85	3.20	4.03	3.43	2.53	3.06	3.69	4.11	1.72	0.00	0.00	0.16	0.00	0.00	0.46
Gravity System(2011/12)	0.00	1.70	3.31	5.36	5.77	5.52	3.25	3.92	2.92	2.01	2.59	2.55	3.27	1.42	2.44	3.09	2.88	3.31	3.92	2.13	0.42	0.47	0.75	0.00	0.18	0.00
Gravity System(2012/13)	3.87	4.93	5.27	5.33	3.27	3.64	3.38	3.84	3.28	3.59	3.72	4.49	4.74	4.20	3.95	3.80	3.57	3.76	1.28	0.50	0.68	0.75	0.42	0.34	0.57	1.22

Table 2-5: L.B. Lifting Irrigation Water (Maha Season MCM/Week)

Description	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	13th	14th	15th	16th	17th	18th	19th	20th	21st	22nd	23rd	24th	25th	26th
PumpedWater (2008/09)	0.03	0.04	0.03	0.04	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.03	0.04	0.03	0.02	0.03	0.05	0.04	0.03	0.00	0.04	0.04	0.04	0.03
PumpedWater (2009/10)	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.02	0.01	0.03	0.01	0.01	0.01	0.03	0.02	0.02	0.01	0.02	0.05	0.04	0.03	0.04	0.05	0.05	0.05	0.00
PumpedWater (2010/11)	0.00	0.00	0.00	0.00	0.00	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.00	0.02	0.02	0.02	0.01	0.02	0.00	0.04	0.03	0.03	0.03	0.03	0.00	0.00
PumpedWater (2011/12)	0.00	0.02	0.00	0.00	0.00	0.01	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.03	0.02	0.02	0.02	0.02	0.02	0.01
PumpedWater (2012/13)	0.03	0.02	0.00	0.00	0.02	0.01	0.01	0.01	0.01	0.03	0.02	0.02	0.01	0.02	0.01	0.03	0.01	0.02	0.01	0.01	0.01	0.02	0.02	0.00	0.02	0.00

Table 2-6: L.B. Lifting Irrigation Water for (Yala Season MCM/Week)

Description	27th	28th	29th	30th	31st	32nd	33rd	34th	35th	36th	37th	38th	39th	40th	41st	42nd	43rd	44th	45th	46th	47th	48th	49th	50th	51st	52nd
PumpedWater (2008/09)	0.05	0.04	0.03	0.02	0.04	0.04	0.04	0.03	0.03	0.05	0.08	0.05	0.05	0.06	0.06	0.05	0.06	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PumpedWater (2009/10)	0.00	0.04	0.04	0.04	0.04	0.03	0.03	0.03	0.03	0.05	0.04	0.06	0.06	0.06	0.07	0.04	0.06	0.05	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PumpedWater (2010/11)	0.00	0.03	0.03	0.04	0.04	0.03	0.03	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.04	0.05	0.06	0.05	0.05	0.00	0.00	0.05	0.00	0.00	0.04
PumpedWater (2011/12)	0.00	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.03	0.03	0.04	0.03	0.04	0.03	0.03	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.02	0.00	0.02	0.00
PumpedWater (2012/13)	0.02	0.02	0.01	0.01	0.01	0.02	0.02	0.02	0.01	0.01	0.02	0.02	0.02	0.02	0.03	0.02	0.02	0.02	0.02	0.01	0.02	0.01	0.02	0.01	0.01	0.02

APPENDIX-3 Anticipated Water Use for the Year 2008/9-2012/13

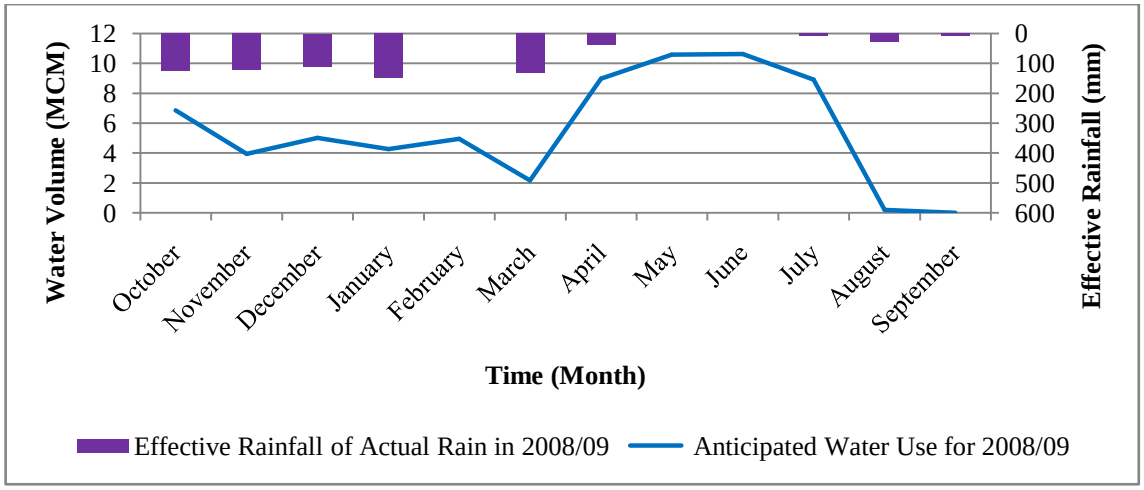


Figure 3-0.1: Anticipated Water Use for 2008/09

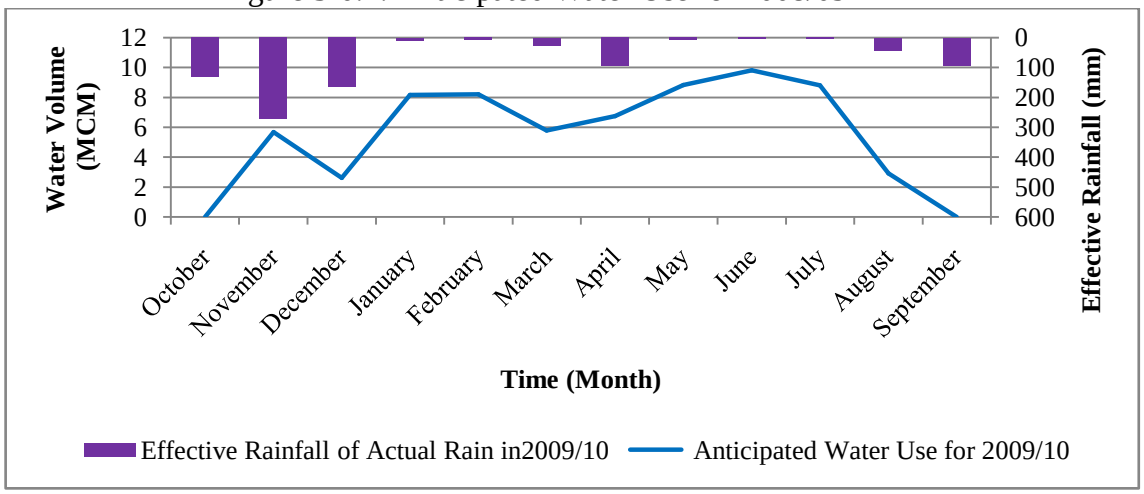


Figure 3-0.2: Anticipated Water Use for 2009/10

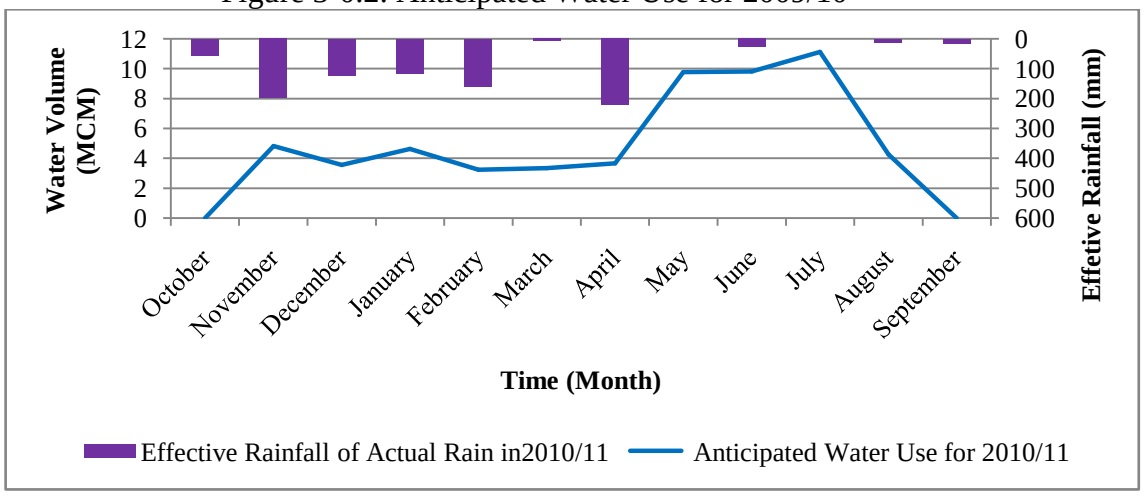


Figure 3-0.3: Anticipated Water Use for 2010/11

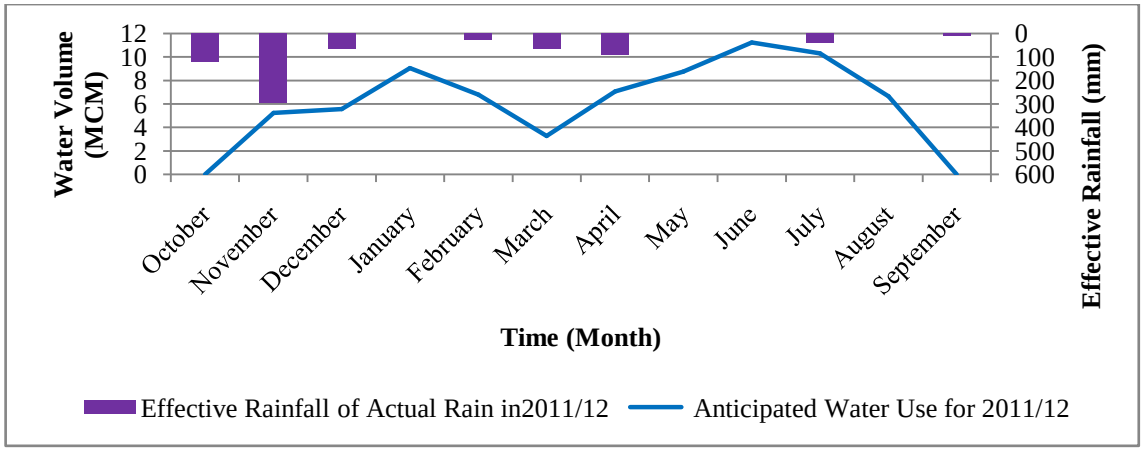


Figure 3-0.4: Anticipated Water Use for 2011/12

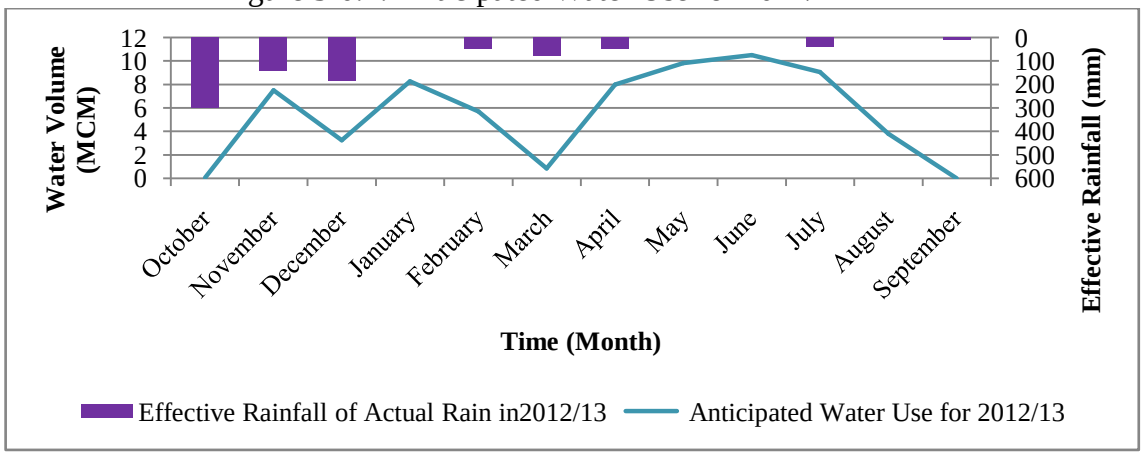


Figure 3-0.5: Anticipated Water Use for 2012/13

Table 3-1: Anticipated Water Use in Maha Season (MCM)

Water Year	October	November	December	January	February	March
2008/2009	6.84	3.93	5.01	4.26	4.93	2.16
2009/2010	0.00	5.67	2.62	8.17	8.20	5.78
2010/2011	0.00	4.80	3.54	4.62	3.22	3.32
2011/2012	0.00	5.22	5.55	9.04	6.78	3.26
2012/2013	0.04	7.48	3.24	8.26	5.68	0.83

Table 3-2: Anticipated Water Use in Yala Season (MCM)

Water Year	April	May	June	July	August	September
2008/2009	8.98	10.57	10.61	8.90	0.19	0.00
2009/2010	6.74	8.82	9.80	8.81	2.91	0.00
2010/2011	3.66	9.76	9.81	11.11	4.25	0.00
2011/2012	7.06	8.74	11.23	10.30	6.63	0.00
2012/2013	7.98	9.80	10.48	9.06	3.78	0.00

APPENDIX-4 Recommended Irrigation Plan from 2008/09 to 2012/13

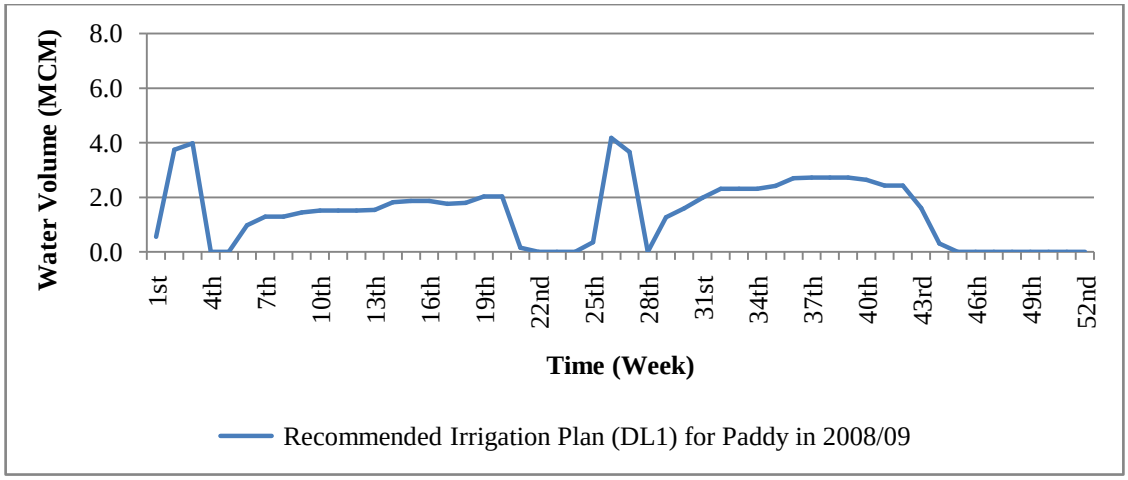


Figure 4-1: Recommended Irrigation Plan (DL1) for paddy in 2008/09

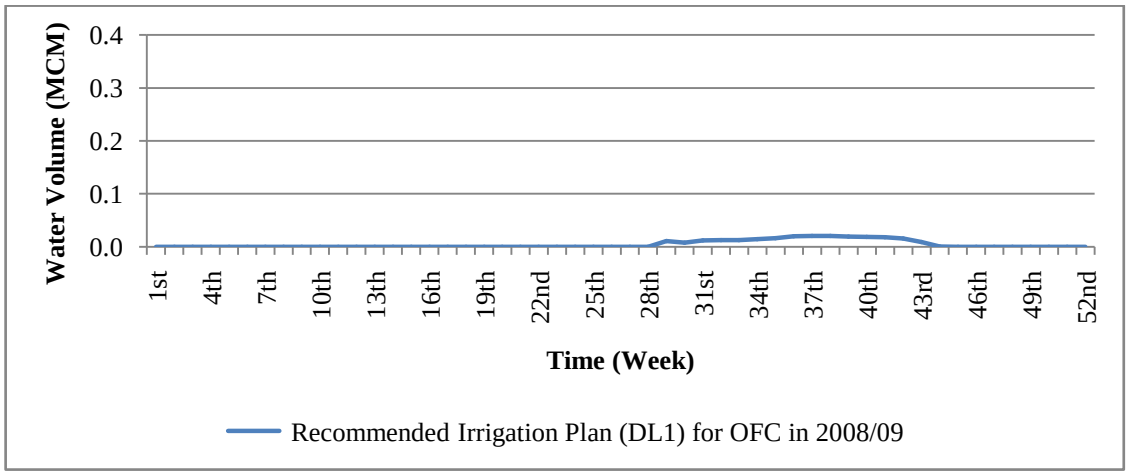


Figure 4-2: Recommended Irrigation Plan (DL1) for OFC in 2008/09

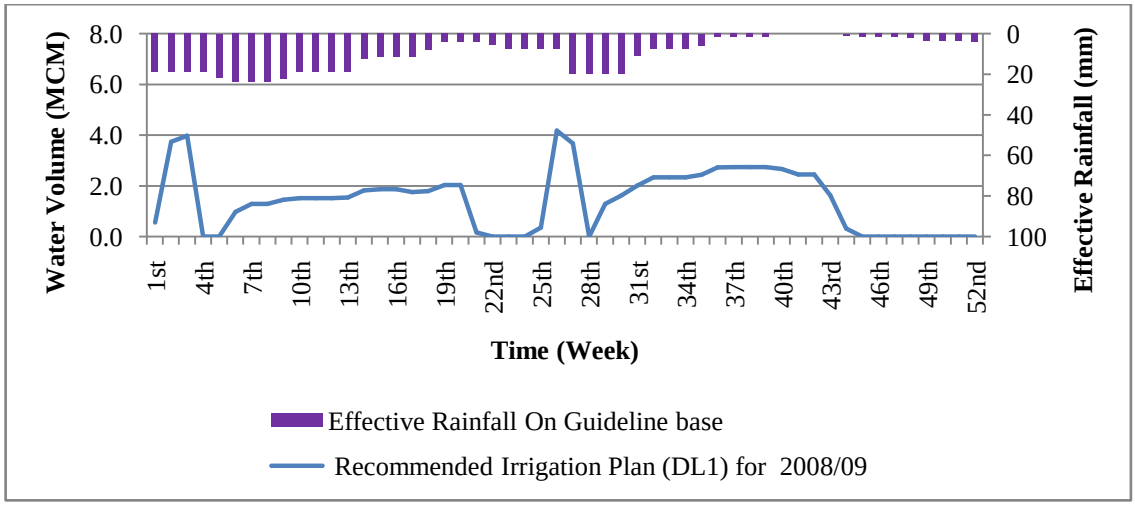


Figure 4-3: Recommended Irrigation Plan (DL1) for 2008/09

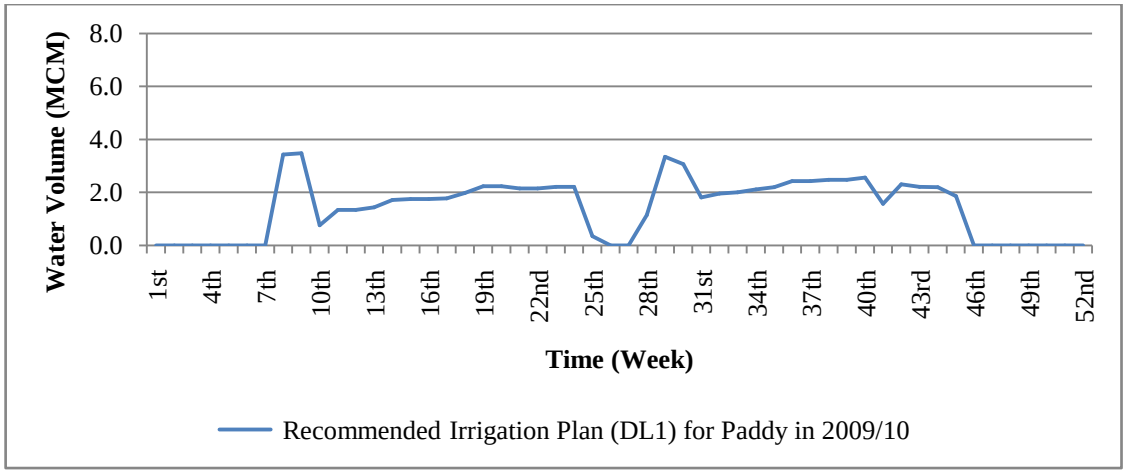


Figure 4-4: Recommended Irrigation Plan (DL1) for Paddy in 2009/10

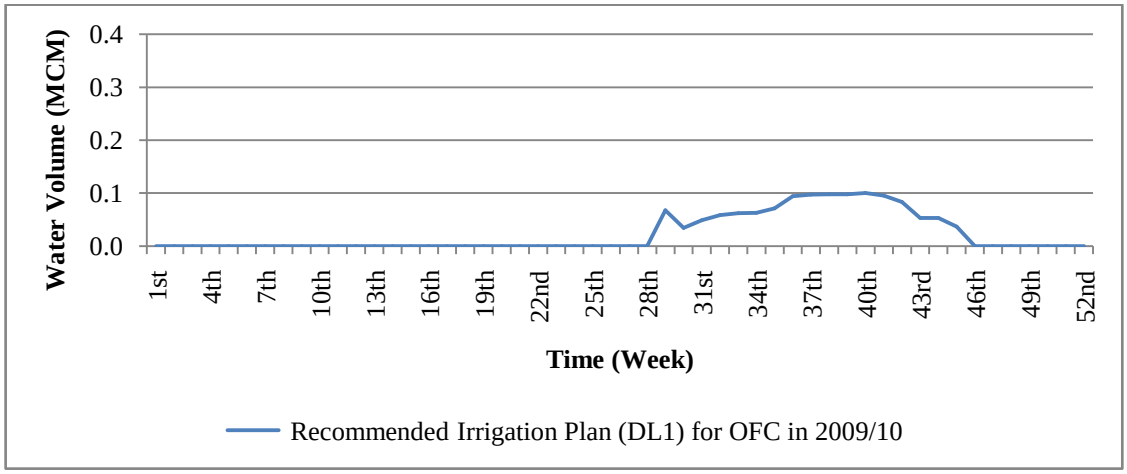


Figure 4-5: Recommended Irrigation Plan (DL1) for OFC in 2009/10

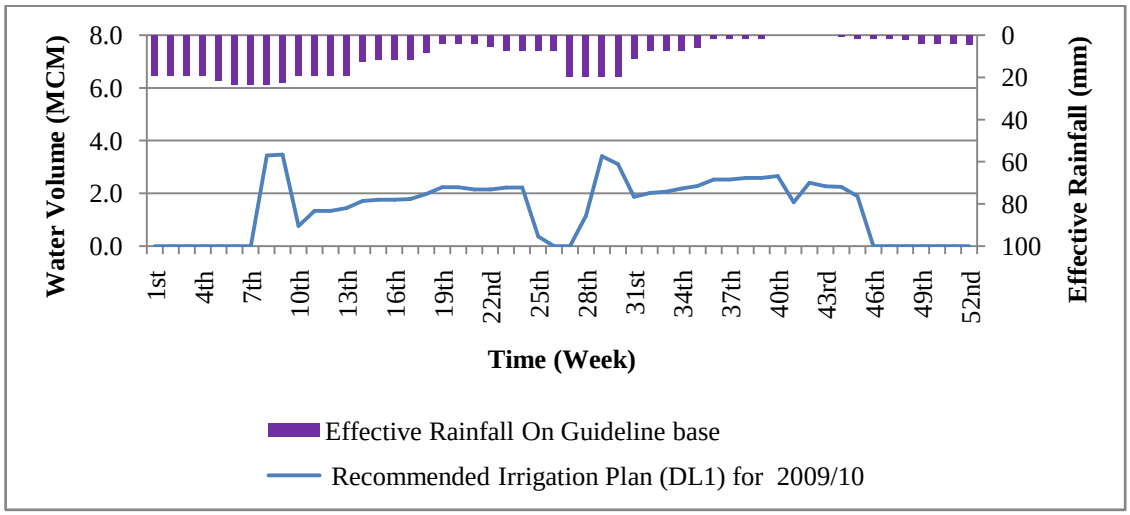


Figure 4-6: Recommended Irrigation Plan (DL1) for 2009/10

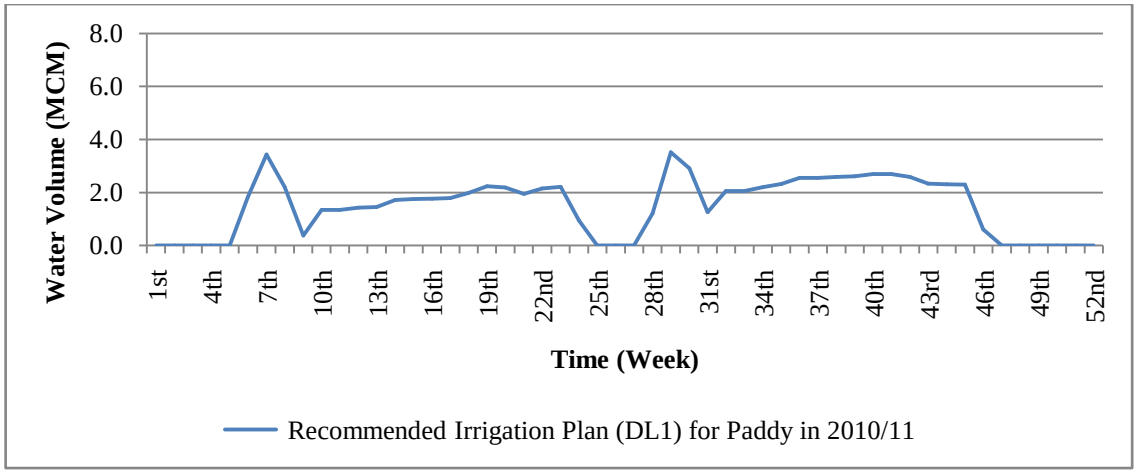


Figure 4-7: Recommended Irrigation Plan (DL1) for Paddy in 2010/11

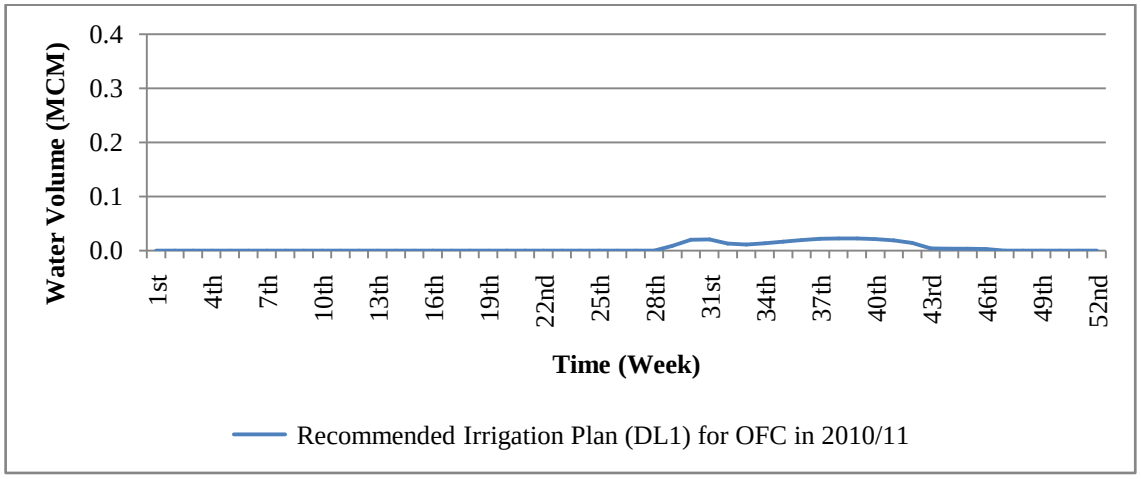


Figure 4-8: Recommended Irrigation Plan (DL1) for OFC in 2010/11

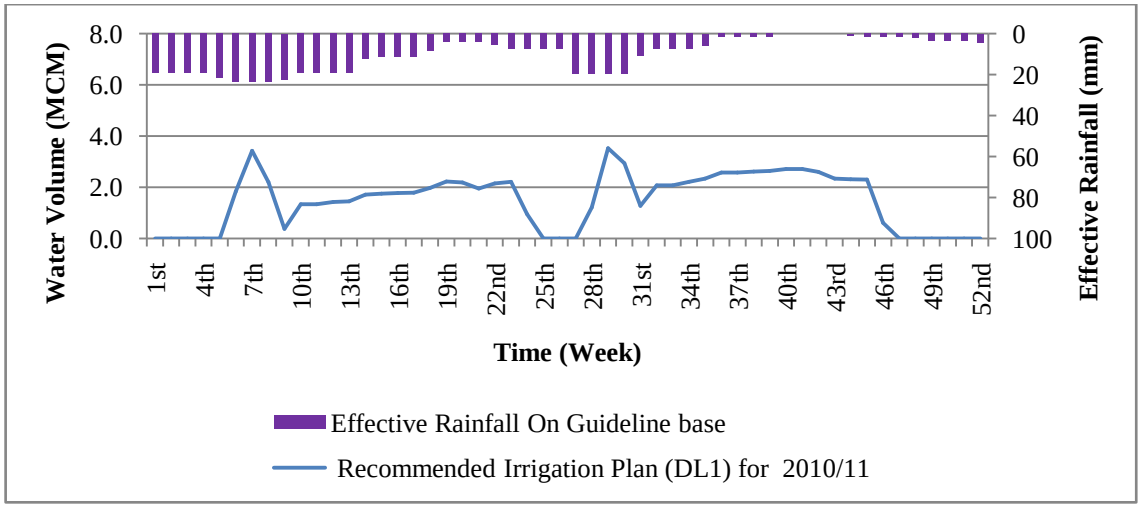


Figure 4-9: Recommended Irrigation Plan (DL1) for 2010/11

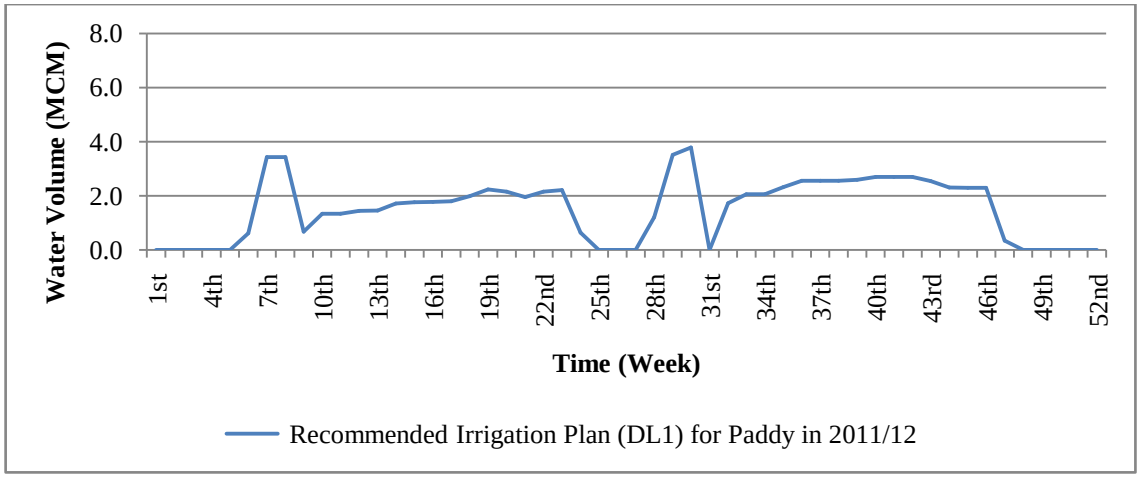


Figure 4-10: Recommended Irrigation Plan (DL1) for Paddy in 2011/12

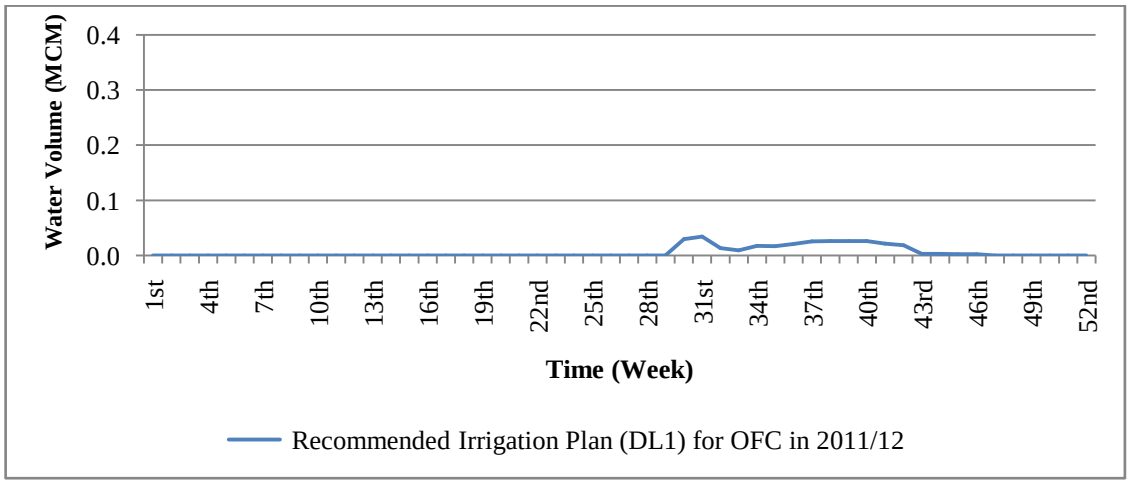


Figure 4-11: Recommended Irrigation Plan(DL1) for OFC in 2011/12

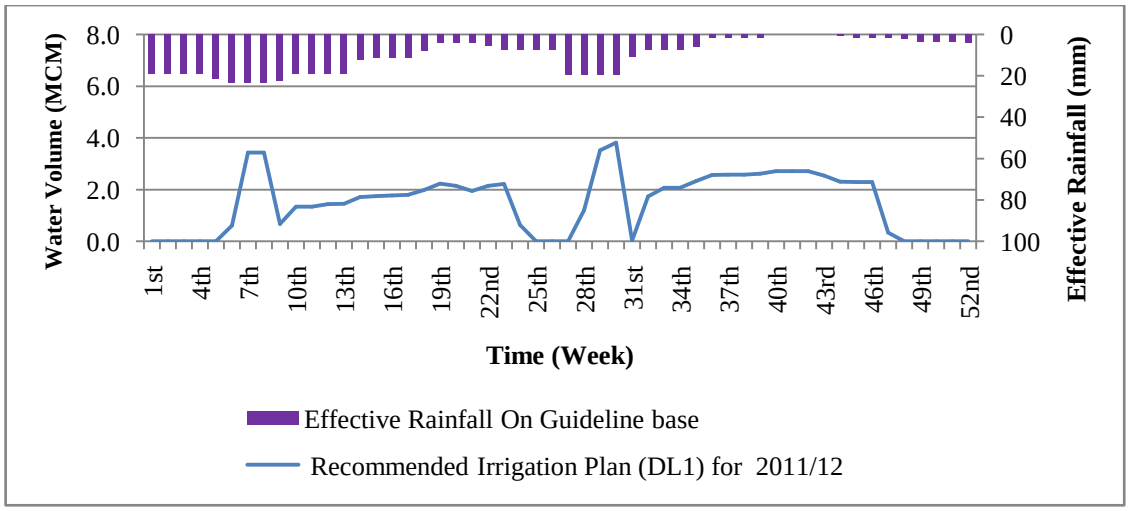


Figure 4-12: Recommended Irrigation Plan (DL1) for 2011/12

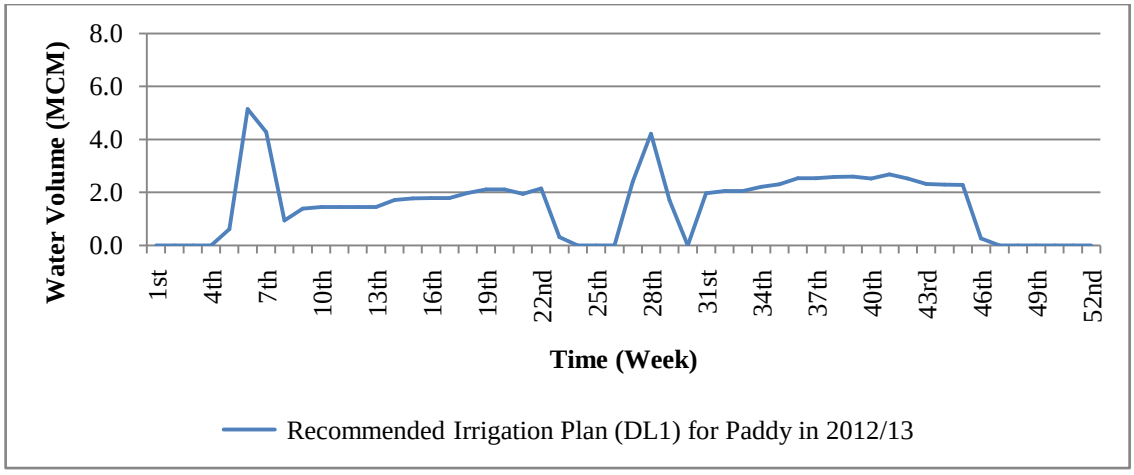


Figure 4-13: Recommended Irrigation Plan (DL1) for Paddy in 2012/13

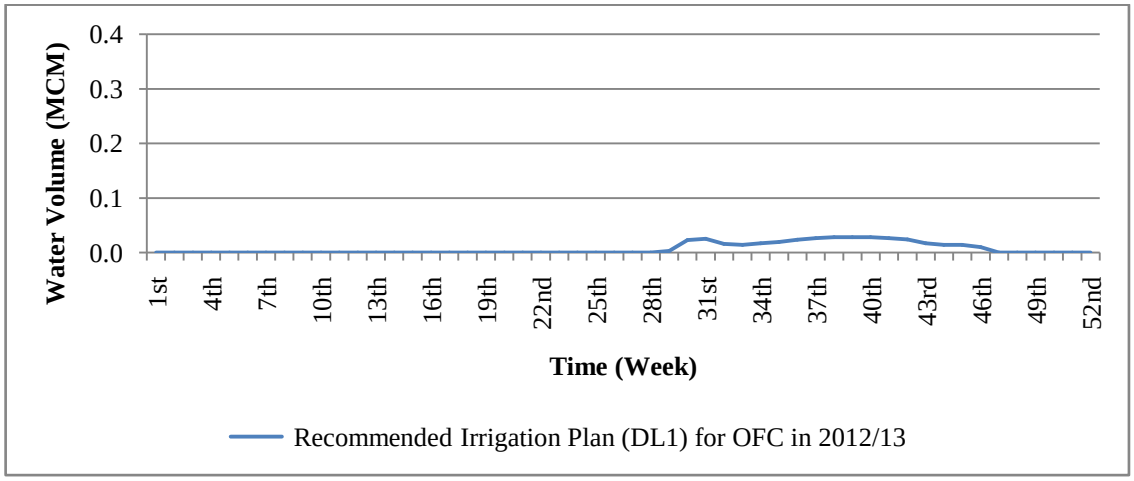


Figure 4-14: Recommended Irrigation Plan (DL1) for OFC in 2012/13

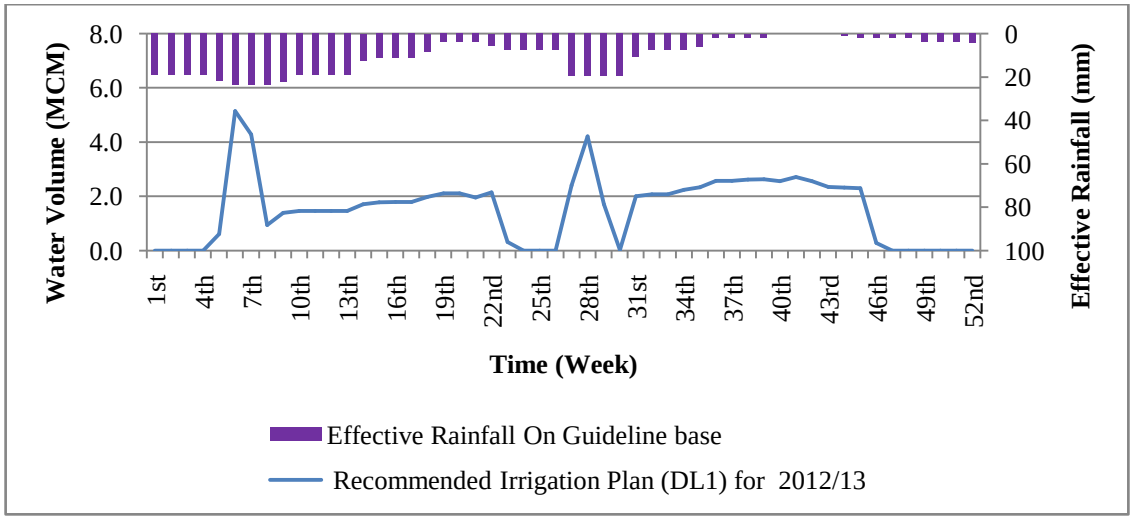


Figure 4-15: Recommended Irrigation Plan (DL1) for 2012/13

Table 4-1: Water Volume of Recommended Irrigation Plan (DL1) for the study period (2008/09-2012/13)

Water Year	October	November	December	January	February	March	April	May	June	July	August	September
2008/09	8.26	4.58	6.75	8.07	4.98	4.53	7.14	10.14	11.64	9.30	0.18	0.00
2009/10	0.00	5.89	6.12	7.88	8.69	5.71	8.21	9.20	10.85	9.96	3.18	0.00
2010/11	0.00	7.73	5.90	7.92	8.45	4.09	8.04	8.92	11.06	11.36	4.22	0.00
2011/12	0.00	7.94	6.01	7.92	8.41	3.77	8.54	7.56	11.01	11.67	6.23	0.00
2012/13	0.26	11.69	6.46	7.97	8.25	1.24	8.92	9.44	11.05	11.15	3.90	0.00

APPENDIX-5 Comparison of "Rajangana ID Plan" (RID) and "Recommended Irrigation Plan" (DL1) (RIP) from 2008/09-2012/13

Table 5-1: Seasonal and Annual Rajangana ID Plan (RID) and Recommended Irrigation Plan (RIP) from 2008/09 to 2012/13

Season	Month	Planned Water Issue Volume (MCM)									
		2008/09		2009/10		2010/11		2011/12		2012/13	
		RIP	RID	RIP	RID	RIP	RID	RIP	RID	RIP	RID
Maha	October	8.26	13.39	0.00	0.00	0.00	0.00	0.00	0.34	0.26	0.97
	November	4.58	8.56	5.89	5.94	7.73	10.15	7.94	8.96	11.69	11.29
	December	6.75	7.88	6.12	10.24	5.90	9.38	6.01	8.76	6.46	8.09
	January	8.07	11.21	7.88	11.01	7.92	11.41	7.92	12.88	7.97	11.00
	February	4.98	6.57	8.69	10.63	8.45	7.49	8.41	12.01	8.25	11.63
	March	4.53	3.58	5.71	7.73	4.09	5.75	3.77	4.89	1.24	2.18
	Sub Total	37.17	51.19	34.29	45.55	34.09	44.18	34.05	47.84	35.87	45.16
Yala	April	7.14	9.04	8.21	7.58	8.04	9.28	8.54	9.25	8.92	17.44
	May	10.14	6.62	9.20	8.65	8.92	15.91	7.56	16.80	9.44	13.52
	June	11.64	10.83	10.85	8.45	11.06	10.35	11.01	11.72	11.05	15.70
	July	9.30	10.92	9.96	9.27	11.36	15.32	11.67	11.43	11.15	15.36
	August	0.18	4.06	3.18	2.37	4.22	7.83	6.23	8.57	3.90	6.59
	September	0.00	4.21	0.00	0.14	0.00	1.31	0.00	1.11	0.00	3.83
	Sub Total	38.40	45.68	41.40	36.46	43.60	60.00	45.01	58.88	44.46	72.44
Annual	Total	75.57	96.87	75.69	82.01	77.69	104.18	79.06	106.72	80.33	117.60

Table 5-2: Seasonal and Annual Water Volume Difference between the Rajangana ID Plan and Recommended Irrigation Plan (DL1)

Season	Month	Rajangana ID Plan and Recommended Irrigation Plan (DL1) Water Volume Differences (MCM)									
		2008/09		2009/10		2010/11		2011/12		2012/13	
		RID-RIP	(RID-RIP)/RIP%	RID-RIP	(RID-RIP)/RIP%	RID-RIP	(RID-RIP)/RIP%	RID-RIP	(RID-RIP)/RIP%	RID-RIP	(RID-RIP)/RIP%
Maha	October	5.13	62%	0.00	0%	0.00	0%	0.34	0%	0.71	267%
	November	3.98	87%	0.05	1%	2.42	31%	1.01	13%	-0.41	-3%
	December	1.13	17%	4.12	67%	3.48	59%	2.76	46%	1.63	25%
	January	3.14	39%	3.13	40%	3.49	44%	4.96	63%	3.03	38%
	February	1.6	32%	1.94	22%	-0.95	-11%	3.6	43%	3.38	41%
	March	-0.95	-21%	2.02	35%	1.67	41%	1.12	30%	0.94	76%
	Sub Total	14.03	38%	11.26	33%	10.11	30%	13.79	40%	9.28	26%
Yala	April	1.9	27%	-0.63	-8%	1.24	15%	0.71	8%	8.52	95%
	May	-3.51	-35%	-0.55	-6%	6.98	78%	9.24	122%	4.08	43%
	June	-0.81	-7%	-2.4	-22%	-0.71	-6%	0.71	6%	4.65	42%
	July	1.62	17%	-0.68	-7%	3.96	35%	-0.25	-2%	4.2	38%
	August	3.88	2169%	-0.81	-25%	3.61	85%	2.34	37%	2.69	69%
	September	4.21	0%	0.14	0%	1.31	0%	1.11	0%	3.83	0%
	Sub Total	7.29	19%	-4.93	-12%	16.39	38%	13.86	31%	27.97	63%
Annual	Total	21.32	28%	6.33	8%	26.5	34%	27.65	35%	37.25	46%

Table 5-3: Summery of Water Quantity Difference between Rajangana ID Plan and Recommended Irrigation Plan (DL1)

Season	Month	Summary of Water Quantity Difference between Plans			
		Maximum	Minimum	Average	Total
Maha	October	5.13	0.00	1.23	6.17
	November	3.98	-0.41	1.41	7.05
	December	4.12	1.13	2.62	13.11
	January	4.96	3.03	3.55	17.75
	February	3.60	-0.95	1.91	9.56
	March	2.02	-0.95	0.96	4.80
Yala	April	8.52	-0.63	2.35	11.74
	May	9.24	-3.51	3.25	16.23
	June	4.65	-2.40	0.29	1.43
	July	4.20	-0.68	1.77	8.86
	August	3.88	-0.81	2.34	11.71
	September	4.21	0.14	2.12	10.60

Table 5-4 : Comparison of Water Plan between Rajangana ID Plan and Recommended Irrigation Plan (DL1)

Water Year	Rajangana ID Plan (MCM)		Recommended Irrigation Plan (MCM)		Difference in Water Use (MCM)			
					Maha Season		Yala Season	
	Maha	Yala	Maha	Yala	Quantity	%	Quantity	%
2008/09	51.19	45.68	32.64	42.96	18.55	57%	27.13	63%
2009/10	45.55	36.47	34.29	41.48	11.26	33%	25.21	61%
2009/11	44.19	59.99	34.08	43.60	10.11	30%	49.89	114%
2010/12	47.84	58.88	34.05	45.02	13.79	40%	45.09	100%
2012/13	45.15	72.42	35.88	44.46	9.27	26%	63.15	142%
Maximum	51.19	72.42	35.88	45.02	18.55	57%	63.15	142%
Minimum	44.19	36.47	32.64	41.48	9.27	26%	25.21	61%
Average	46.78	54.69	34.19	43.51	12.59	37%	42.09	96%

APPENDIX-6 Comparison between "Actual Water Use" (AWU) and "Recommended Irrigation Plan" (DL1) (RIP) from 2008/09-2012/13

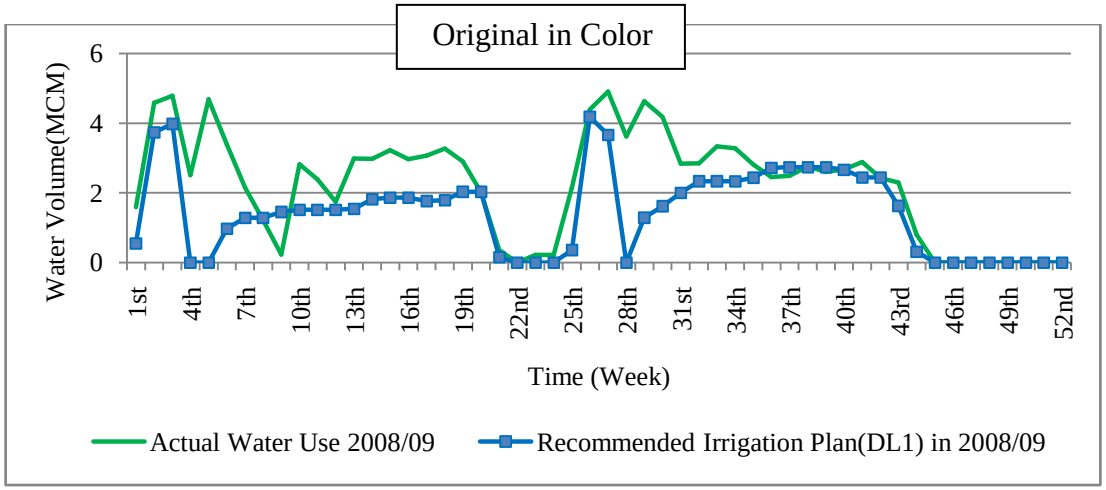


Figure 6-0.1: Water Volume of Actual Water Use and Recommended Irrigation Plan (DL1) in 2008/09

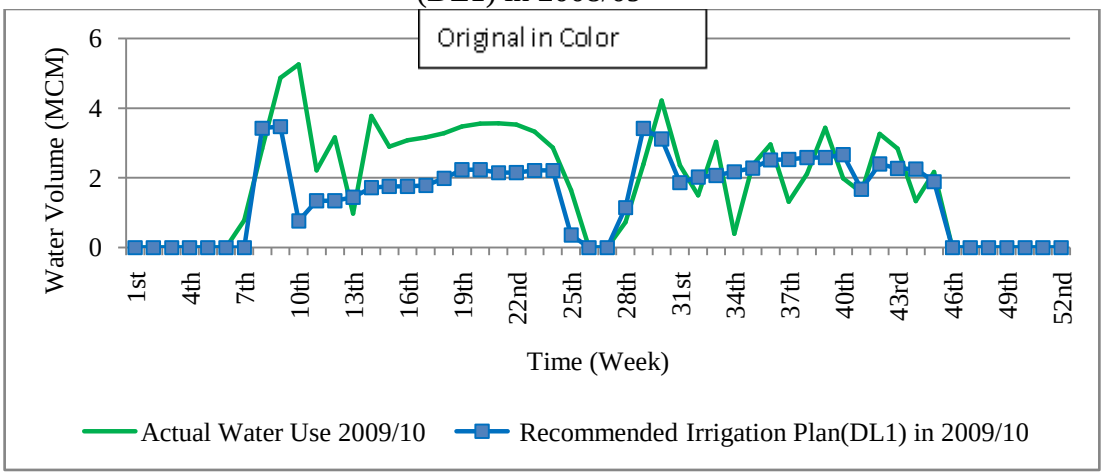


Figure 6-2: Water Volume of Actual Water Use and Recommended Irrigation Plan (DL1) in 2009/10

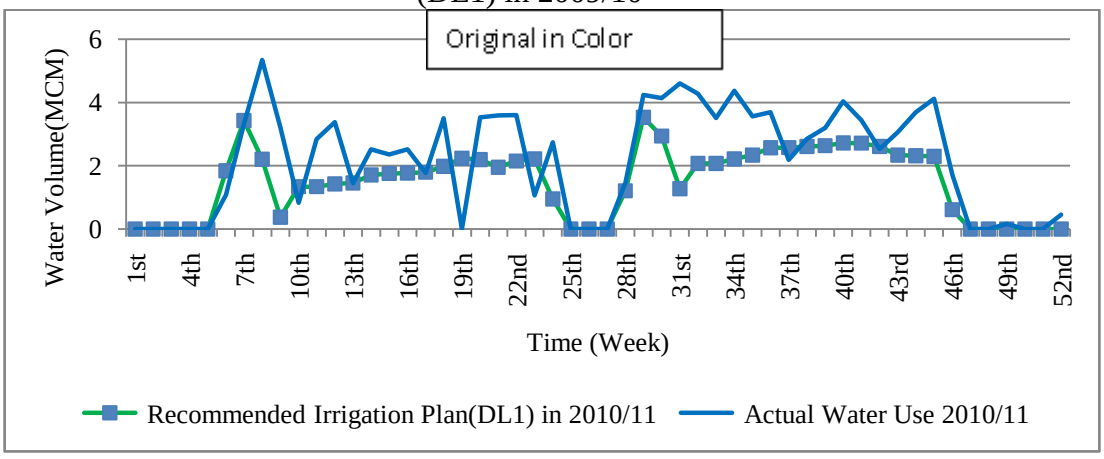


Figure 6-3: Water Volume of Actual Water Use and Recommended Irrigation Plan (DL1) 2010/11

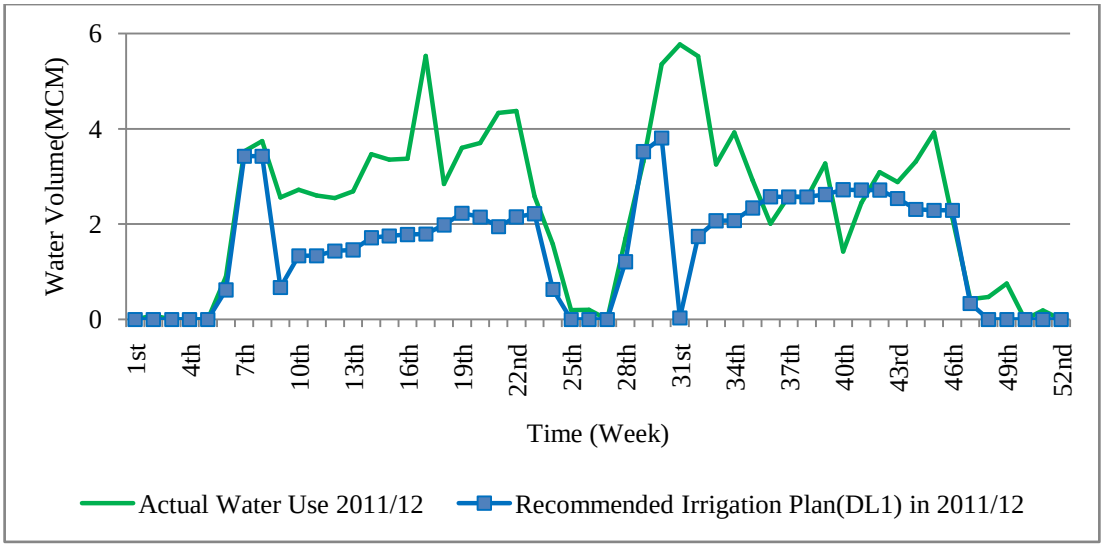


Figure 6-4: Water Volume of Actual Water Use and Recommended Irrigation Plan (DL1) in 2011/12

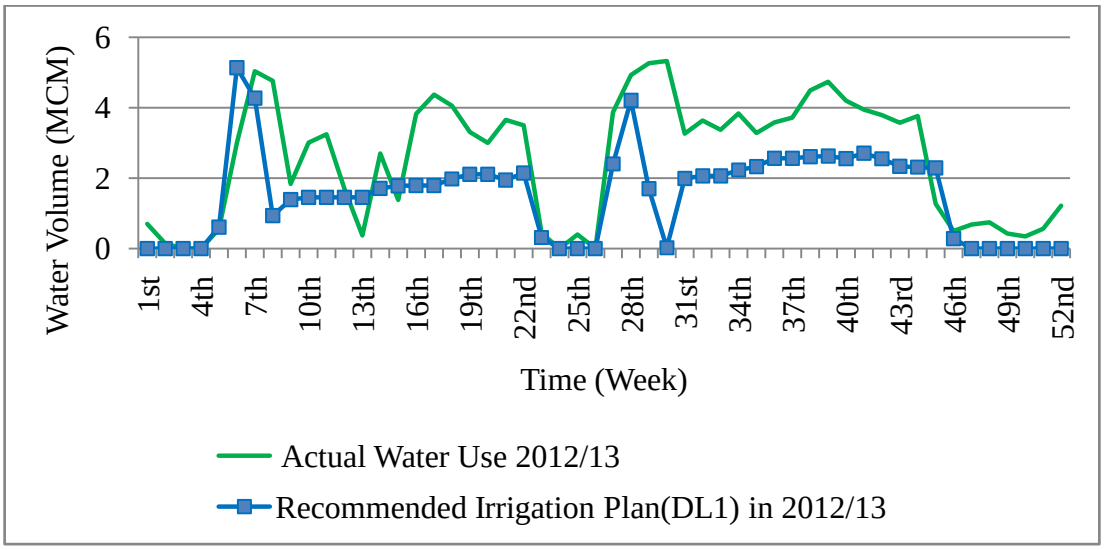


Figure 6-5: Water Volume of Actual Water Use and Recommended Irrigation Plan (DL1) in 2012/13

Table 6-1: Seasonal and Annual Actual Water Use (AWU) and Recommended Irrigation Plan (RIP) from 2008/09 to 2012/13

Season	Month	Planned Water Issue Volume (MCM)									
		2008/09		2009/10		2010/11		2011/12		2012/13	
		RIP	AWU	RIP	AWU	RIP	AWU	RIP	AWU	RIP	AWU
Maha	October	8.26	15.47	0.00	0.01	0.00	0.00	0.00	0.08	0.26	1.09
	November	4.58	9.58	5.89	7.07	7.73	12.01	7.94	9.98	11.69	14.44
	December	6.75	10.40	6.12	13.54	5.90	9.77	6.01	11.77	6.46	9.24
	January	8.07	13.67	7.88	14.24	7.92	10.80	7.92	16.84	7.97	14.23
	February	4.98	6.68	8.69	14.01	8.45	10.68	8.41	15.34	8.25	13.71
	March	4.53	6.97	5.71	9.34	4.09	5.34	3.77	6.43	1.24	2.35
	Sub Total	37.17	62.77	34.29	58.21	34.09	48.60	34.05	60.44	35.87	55.06
Yala	April	7.14	18.15	8.21	8.01	8.04	11.17	8.54	12.03	8.92	20.35
	May	10.14	13.47	9.20	8.26	8.92	17.95	7.56	18.86	9.44	15.51
	June	11.64	11.10	10.85	10.49	11.06	12.96	11.01	11.26	11.05	17.49
	July	9.30	10.61	9.96	10.22	11.36	14.64	11.67	11.26	11.15	17.14
	August	0.18	0.46	3.18	2.93	4.22	7.93	6.23	8.76	3.90	5.25
	September	0.00	0.00	0.00	0.00	0.00	0.62	0.00	1.00	0.00	2.65
	Sub Total	38.40	53.79	41.40	39.91	43.60	65.27	45.01	63.17	44.46	78.39
Annual	Total	75.57	116.56	75.69	98.12	77.69	113.87	79.06	123.61	80.33	133.45

Table 6-2: Seasonal and Annual Water Volume Difference between the Actual Water Use and Recommended Irrigation Plan (DL1)

Season	Month	Planned Water Issue Volume (MCM)									
		2008/09		2009/10		2010/11		2011/12		2012/13	
		AWU-RIP	(AWU-RIP)/RIP %	AWU-RIP	(AWU-RIP)/RIP %	AWU-RIP	(AWU-RIP)/RIP %	AWU-RIP	(AWU-RIP)/RIP %	AWU-RIP	(AWU-RIP)/RIP %
Maha	October	7.21	87%	0.01	0%	0.00	0%	0.08	0%	0.82	312%
	November	5.01	109%	1.18	20%	4.28	55%	2.04	26%	2.75	23%
	December	3.65	54%	7.42	121%	3.87	65%	5.77	96%	2.78	43%
	January	5.60	69%	6.36	81%	2.88	36%	8.92	113%	6.26	79%
	February	1.71	34%	5.32	61%	2.24	26%	6.93	82%	5.47	66%
	March	2.44	54%	3.64	64%	1.26	31%	2.66	70%	1.11	89%
	Sub Total	25.62	69%	23.93	70%	14.53	43%	26.40	78%	19.19	53%
Yala	April	11.01	154%	-0.20	-2%	3.13	39%	3.49	41%	11.43	128%
	May	3.33	33%	-0.94	-10%	9.03	101%	11.30	149%	6.07	64%
	June	-0.53	-5%	-0.37	-3%	1.90	17%	0.25	2%	6.44	58%
	July	1.31	14%	0.26	3%	3.28	29%	-0.42	-4%	5.98	54%
	August	0.28	155%	-0.25	-8%	3.71	88%	2.53	41%	1.35	35%
	September	0.00	0%	0.00	0%	0.62	0%	1.00	0%	2.65	0%
	Sub Total	15.40	40%	-1.50	-4%	21.67	50%	18.15	40%	33.92	76%
Annual	Total	41.02	54%	22.43	30%	36.20	47%	44.55	56%	53.11	66%

Table 6-3: Summery of Water Quantity Difference between Actual Water Use and Recommended Irrigation Plan (DL1)

Season	Month	Summary of Water Quantity Difference between Plans			
		Maximum	Minimum	Average	Total
Maha	October	7.21	0.00	1.63	8.13
	November	5.01	1.18	3.05	15.25
	December	7.42	2.78	4.69	23.47
	January	8.92	2.88	6.00	30.02
	February	6.93	1.71	4.33	21.66
	March	3.64	1.11	2.22	11.10
Yala	April	11.43	-0.20	5.77	28.86
	May	11.30	-0.94	5.76	28.79
	June	6.44	-0.53	1.54	7.69
	July	5.98	-0.42	2.08	10.42
	August	3.71	-0.25	1.52	7.62
	September	2.65	0.00	0.85	4.27

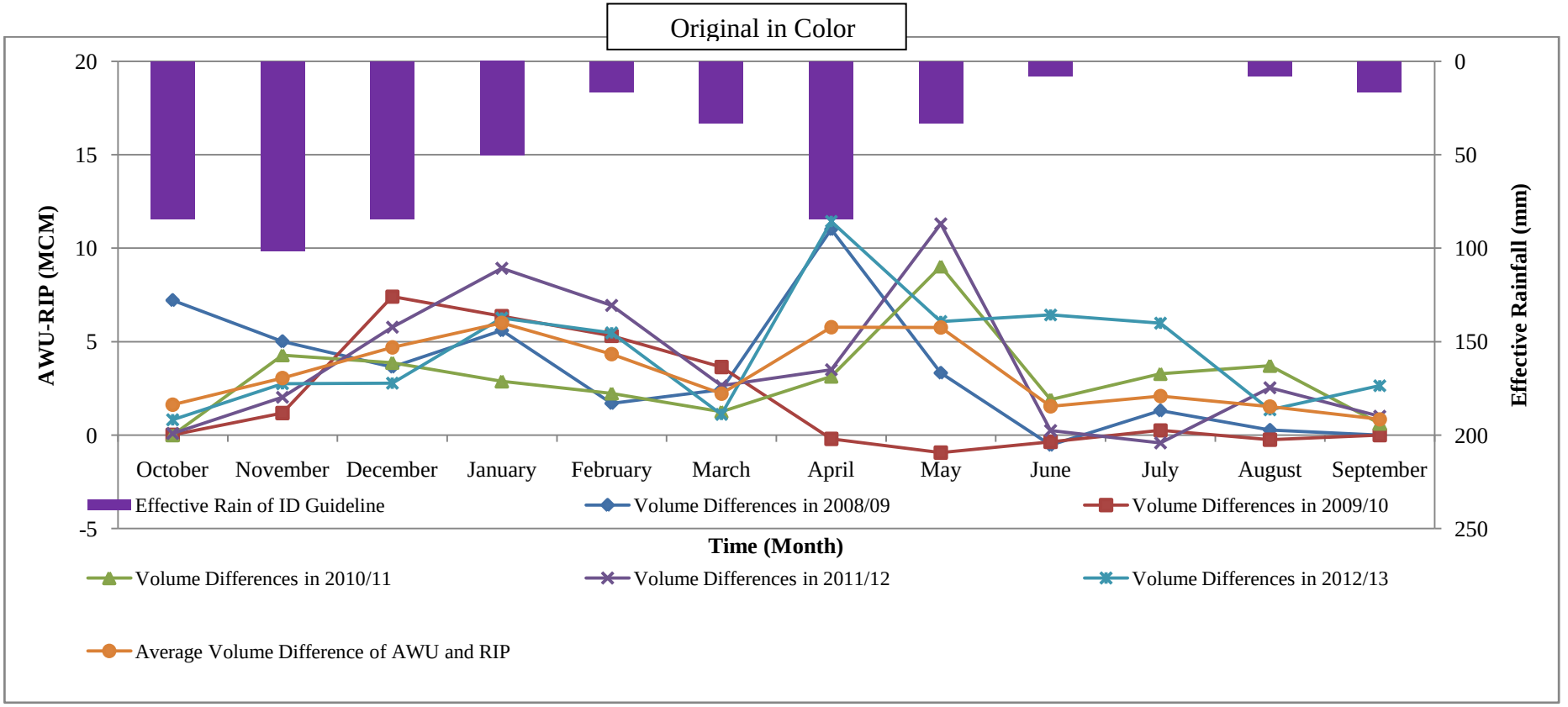


Figure 6-6: Water Volume of Actual Water Use and Recommended Irrigation Plan (DL1) Differences from 2008/09 to 2012/13

Table 6-4: Comparison between Actual Water Use, Rajangana ID Plan and Recommended Irrigation Plan (DL1) in Maha Season

Water Year	Water Use	Comparison of Water Volume between Actual Water Use, Rajangana ID Plan and Recommended Irrigation Plan (DL1) in Maha Season					
		Oct	Nov	Dec	Jan	Feb	March
2008/09	AWU	15.47	9.58	10.40	13.67	6.68	6.97
	RID	13.39	8.56	7.88	11.21	6.57	3.58
	RIP	8.26	4.58	6.75	8.07	4.98	4.53
	AWU-RID	2.08	1.03	2.52	2.46	0.11	3.39
	AWU-RIP	7.21	5.01	3.65	5.60	1.71	2.44
2009/10	AWU	0.01	7.07	13.54	14.24	14.01	9.34
	RID	0.00	5.94	10.24	11.01	10.63	7.73
	RIP	0.00	5.89	6.12	7.88	8.69	5.71
	AWU-RID	0.01	1.13	3.30	3.23	3.38	1.62
	AWU-RIP	0.01	1.18	7.42	6.36	5.32	3.64
2010/11	AWU	0.00	12.01	9.77	10.80	10.68	5.34
	RID	0.00	10.15	9.38	11.41	7.49	5.75
	RIP	0.00	7.73	5.90	7.92	8.45	4.09
	AWU-RID	0.00	1.86	0.39	-0.61	3.19	-0.41
	AWU-RIP	0.00	4.28	3.87	2.88	2.24	1.26
2011/12	AWU	0.08	9.98	11.77	16.84	15.34	6.43
	RID	0.34	8.96	8.76	12.88	12.01	4.89
	RIP	0.00	7.94	6.01	7.92	8.41	3.77
	AWU-RID	-0.26	1.02	3.01	3.96	3.33	1.54
	AWU-RIP	0.08	2.04	5.77	8.92	6.93	2.66
2012/13	AWU	1.09	14.44	9.24	14.23	13.71	2.35
	RID	0.97	11.29	8.09	11.00	11.63	2.18
	RIP	0.26	11.69	6.46	7.97	8.25	1.24
	AWU-RID	0.12	3.15	1.15	3.23	2.08	0.17
	AWU-RIP	0.82	2.75	2.78	6.26	5.47	1.11

Table 6-5: Comparison between Actual Water Use, Rajangana ID Plan and Recommended Irrigation Plan (DL1) in Maha Season

Water Year	Water Use	Comparison of Water Volume between Actual Water Use, Rajangana ID Plan and Recommended Irrigation Plan (DL1) in Yala Season					
		April	May	June	July	August	September
2008/09	AWU	18.15	13.47	11.10	10.61	0.46	0.00
	RID	9.04	6.62	10.83	10.92	4.06	4.21
	RIP	7.14	10.14	11.64	9.30	0.18	0.00
	AWU-RID	9.11	6.84	0.28	-0.31	-3.60	-4.21
	AWU-RIP	11.01	3.33	-0.53	1.31	0.28	0.00
2009/10	AWU	8.01	8.26	10.49	10.22	2.93	0.00
	RID	7.58	8.65	8.45	9.27	2.37	0.14
	RIP	8.21	9.20	10.85	9.96	3.18	0.00
	AWU-RID	0.42	-0.38	2.04	0.95	0.56	-0.14
	AWU-RIP	-0.20	-0.94	-0.37	0.26	-0.25	0.00
2010/11	AWU	11.17	17.95	12.96	14.64	7.93	0.62
	RID	9.28	15.91	10.35	15.32	7.83	1.31
	RIP	8.04	8.92	11.06	11.36	4.22	0.00
	AWU-RID	1.89	2.05	2.61	-0.69	0.10	-0.69
	AWU-RIP	3.13	9.03	1.90	3.28	3.71	0.62
2011/12	AWU	12.03	18.86	11.26	11.26	8.76	1.00
	RID	9.25	16.80	11.72	11.43	8.57	1.11
	RIP	8.54	7.56	11.01	11.67	6.23	0.00
	AWU-RID	2.79	2.06	-0.46	-0.17	0.19	-0.11
	AWU-RIP	3.49	11.30	0.25	-0.42	2.53	1.00
2012/13	AWU	20.35	15.51	17.49	17.14	5.25	2.65
	RID	17.44	13.52	15.70	15.36	6.59	3.83
	RIP	8.92	9.44	11.05	11.15	3.90	0.00
	AWU-RID	2.91	2.00	1.79	1.78	-1.34	-1.17
	AWU-RIP	11.43	6.07	6.44	5.98	1.35	2.65

Table 6-6: Comparison of Recommended Irrigation Plan (DL1) and Actual Water Use in Growth Stages

Season	Crop Growth Stage	2008/09		2009/10		2010/11		2011/12		2012/13		Average	
		RIP	**AWU**	**RIP**	**AWU**	**RIP**	**AWU**	**RIP**	**AWU**	**RIP**	**AWU**	**RIP**	**AWU**
Maha Season	Land Preparation	8.26	6.84	6.90	8.49	7.47	9.74	7.47	8.24	10.03	9.45	8.03	8.55
	Initial Stage	3.55	15.61	3.64	10.76	3.46	7.85	3.55	8.23	3.79	9.62	3.60	10.41
	Development Stage	6.43	10.03	7.22	11.93	6.94	10.14	6.92	13.14	6.59	8.42	6.82	10.73
	Mid Stage	7.64	19.71	8.98	14.63	8.65	9.39	8.54	16.51	8.03	15.14	8.37	15.08
	Late Stage	6.75	4.05	7.56	12.39	7.57	11.48	7.57	14.32	7.43	12.43	7.37	10.93
Maha Season Total		**32.64**	**56.24**	**34.29**	**58.20**	**34.08**	**48.60**	**34.05**	**60.44**	**35.88**	**55.06**	**34.19**	**55.71**
Yala Season	Land Preparation	8.19	11.44	7.27	6.73	7.67	9.84	8.54	5.76	8.34	9.54	8.00	8.66
	Initial Stage	4.90	12.82	5.78	6.59	5.73	13.00	5.88	15.89	6.13	13.13	5.68	12.29
	Development Stage	10.20	13.10	10.08	7.89	10.50	14.42	10.81	12.85	10.45	15.18	10.41	12.69
	Mid Stage	11.66	11.14	10.18	10.04	11.40	14.09	11.44	10.47	11.21	17.89	11.18	12.72
	Late Stage	8.01	11.82	8.18	8.64	8.30	13.92	8.31	18.21	8.32	22.64	8.22	15.05
Yala Season Total		**42.96**	**60.32**	**41.48**	**39.90**	**43.60**	**65.27**	**44.98**	**63.17**	**44.44**	**78.39**	**43.49**	**61.41**
Annual Total		**75.60**	**116.56**	**75.78**	**98.11**	**77.69**	**113.87**	**79.03**	**123.61**	**80.32**	**133.45**	**77.68**	**117.12**

Table 6-7: Difference between the Actual Water Use and Recommendation Irrigation Plan (DL1)

Season	Crop Growth Stage	Differences between the Actual Water Use and Recommended Irrigation Plan (DL1)															
		2008/09		2009/10		2010/11		2011/12		2012/13		Maximum Difference		Minimum Difference		Average Difference	
		AWU-RIP (MCM)	Percentage	AWU-RIP (MCM)	Percentage	AWU-RIP (MCM)	Percentage	AWU-RIP (MCM)	Percentage	AWU-RIP (MCM)	Percentage	Water Vol. (MCM)	Percentage	Water Vol. (MCM)	Percentage	Water Vol. (MCM)	Percentage
Maha Season	Land Preparation	-1.42	-17%	1.58	23%	2.27	30%	0.78	10%	-0.58	-6%	2.27	30%	-1.42	-17%	0.53	8%
	Initial Stage	12.06	340%	7.13	196%	4.39	127%	4.68	132%	5.83	154%	12.06	340%	4.39	127%	6.82	190%
	Development Stage	3.59	56%	4.72	65%	3.20	46%	6.22	90%	1.83	28%	6.22	90%	1.83	28%	3.91	57%
	MidStage	12.07	158%	5.65	63%	0.74	9%	7.97	93%	7.11	88%	12.07	158%	0.74	9%	6.71	82%
	Late Stage	-2.70	-40%	4.83	64%	3.92	52%	6.75	89%	5.00	67%	6.75	89%	-2.70	-40%	3.56	46%
Yala Season	Land Preparation	3.25	40%	-0.54	-7%	2.17	28%	-2.78	-33%	1.20	14%	3.25	40%	-2.78	-33%	0.66	8%
	Initial Stage	7.92	161%	0.82	14%	7.27	127%	10.01	170%	7.01	114%	10.01	170%	0.82	14%	6.60	117%
	Development Stage	2.90	28%	-2.19	-22%	3.92	37%	2.04	19%	4.73	45%	4.73	45%	-2.19	-22%	2.28	22%
	MidStage	-0.52	-4%	-0.14	-1%	2.69	24%	-0.98	-9%	6.68	60%	6.68	60%	-0.98	-9%	1.55	14%
	Late Stage	3.82	48%	0.47	6%	5.62	68%	9.90	119%	14.33	172%	14.33	172%	0.47	6%	6.83	82%

Table 6-8: Difference between the Actual Water Use and Recommended Irrigation Plan (DL1) from 2008/09 to 2012/13

Water Year	Recommended Irrigation Plan (DL1) (MCM)		Actual Water Use (MCM)		Difference in Water Use (AWU- RIP)			
					Maha Season (MCM)		Yala Season (MCM)	
	Maha	Yala	Maha	Yala	Quantity	Percent	Quantity	Percent
2008/09	32.64	42.96	56.24	60.32	23.60	72%	17.36	53%
2009/10	34.29	41.48	58.20	39.90	23.91	70%	-1.58	-5%
2009/11	34.08	43.60	48.60	65.27	14.52	43%	21.67	64%
2010/12	34.05	45.02	60.44	63.17	26.39	78%	18.15	53%
2012/13	35.88	44.46	55.06	78.39	19.18	53%	33.93	95%
Maximum	35.88	45.02	60.44	78.39	26.39	78%	33.93	95%
Minimum	32.64	41.48	48.60	39.90	14.52	43%	-1.58	-5%
Average	34.19	43.51	55.71	61.41	21.52	63%	17.91	52%

Table 6-9: Annual Comparison of Recommended Irrigation Plan (DL1) and Actual Water Use from 2008/09 to 2012/13

Water Year	Total Quantity MCM		Annual Difference (AWP-RIP)	
	RIP	AWU	Quantity MCM	Percentage
2008/09	75.60	116.56	40.96	54%
2009/10	75.77	98.11	22.33	29%
2009/11	77.68	113.87	36.19	47%
2010/12	79.07	123.61	44.54	56%
2012/13	80.34	133.45	53.11	66%
Maximum	80.34	133.45	53.11	66%
Minimum	75.60	98.11	22.33	29%
Average	77.69	117.12	39.43	51%

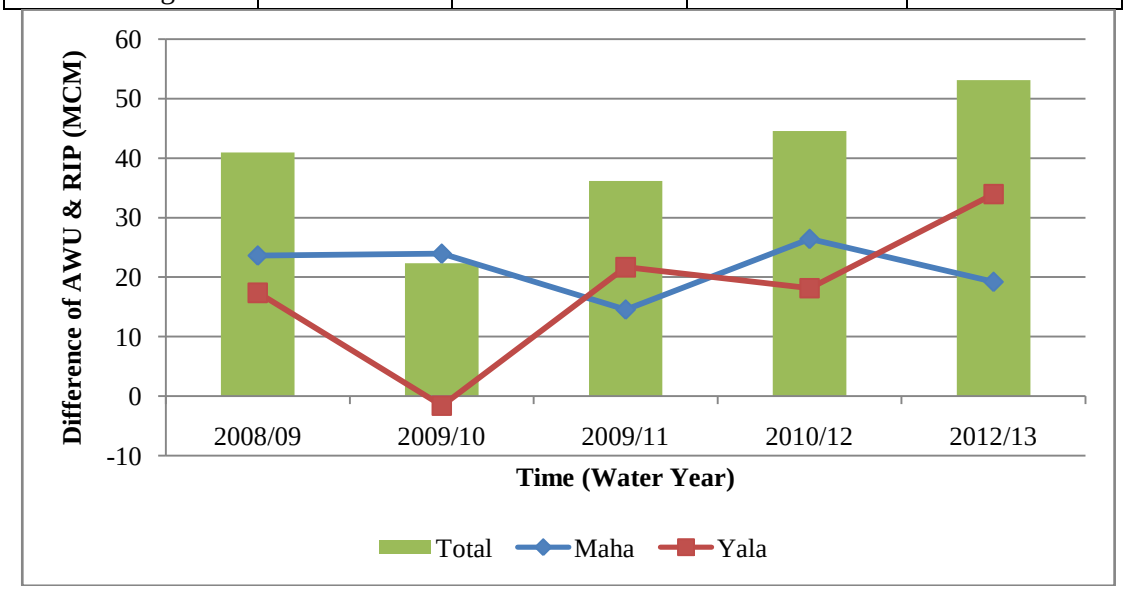


Figure 6-7: Seasonal Differences in Actual Water Use Compared with Recommended Irrigation Plan (DL1).

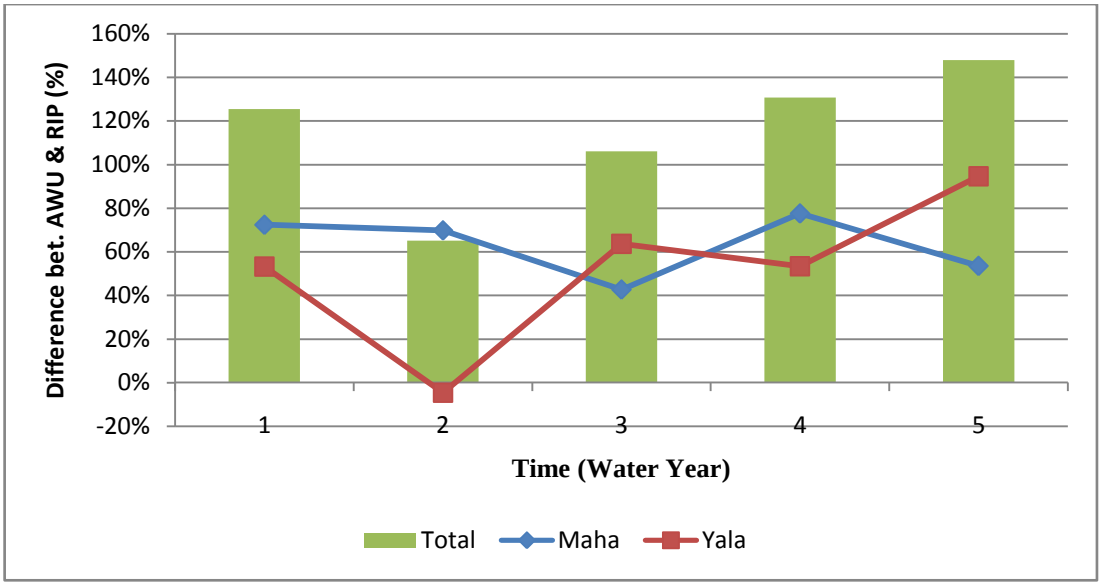


Figure 6-8: Seasonal Differences Percentage in Actual Water Use Compared with Recommended Irrigation Plan (DL1).

Table 6-10: Seasonal Water Duty Comparison between Actual Water Use and Recommended Irrigation Plan (DL1)

Water Year	Maha Season				Yala Season			
	Water Duty (m)		Difference		Water Duty (m)		Difference	
	Actual Water Use	Recommended Irrigation Plan (DL1)	Difference Duty(m)	Percentage	Actual Water Use	Recommended Irrigation Plan (DL1)	Difference Duty(m)	Percentage
2008/09	2.20	1.28	0.92	72%	2.36	1.68	0.68	40%
2009/10	2.27	1.34	0.93	70%	1.56	1.62	-0.06	-4%
2010/11	1.90	1.33	0.57	43%	2.55	1.70	0.85	50%
2011/12	2.36	1.33	1.03	78%	2.47	1.76	0.71	40%
2012/13	2.15	1.40	0.75	53%	3.06	1.74	1.33	76%
Maximum	2.36	1.40	1.03	78%	3.06	1.76	1.33	76%
Minimum	1.90	1.28	0.57	43%	1.56	1.62	-0.06	-4%
Average	2.18	1.34	0.84	63%	2.40	1.70	0.70	41%

APPENDIX-7 Comparison between “Actual Water Use” (AWU) and “Anticipated Water Use” (ANWU) from 2008/09-2012/13

Table 7-1: Seasonal and Annual Actual Water Use and Anticipated Water Use from 2008/09 to 2012/13

Season	Month	Water Volume of Actual Water Use (AWU) and Anticipated Water Use (ANWU) (MCM)									
		2008/09		2009/10		2010/11		2011/12		2012/13	
		ANWU	AWU	ANWU	AWU	ANWU	AWU	ANWU	AWU	ANWU	AWU
Maha	October	6.84	15.47	0.00	0.00	0.00	0.00	0.00	0.08	0.04	1.09
	November	3.93	9.58	5.67	7.07	4.80	12.01	5.22	9.98	7.48	14.44
	December	5.01	10.40	2.62	13.54	3.54	9.77	5.55	11.77	3.24	9.24
	January	4.26	13.67	8.17	14.24	4.62	10.80	9.04	16.84	8.26	14.23
	February	4.93	6.68	8.20	14.01	3.22	10.68	6.78	15.34	5.68	13.71
	March	2.16	6.97	5.78	9.34	3.32	5.34	3.26	6.43	0.83	2.35
Yala	April	8.98	18.15	6.74	8.01	3.66	11.17	7.06	12.03	7.98	20.35
	May	10.57	13.47	8.82	8.26	9.76	17.95	8.74	18.86	9.80	15.51
	June	10.61	11.10	9.80	10.49	9.81	12.96	11.23	11.26	10.48	17.49
	July	8.90	10.61	8.81	10.22	11.11	14.64	10.30	11.26	9.06	17.14
	August	0.19	0.46	2.91	2.93	4.25	7.93	6.63	8.76	3.78	5.25
	September	0.00	0.00	0.00	0.00	0.00	0.62	0.00	1.00	0.00	2.65
Annual	Total	66.39	116.56	67.52	98.11	58.10	113.87	73.80	123.61	66.63	133.45

Table 7-2: Seasonal and Annual Water Volume Difference between the Actual Water Use and Anticipated Water Use

Season	Month	Volume Differences in Actual Water Use (AWU) and Anticipated Water Use (ANWU) (MCM)									
		2008/09		2009/10		2010/11		2011/12		2012/13	
		AWU-ANWU	Percentage	AWU-ANWU	Percentage	AWU-ANWU	Percentage	AWU-ANWU	Percentage	AWU-ANWU	Percentage
Maha	Oct	8.63	126%	0.00	-	0.00	-	0.08	-	1.04	2317%
	Nov	5.65	144%	1.41	25%	7.21	150%	4.76	91%	6.96	93%
	Dec	5.39	108%	10.92	418%	6.23	176%	6.22	112%	6.00	185%
	Jan	9.41	221%	6.08	74%	6.17	134%	7.80	86%	5.97	72%
	Feb	1.75	35%	5.80	71%	7.46	232%	8.56	126%	8.03	141%
	Mar	4.81	223%	3.57	62%	2.02	61%	3.17	97%	1.52	184%
Yala	Apr	9.17	102%	1.26	19%	7.52	206%	4.98	71%	12.38	155%
	May	2.90	27%	-0.56	-6%	8.19	84%	10.12	116%	5.72	58%
	June	0.49	5%	0.69	7%	3.14	32%	0.02	0%	7.00	67%
	July	1.71	19%	1.41	16%	3.53	32%	0.96	9%	8.08	89%
	Aug	0.26	137%	0.01	0%	3.69	87%	2.13	32%	1.47	39%
	Sept	0.00	-	0.00	-	0.62	-	1.00	-	2.65	-
Annual	Total	50.17	76%	30.59	45%	55.77	96%	49.81	67%	66.82	100%

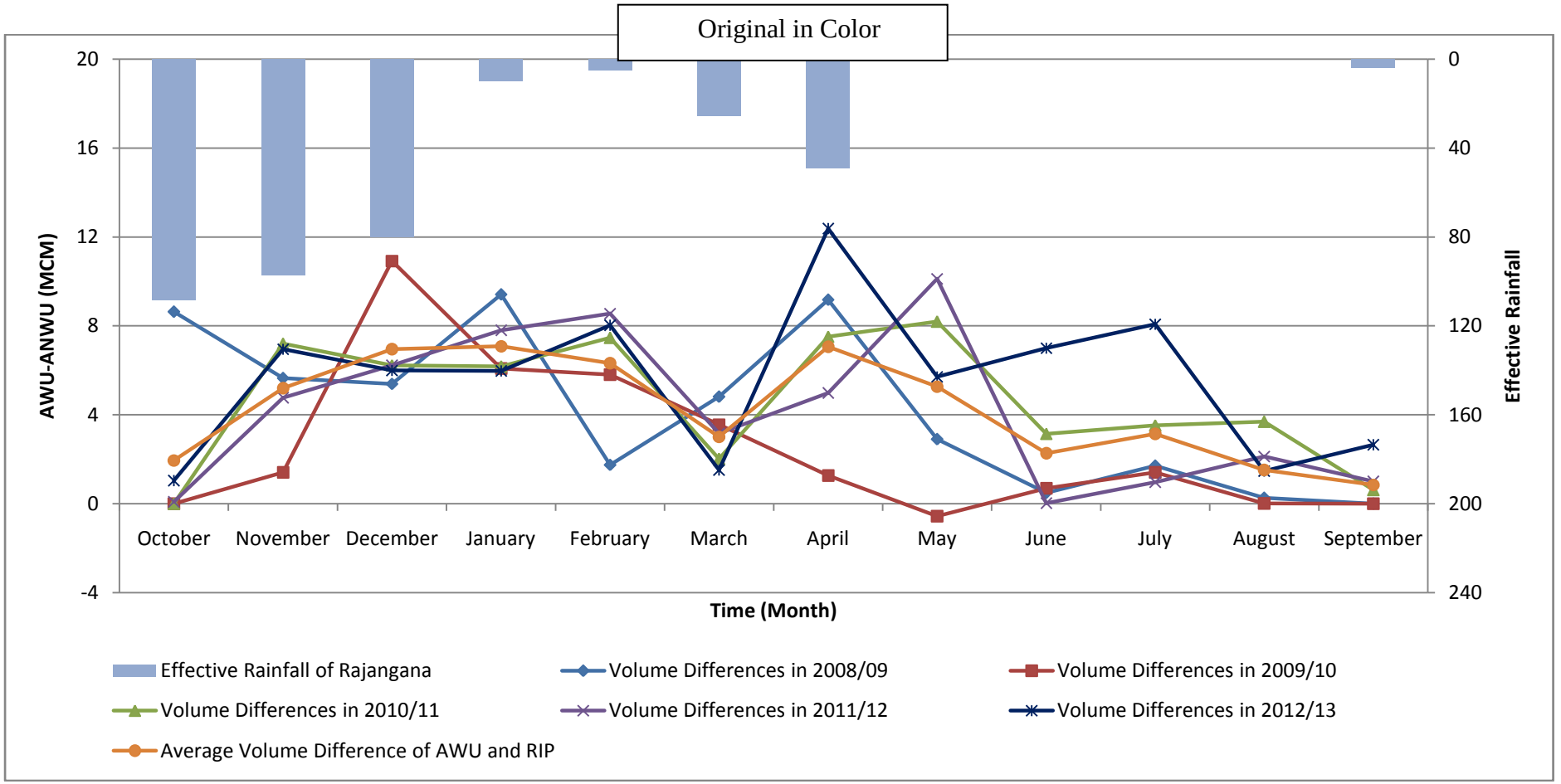


Figure 7-0.1: Water Volume Difference between Actual Water Use and Anticipated Water Use from 2008/09 to 2012/13

Table 7-3: Summery of Seasonal Water Quantity Difference between Actual Water Use and Anticipated Water Use (2008/09 – 2012/13)

Season	Month	Water Quantity Difference (AWU- ANWU)			
		Maximum	Minimum	Average	Total
Maha	October	8.63	0.00	1.95	9.75
	November	7.21	1.41	5.20	25.98
	December	10.92	5.39	6.95	34.76
	January	9.41	5.97	7.09	35.43
	February	8.56	1.75	6.32	31.60
	March	4.81	1.52	3.02	15.09
Yala	April	12.38	1.26	7.06	35.30
	May	10.12	-0.56	5.27	26.37
	June	7.00	0.02	2.27	11.35
	July	8.08	0.96	3.14	15.69
	August	3.69	0.01	1.51	7.57
	September	2.65	0.00	0.85	4.27

Table 7-4: Comparison between Anticipated Water Use (ANWU) and Actual Water Use (AWU) in Crop Growth Stage Period

Season	Crop Growth Stage	2008/2009		2009/2010		2010/2011		2011/2012		2012/2013		Average	
		ANWU	AWU	ANWU	AWU	ANWU	AWU	ANWU	AWU	ANWU	AWU	ANWU	AWU
Maha Season	Land Preparation	6.84	6.84	6.72	8.49	4.80	9.74	4.29	8.24	6.21	9.45	5.77	8.55
	Initial Stage	3.00	15.61	1.30	10.76	1.78	7.85	3.90	8.23	2.71	9.62	2.54	10.41
	Developing Stage	4.26	10.03	6.16	11.93	4.21	10.14	7.21	13.14	3.96	8.42	5.16	10.73
	Mid Stage	4.12	19.71	8.70	14.63	3.93	9.39	7.68	16.51	7.24	15.14	6.33	15.08
	Late Stage	6.76	4.05	7.55	12.39	4.79	11.48	6.76	14.32	5.42	12.43	6.26	10.93
Maha Season Total		24.98	56.24	30.43	58.20	19.52	48.60	29.85	60.44	25.54	55.06	26.06	55.71
Yala Season	Land Preparation	6.45	11.44	5.89	6.73	3.20	9.84	7.05	5.76	7.40	9.54	6.00	8.66
	Initial Stage	6.28	12.82	5.45	6.59	6.44	13.00	6.87	15.89	6.31	13.13	6.27	12.29
	Developing Stage	10.39	13.10	9.48	7.89	9.60	14.42	11.19	12.85	10.29	15.18	10.19	12.69
	Mid Stage	10.70	11.14	9.03	10.04	11.10	14.09	10.04	10.47	9.08	17.89	9.99	12.72
	Late Stage	7.59	11.82	7.23	8.64	8.25	13.92	8.81	18.21	8.02	22.64	7.98	15.05
Yala Season Total		41.41	60.32	37.09	39.90	38.58	65.27	43.96	63.17	41.09	78.39	40.43	61.41
Annual Total		66.39	116.56	67.52	98.11	58.10	113.87	73.80	123.61	66.63	133.45	66.49	117.12

Table 7-5: Difference between the Actual Water Use and Anticipated Water Use According to Crop Growth Stage Period

Season	Crop Growth Stage	2008/2009		2009/2010		2010/2011		2011/2012		2012/2013		Maximum Difference		Minimum Difference		Average Difference	
		AWU-ANWU (MCM)	Percentage	AWU-ANWU (MCM)	Percentage	AWU-ANWU (MCM)	Percentage	AWU-ANWU (MCM)	Percentage	AWU-ANWU (MCM)	Percentage	Water Volume (MCM)	Percentage	Water Volume (MCM)	Percentage	Water Volume (MCM)	Percentage
Maha Season	Land Prep.	0.00	0%	1.76	26%	4.93	103 %	3.95	92%	3.24	52%	4.93	103 %	0.00	0%	2.78	55%
	Initial Stage	12.61	420 %	9.46	729 %	6.07	342 %	4.33	111 %	6.91	255 %	12.61	729 %	4.33	111 %	7.88	372 %
	Develop. Stage	5.77	135 %	5.77	94%	5.93	141 %	5.93	82%	4.46	113 %	5.93	141 %	4.46	82%	5.57	113 %
	Mid Stage	15.59	378 %	5.94	68%	5.46	139 %	8.83	115 %	7.90	109 %	15.59	378 %	5.46	68%	8.74	162 %
	Late Stage	-2.70	-40%	4.84	64%	6.69	140 %	7.56	112 %	7.00	129 %	7.56	140 %	-2.70	-40%	4.68	81%
Yala Season	Land Prep.	4.99	77%	0.84	14%	6.64	208 %	-1.29	-18%	2.15	29%	6.64	208 %	-1.29	-18%	2.67	62%
	Initial Stage	6.54	104 %	1.14	21%	6.56	102 %	9.02	131 %	6.83	108 %	9.02	131 %	1.14	21%	6.02	93%
	Develop. Stage	2.71	26%	-1.59	-17%	4.82	50%	1.66	15%	4.89	48%	4.89	50%	-1.59	-17%	2.50	24%
	Mid Stage	0.44	4%	1.01	11%	2.99	27%	0.42	4%	8.81	97%	8.81	97%	0.42	4%	2.73	29%
	Late Stage	4.23	56%	1.41	20%	5.67	69%	9.40	107 %	14.63	182 %	14.63	182 %	1.41	20%	7.07	87%

Table 7-6: Difference between the Actual Water Use and Anticipated Water Use from 2008/09 to 2012/13

Water Year	Anticipated Water Use (MCM)		Actual Water Use (MCM)		Difference in Water Use			
					Maha Season		Yala Season	
	Maha	Yala	Maha	Yala	(AWU-ANWU)MCM	(AWU-ANWU)/ANWU %	(AWU-ANWU)MCM	(AWU-ANWU)/ANWU %
2008/09	24.98	41.41	56.24	60.32	31.26	125%	18.91	46%
2009/10	30.43	37.09	58.20	39.90	27.78	91%	2.82	8%
2010/11	19.52	38.58	48.60	65.27	29.09	149%	26.69	69%
2011/12	29.85	43.96	60.44	63.17	30.60	103%	19.22	44%
2012/13	25.54	41.09	55.06	78.39	29.52	116%	37.30	91%
Maximum	30.43	43.96	60.44	78.39	31.26	149%	37.30	91%
Minimum	19.52	37.09	48.60	39.90	27.78	91%	2.82	8%
Average	26.06	40.43	55.71	61.41	29.65	117%	20.99	51%

Table 7-7: Annual Comparison between Anticipated Water Use and Actual Water Use from 2008/09 to 2012/13

Water Year	Total Quantity MCM		Annual Difference	
	ANWU	AWU	(AWU-ANWU) MCM	(AWU-ANWU)/ANWU %
2008/09	66.39	116.56	50.17	76%
2009/10	67.52	98.11	30.59	45%
2009/11	58.10	113.87	55.77	96%
2010/12	73.80	123.61	49.81	67%
2012/13	66.63	133.45	66.82	100%
Maximum	73.80	133.45	66.82	100%
Minimum	58.10	98.11	30.59	45%
Average	66.49	117.12	50.63	77%

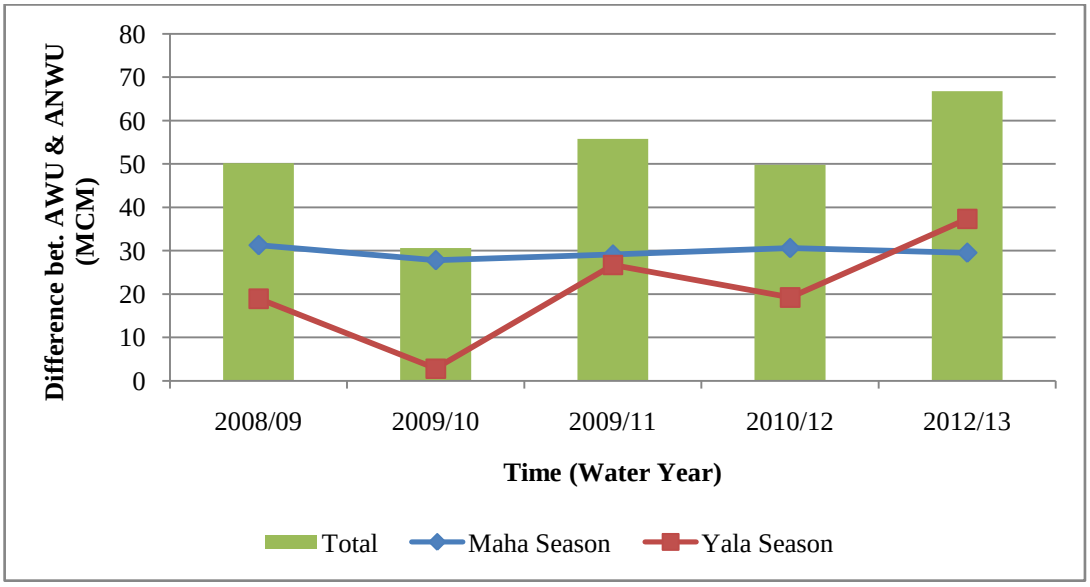


Figure 7-0.2: Seasonal Differences in Actual Water Use Compared with Anticipated Water Use

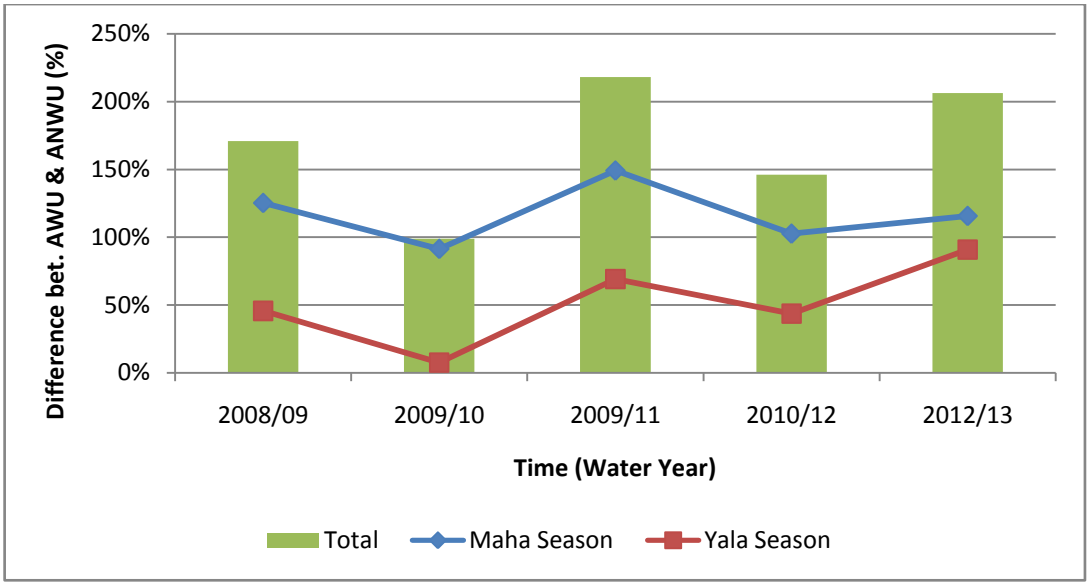


Figure 7-0.3: Seasonal Differences Percentage in Actual Water Use Compared with Anticipated Water Use (DL1)

Table 7-8: Seasonal Water Duty Comparison between Actual Water Use and Anticipated Water Use

Water Year	Maha Season				Yala Season			
	Water Duty of Actual Water Use (m)	Water Duty of Anticipated Water Use (m)	Difference		Water Duty of Actual Water Use	Water Duty of Anticipated Water Use	Difference	
			Water Duty(m)	Percentage			Water Duty(m)	Percentage
2008/09	2.20	0.98	1.22	125%	2.36	1.62	0.74	46%
2009/10	2.27	1.19	1.09	91%	1.56	1.45	0.11	8%
2010/11	1.90	0.76	1.14	149%	2.55	1.51	1.04	69%
2011/12	2.36	1.17	1.20	103%	2.47	1.72	0.75	44%
2012/13	2.15	1.00	1.15	116%	3.06	1.61	1.46	91%
Maximum	2.36	1.19	1.22	149%	3.06	1.72	1.46	91%
Minimum	1.90	0.76	1.09	91%	1.56	1.45	0.11	8%
Average	2.18	1.02	1.16	117%	2.40	1.58	0.82	51%

APPENDIX-8 Comparison between "Recommended Irrigation Plan" (DL1) (RIP) and "Anticipated Water Use" (ANWU) from 2008/09-2012/13

Table 8-1:Seasonal and Annual Recommended Irrigation Plan and Anticipated Water Use from 2008/09 to 2012/13

Season	Month	Water Volume of Anticipated Water Use and Recommended Irrigation Plan (MCM)									
		2008/09		2009/10		2010/11		2011/12		2012/13	
		ANWU	RIP	ANWU	RIP	ANWU	RIP	ANWU	RIP	ANWU	RIP
Maha	October	6.84	8.26	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.26
	November	3.93	4.58	5.67	5.89	4.80	7.73	5.22	7.94	7.48	11.69
	December	5.01	6.75	2.62	6.12	3.54	5.90	5.55	6.01	3.24	6.46
	January	4.26	8.07	8.17	7.88	4.62	7.92	9.04	7.92	8.26	7.97
	February	4.93	4.98	8.20	8.69	3.22	8.45	6.78	8.41	5.68	8.25
	March	2.16	4.53	5.78	5.71	3.32	4.09	3.26	3.77	0.83	1.24
	Sub Total	27.13	37.17	30.44	34.29	19.50	34.09	29.85	34.05	25.53	35.87
Yala	April	8.98	7.14	6.74	8.21	3.66	8.04	7.06	8.54	7.98	8.92
	May	10.57	10.14	8.82	9.20	9.76	8.92	8.74	7.56	9.80	9.44
	June	10.61	11.64	9.80	10.85	9.81	11.06	11.23	11.01	10.48	11.05
	July	8.90	9.30	8.81	9.96	11.11	11.36	10.30	11.67	9.06	11.15
	August	0.19	0.18	2.91	3.18	4.25	4.22	6.63	6.23	3.78	3.90
	September	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Sub Total	39.25	38.40	37.08	41.40	38.59	43.60	43.96	45.01	41.10	44.46
Annual	Total	66.38	75.57	67.52	75.69	58.09	77.69	73.81	79.06	66.63	80.33

Table 8-2: Seasonal and Annual Water Volume Difference between the Recommendation Irrigation Plan and Anticipated Water Use

Season	Month	Difference between Recommended Irrigation Plan(DL1) (RIP) and Anticipated Water Use (ANWU) (MCM)									
		2008/09		2009/10		2010/11		2011/12		2012/13	
		RIP- ANWU	(RIP-ANWU)/ANWU %	RIP- ANWU	(RIP-ANWU)/ANWU %	RIP- ANWU	(RIP-ANWU)/ANWU %	RIP- ANWU	(RIP-ANWU)/ANWU %	RIP- ANWU	(RIP-ANWU)/ANWU %
Maha	October	1.42	21%	0	0%	0	0%	0	0%	0.22	487%
	November	0.65	16%	0.23	4%	2.93	61%	2.73	52%	4.21	56%
	December	1.74	35%	3.5	134%	2.36	67%	0.46	8%	3.23	100%
	January	3.81	89%	-0.28	-3%	3.29	71%	-1.12	-12%	-0.29	-4%
	February	0.04	1%	0.49	6%	5.22	162%	1.62	24%	2.56	45%
	March	2.37	110%	-0.07	-1%	0.76	23%	0.51	16%	0.41	50%
	Sub Total	10.03	37%	3.87	13%	14.56	75%	4.20	14%	10.34	41%
Yala	April	-1.84	-21%	1.47	22%	4.38	120%	1.48	21%	0.95	12%
	May	-0.43	-4%	0.38	4%	-0.84	-9%	-1.17	-13%	-0.36	-4%
	June	1.02	10%	1.06	11%	1.25	13%	-0.22	-2%	0.56	5%
	July	0.4	4%	1.15	13%	0.25	2%	1.38	13%	2.1	23%
	August	-0.01	-7%	0.26	9%	-0.02	-1%	-0.4	-6%	0.12	3%
	September	0	0%	0	0%	0	0%	0	0%	0	0%
	Sub Total	-0.86	-2%	4.32	12%	5.02	13%	1.07	2%	3.37	8%
Annual	Total	9.17	14%	8.19	12%	19.58	34%	5.27	7%	13.71	21%

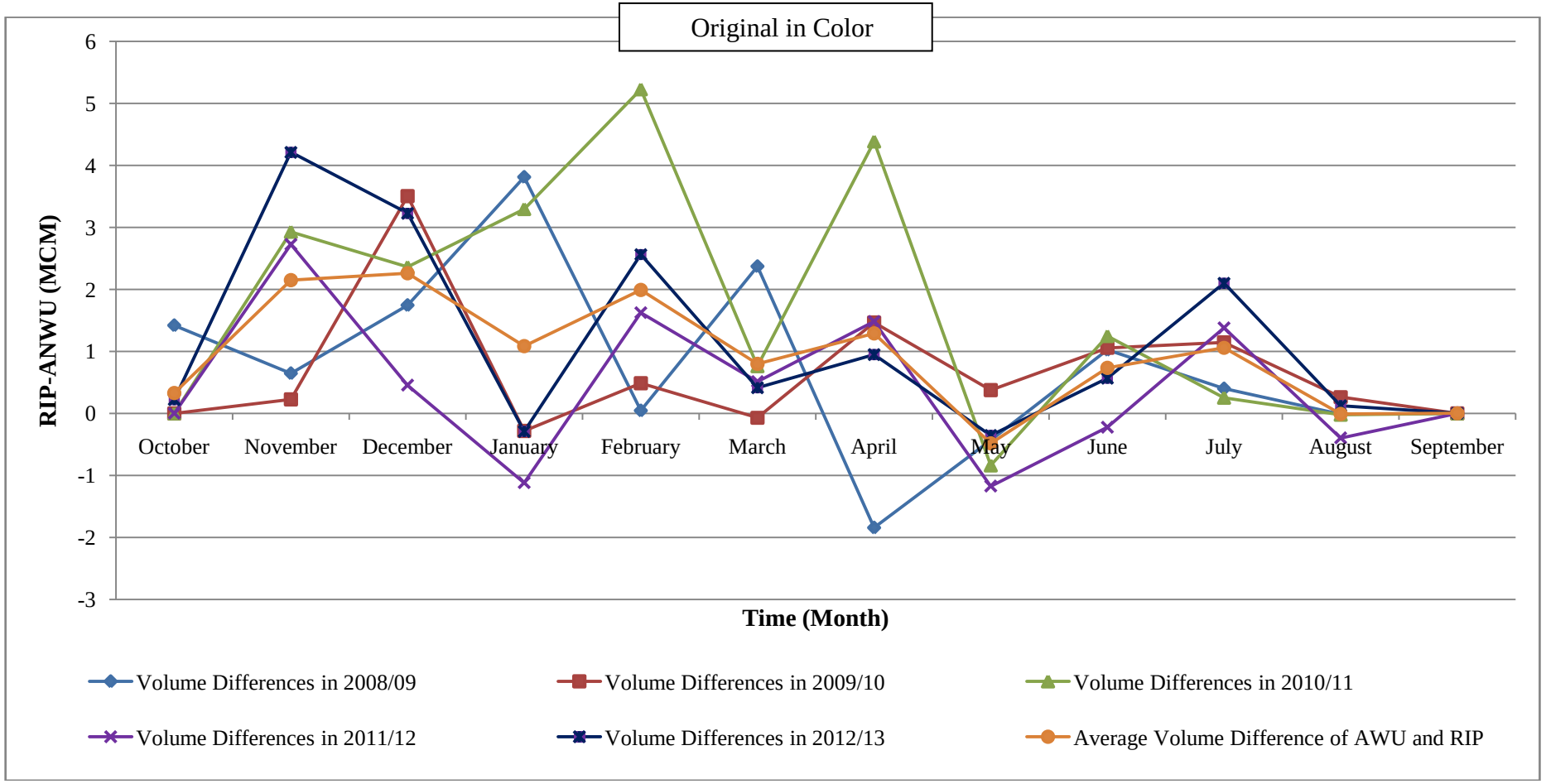


Figure 8-0.1: Water Volume Difference between Recommended Irrigation Plan (DL1) and Anticipated Water Use from 2008/09 to 2012/13

Table 8-3: Summery of Seasonal Water Quantity Difference between Recommended Irrigation Plan (DL1) and Anticipated Water Use

Season	Month	Summary of Water Quantity Difference between Recommended Irrigation Plan (DL1) and Anticipated Water Use (MCM)			
		Maximum	Minimum	Average	Total
Maha	October	1.42	0.00	0.33	1.64
	November	4.21	0.23	2.15	10.74
	December	3.50	0.46	2.26	11.29
	January	3.81	-1.12	1.08	5.41
	February	5.22	0.04	1.99	9.94
	March	2.37	-0.07	0.80	3.99
Yala	April	4.38	-1.84	1.29	6.44
	May	0.38	-1.17	-0.49	-2.43
	June	1.25	-0.22	0.73	3.67
	July	2.10	0.25	1.06	5.28
	August	0.26	-0.40	-0.01	-0.05
	September	0.00	0.00	0.00	0.00

Table 8-4: Comparison between Anticipated Water Use (ANWU) and Recommended Irrigation Plan (DL1) in Crop Growth Stage Period

Season	Growth stage	2008/2009		2009/2010		2010/2011		2011/2012		2012/2013		Average	
		Anticipated Water Use	Rec. ID Plan	Anticipated Water Use	Rec. ID Plan	Anticipated Water Use	Rec. ID Plan	Anticipated Water Use	Rec. ID Plan	Anticipated Water Use	Rec. ID Plan	Anticipated Water Use	Rec. ID Plan
Maha Season	LP	6.84	4.84	6.72	6.90	4.80	7.47	4.29	7.47	6.21	10.03	5.77	7.34
	IP	3.00	4.95	1.30	3.64	1.78	3.46	3.90	3.55	2.71	3.79	2.54	3.88
	DP	4.26	8.22	6.16	7.22	4.21	6.94	7.21	6.92	3.96	6.59	5.16	7.18
	MP	4.12	11.58	8.70	8.98	3.93	8.65	7.68	8.54	7.24	8.03	6.33	9.16
	Late P	6.76	3.05	7.55	7.56	4.79	7.57	6.76	7.57	5.42	7.43	6.26	6.63
Maha Season Total		24.98	32.64	30.43	34.29	19.52	34.08	29.85	34.05	25.54	35.88	26.06	34.19
Yala Season	LP	6.45	8.19	5.89	7.23	3.20	7.67	7.05	5.26	7.40	6.86	6.00	7.04
	IP	6.28	3.17	5.45	5.78	6.44	5.73	6.87	5.05	6.31	3.48	6.27	4.64
	DP	10.39	9.76	9.48	10.09	9.60	10.50	11.19	9.79	10.29	9.44	10.19	9.92
	MP	10.70	11.52	9.03	10.18	11.10	11.40	10.04	11.28	9.08	11.09	9.99	11.09
	Late P	7.59	10.27	7.23	8.11	8.25	8.31	8.81	13.64	8.02	13.59	7.98	10.79
Yala Season Total		41.41	42.92	37.09	41.39	38.58	43.61	43.96	45.02	41.09	44.46	40.43	43.48
Annual Total		66.39	75.56	67.52	75.69	58.10	77.69	73.80	79.07	66.63	80.34	66.49	77.67

Table 8-5: Difference between the Recommended Irrigation Plan (DL1) (RIP) and Anticipated Water Use (ANWU) According to Crop Growth Stage Period

Season	Crop Growth stage	2008/2009		2009/2010		2010/2011		2011/2012		2012/2013		Maximum Difference		Minimum Difference		Average Difference	
		RIP-ANWU	%	RIP-ANWU	%	RIP-ANWU	%	RIP-ANWU	%	RIP-ANWU	%	Water Vol.	%	Water Vol.	%	Water Vol.	%
Maha Season	Land Prep.	-2.00	-29%	0.18	3%	2.66	55%	3.17	74%	3.83	62%	3.83	74%	-2.00	-29%	1.57	33%
	Initial Stage	1.95	65%	2.34	180%	1.69	95%	-0.35	-9%	1.08	40%	2.34	180%	-0.35	-9%	1.34	74%
	Develop Stage	3.96	93%	1.06	17%	2.73	65%	-0.29	-4%	2.63	66%	3.96	93%	-0.29	-4%	2.02	47%
	Mid Stage	7.46	181%	0.28	3%	4.72	120%	0.86	11%	0.79	11%	7.46	181%	0.28	3%	2.82	65%
	Late Stage	-3.70	-55%	0.01	0%	2.78	58%	0.81	12%	2.01	37%	2.78	58%	-3.70	-55%	0.38	10%
Yala Season	Land Prep.	1.74	27%	1.34	23%	4.48	140%	-1.79	-25%	-0.54	-7%	4.48	140%	-1.79	-25%	1.05	31%
	Initial Stage	-3.11	-49%	0.33	6%	-0.71	-11%	-1.82	-27%	-2.82	-45%	0.33	6%	-3.11	-49%	-1.63	-25%
	Develop Stage	-0.64	-6%	0.61	6%	0.90	9%	-1.39	-12%	-0.85	-8%	0.90	9%	-1.39	-12%	-0.27	-2%
	Mid Stage	0.82	8%	1.14	13%	0.30	3%	1.24	12%	2.01	22%	2.01	22%	0.30	3%	1.10	12%
	Late Stage	2.73	36%	0.97	13%	0.06	1%	4.83	55%	5.58	70%	5.58	70%	0.06	1%	2.83	35%

Table 8-6: Difference between the Anticipated Water Use (ANWU) and Recommended Irrigation Plan (RIP) (DL1) (2008/09 to 2012/13)

Water Year	(ANWU)MCM		(RIP) MCM		Difference			
					Maha Season		Yala Season	
	Maha	Yala	Maha	Yala	(RIP-ANWU)MCM	(RIP-ANWU)/ANWU %	(RIP-ANWU)MCM	(RIP-ANWU)/ANWU %
2008/09	24.98	41.41	32.64	42.92	7.66	31%	1.50	4%
2009/10	30.43	37.09	34.29	41.39	3.86	13%	4.31	12%
2010/11	19.52	38.58	34.08	43.61	14.57	75%	5.02	13%
2010/12	29.85	43.96	34.05	45.02	4.20	14%	1.07	2%
2012/13	25.54	41.09	35.88	44.46	10.34	40%	3.37	8%
Maximum	30.43	43.96	35.88	45.02	14.57	75%	5.02	13%
Minimum	19.52	37.09	32.64	41.39	3.86	13%	1.07	2%
Average	26.06	40.43	34.19	43.48	8.13	35%	3.05	8%

Table 8-7: Annual Comparison between Anticipated Water Use and Recommended Irrigation Plan (DL1) from 2008/09 to 2012/13

Water Year	Total Quantity (MCM)		Difference	
	Anticipated Water Use	Recommended Irrigation Plan	(RIP-ANWU) MCM	(RIP-ANWU)/ ANWU %
2008/09	66.39	75.56	9.17	14%
2009/10	67.52	75.69	8.17	12%
2009/11	58.10	77.69	19.59	34%
2010/12	73.80	79.07	5.27	7%
2012/13	66.63	80.34	13.71	21%
Maximum	73.80	80.34	19.59	34%
Minimum	58.10	75.56	5.27	7%
Average	66.49	77.67	11.18	17%

Table 8-8: Seasonal Water Duty Comparison between Anticipated Water Use and Recommended Irrigation Plan (DL1)

Water Year	Maha Season				Yala Season			
	Water Duty (m)		Difference		Water Duty (m)		Difference	
	Recommended Irrigation Plan (RIP)	Anticipated Water Use (ANWU)	(RIP-ANWU)m	(RIP-ANWU)/ANWU %	Recommended Irrigation Plan (RIP)	Anticipated Water Use (ANWU)	(RIP-ANWU)m	(RIP-ANWU)/ANWU %
2008/09	1.28	0.98	0.30	31%	1.68	1.62	0.06	4%
2009/10	1.34	1.19	0.15	13%	1.62	1.45	0.17	12%
2010/11	1.33	0.76	0.57	75%	1.70	1.51	0.20	13%
2011/12	1.33	1.17	0.16	14%	1.76	1.72	0.04	2%
2012/13	1.40	1.00	0.40	40%	1.74	1.61	0.13	8%
Maximum	1.40	1.19	0.57	75%	1.76	1.72	0.20	13%
Minimum	1.28	0.76	0.15	13%	1.62	1.45	0.04	2%
Average	1.34	1.02	0.32	35%	1.70	1.58	0.12	8%

APPENDIX-9 Specimen Calculations

1. Water Year 2008/09
2. Maha season cultivation area :2559.44 Ha
3. Yala season cultivation area: 2559.44 Ha
4. Cultivation :

Maha Season(Ha)	Yala Season(Ha)						
Paddy	Paddy	Green gram	Soybean	Cow Pea	Groundnut	Undu	Maize
2559.44	2525.45	3.99	-	8	2	2	17.99

5. Cultivation
    a. Maha cultivation :October 1st to March 31st
    b. Yala cultivation :April 1st to September 30th
6. Weekly Pan Evapotranspiration (ET0) of 2008/09

1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
16.67	16.67	16.67	16.67	15.91	15.41	15.41	15.41	15.71	16.45
11th	12th	13th	14th	15th	16th	17th	18th	19th	20th
16.45	16.45	16.45	14.35	14.35	14.35	14.35	15.86	18.34	18.34
21st	22nd	23rd	24th	25th	26th	27th	28th	29th	30th
18.34	19.50	21.04	21.04	21.04	21.04	23.12	23.12	23.12	23.12
31st	32nd	33rd	34th	35th	36th	37th	38th	39th	40th
25.10	25.89	25.89	25.89	25.97	26.16	26.16	26.16	26.16	33.10
41st	42nd	43rd	44th	45th	46th	47th	48th	49th	50th
33.10	33.10	33.10	30.26	28.13	28.13	28.13	28.30	29.30	29.30
51st	52nd								
29.30	33.49								

7. Crop Coefficients of the Paddy and OFC crops and its related growth stages

Crop Growth stages and Crop coefficient

Crop		Growth Stages			
		Initial	Development	Mid	Late
Lowland Paddy Maha	Crop Coefficient	1.00	1.15	1.20	0.90
	Crop growth stage	30	40	45	20
Lowland Paddy Yala	Crop Coefficient	1.00	1.15	1.20	0.90
	Crop growth stage	20	30	30	25
Cow Pea	Crop Coefficient	0.70	0.90	1.10	1.00
	Crop growth stage	15	25	35	15
Groundnut	Crop Coefficient	0.65	0.80	1.00	0.80
	Crop growth stage	20	30	40	20
Pulse	Crop Coefficient	15	25	35	15
	Crop growth stage	0.50	0.80	1.05	0.50
Green gram	Crop Coefficient	0.50	0.80	1.05	0.7
	Crop growth stage	15	20	25	15
Soybean	Crop Coefficient	0.65	0.85	1.05	0.75
	Crop growth stage	15	20	50	20
Maize (Irringu)	Crop Coefficient	0.69	0.87	1.05	0.8
	Crop growth stage	20	35	40	30

8. Weekly Rainfall of Rajangana Station

1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
42.05	46.97	70.01	83.41	51.86	103	70.78	55.83	31.28	37.07
11th	12th	13th	14th	15th	16th	17th	18th	19th	20th
46.58	64.32	15.89	14.39	28.18	12.26	7.07	25.35	22.06	3.82
21st	22nd	23rd	24th	25th	26th	27th	28th	29th	30th
9.05	13.48	18.46	24.10	15.71	54.50	29.33	40.08	29.32	41.61
31st	32nd	33rd	34th	35th	36th	37th	38th	39th	40th
14.76	6.33	4.76	2.27	2.73	5.25	1.03	3.05	0.00	0.00
41st	42nd	43rd	44th	45th	46th	47th	48th	49th	50th
11.20	11.50	7.36	8.77	0.00	2.59	11.79	11.14	3.34	3.93
51st	52nd								
1.71	39.37								

9. Weekly Rainfall of 75% Probability

1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
0.00	5.00	4.10	3.00	19.30	12.30	11.30	17.30	0.00	8.70
11th	12th	13th	14th	15th	16th	17th	18th	19th	20th
7.20	17.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21st	22nd	23rd	24th	25th	26th	27th	28th	29th	30th
0.00	10.50	0.00	5.00	0.00	0.00	3.80	18.00	0.00	0.00
31st	32nd	33rd	34th	35th	36th	37th	38th	39th	40th
0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.50	0.00	0.00
41st	42nd	43rd	44th	45th	46th	47th	48th	49th	50th
12.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
51st	52nd								
0.00	0.00								

10. Effective Rainfall

1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
0.00	2.68	2.08	1.34	12.26	7.57	6.9	10.92	0.00	5.16
11th	12th	13th	14th	15th	16th	17th	18th	19th	20th
4.15	11.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21st	22nd	23rd	24th	25th	26th	27th	28th	29th	30th
0.00	6.36	0.00	2.68	0.00	0.00	1.88	11.39	0.00	0.00
31st	32nd	33rd	34th	35th	36th	37th	38th	39th	40th
0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.35	0.00	0.00
41st	42nd	43rd	44th	45th	46th	47th	48th	49th	50th
7.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
51st	52nd								
0.00	0.00								

11. Conveyance Efficiency :70%

12. Irrigation Demand Computation according to recommended format by the Irrigation Department

Table 9-1: Irrigation demand calculation for paddy cultivation in Maha season (2008-09)

Start time:		1/10/2008	8/10/2008	15/10/2008	22/10/2008	29/10/2008	5/11/2008	12/11/2008	19/11/2008	26/11/2008	3/12/2008	10/12/2008	17/12/2008	24/12/2008	31/12/2008	7/1/2009	14/1/2009	21/1/2009	28/1/2009	4/2/2009	11/2/2009	18/2/2009	25/2/2009
End Time :		7/10/2008	14/10/2008	21/10/2008	28/10/2008	4/11/2008	11/11/2008	18/11/2008	25/11/2008	2/12/2008	9/12/2008	16/12/2008	23/12/2008	30/12/2008	6/1/2009	13/1/2009	20/1/2009	27/1/2009	3/2/2009	10/2/2009	17/2/2009	24/2/2009	3/3/2009
	Season	Maha																					
	Week	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	13th	14th	15th	16th	17th	18th	19th	20th	21st	22nd
	ET_0	16.57	16.57	16.57	16.57	15.91	15.41	15.41	15.41	15.71	16.45	16.45	16.45	16.45	14.35	14.00	14.00	14.00	15.86	18.34	18.34	18.34	19.50
	Assuming 1staggers and a 15 day for each section land preparation																						
	Stagger 1	15		6			30 days Kc=1		3	4			40 days Kc=1.15		1	6days			45 days Kc=1.20		4	3day		20 days Kc=0.9	3
	Kc	0	0	1	1	1	1	1.075	1.15	1.15	1.15	1.15	1.15	1.175	1.2	1.2	1.2	1.2	1.2	1.05	0.9	0.9	0.9
	ET (S_1)	-	-	14.20	16.57	15.91	15.41	16.73	17.72	18.06	18.92	18.92	18.92	19.62	17.23	16.81	16.81	16.81	19.04	19.65	16.51	16.51	7.52
	ET_c	-	-	14.20	16.57	15.91	15.41	16.73	17.72	18.06	18.92	18.92	18.92	19.62	17.23	16.81	16.81	16.81	19.04	19.65	16.51	16.51	7.52
	LP (Land Preparation)	83.07	83.07	11.87																			
	Farm loss	34.32	34.32	34.32	34.32	34.32	34.32	34.32	34.32	34.32	34.32	34.32	34.32	34.32	34.32	34.32	34.32	34.32	34.32	34.32	34.32	34.32	34.32
	FWR (8+9+10)	117.39	117.39	60.39	50.89	50.23	49.73	51.05	52.05	52.39	53.24	53.24	53.24	53.95	51.55	51.13	51.13	51.13	53.36	53.97	50.83	50.83	41.84
	ER	-	2.68	2.08	1.34	12.26	7.57	6.90	10.92	-	5.16	4.15	11.06	-	-	-	-	-	-	-	-	-	6.36
	FIR (FWR-ER)	117.39	114.71	58.31	49.55	37.97	42.16	44.15	41.12	52.39	48.08	49.09	42.19	53.95	51.55	51.13	51.13	51.13	53.36	53.97	50.83	50.83	35.48
	ID	167.70	163.87	83.30	70.78	54.24	60.23	63.08	58.75	74.84	68.69	70.12	60.26	77.06	73.64	73.04	73.04	73.04	76.23	77.10	72.61	72.61	50.69

Original in Color

Table 9-2: Irrigation demand calculation for paddy in Yala season (2008-09)

Start time:		1/10/2008	8/10/2008	15/10/2008	22/10/2008	29/10/2008	5/11/2008	12/11/2008	19/11/2008	26/11/2008	3/12/2008	10/12/2008	17/12/2008	24/12/2008	31/12/2008	7/1/2009	14/1/2009	21/1/2009	28/1/2009	4/2/2009	11/2/2009	18/2/2009	25/2/2009	4/3/209
End Time :		7/10/2008	14/10/2008	21/10/2008	28/10/2008	4/11/2008	11/11/2008	18/11/2008	25/11/2008	2/12/2008	9/12/2008	16/12/2008	23/12/2008	30/12/2008	6/1/2009	13/1/2009	20/1/2009	27/1/2009	3/2/2009	10/2/2009	17/2/2009	24/2/2009	3/3/2009	10/3/209
Pump Discharge																							
	Season	Maha																					
	Week	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	13th	14th	15th	16th	17th	18th	19th	20th	21st	22nd	23rd
	ET_0	16.57	16.57	16.57	16.57	15.91	15.41	15.41	15.41	15.71	16.45	16.45	16.45	16.45	14.35	14.00	14.00	14.00	15.86	18.34	18.34	18.34	19.50	21.04
	Assuming 1staggers and a 15 day for each section land preparation																							
1	**Stagger 1**	15		6	30 days Kc=1			3	4	40 days Kc=1.15			1	6days	45 days Kc=1.20			4	3day	20 days Kc=0.9		3			
2	**ET (S_1)**	-	-	14.20	16.57	15.91	15.41	16.73	17.72	18.06	18.92	18.92	18.92	19.62	17.23	16.81	16.81	16.81	19.04	19.65	16.51	16.51	7.52	
3	**ET_c**	-	-	14.20	16.57	15.91	15.41	16.73	17.72	18.06	18.92	18.92	18.92	19.62	17.23	16.81	16.81	16.81	19.04	19.65	16.51	16.51	7.52	
4	**LP (Land Preparation)**	83.07	83.07	11.87																				
5	**Farm loss**	34.32	34.32	34.32	34.32	34.32	34.32	34.32	34.32	34.32	34.32	34.32	34.32	34.32	34.32	34.32	34.32	34.32	34.32	34.32	34.32	34.32	34.32	
6	**FWR (8+9+10)**	117.39	117.39	60.39	50.89	50.23	49.73	51.05	52.05	52.39	53.24	53.24	53.24	53.95	51.55	51.13	51.13	51.13	53.36	53.97	50.83	50.83	41.84	
7	**ER**	-	2.68	2.08	1.34	12.26	7.57	6.90	10.92	-	5.16	4.15	11.06	-	-	-	-	-	-	-	-	-	6.36	
8	**FIR** (FWR-ER)	117.39	114.71	58.31	49.55	37.97	42.16	44.15	41.12	52.39	48.08	49.09	42.19	53.95	51.55	51.13	51.13	51.13	53.36	53.97	50.83	50.83	35.48	
9	**ID**	167.70	163.87	83.30	70.78	54.24	60.23	63.08	58.75	74.84	68.69	70.12	60.26	77.06	73.64	73.04	73.04	73.04	76.23	77.10	72.61	72.61	50.69	

Original in Color

Table 9-3: Green gram cultivation of Yala season for 2008-09

Start time:		25/3/2009	1/4/2008	8/4/2008	15/4/2008	22/4/2008	29/4/2008	6/5/2008	13/5/2008	20/5/2008	27/5/2008	3/6/2008	10/6/2008	17/6/2008	24/6/2008	1/7/2008	8/7/2008	15/7/2008	22/7/2008	29/7/2008
End Time :		31/3/2009	7/4/2008	14/4/2008	21/4/2008	28/4/2008	5/5/2008	12/5/2008	19/5/2008	26/5/2008	2/6/2008	9/6/2008	16/6/2008	23/6/2008	30/6/2008	7/7/2008	14/7/2008	21/7/2008	28/7/2008	4/8/2008
Pump Discharge																				
	Season		Yala																	
	Week	26th	27th	28th	29th	30th	31st	32nd	33rd	34th	35th	36th	37th	38th	39th	40th	41st	42nd	43rd	44th
	ET_0	21.04	23.12	23.12	23.12	23.12	25.10	25.89	25.89	25.89	25.97	26.16	26.16	26.16	26.16	33.10	33.10	33.10	33.10	30.26
	Assuming		Assuming 1 staggers and a 15 day for each section land preparation																	
1	Stagger 1		15	6	20 days Kc=1		30 Days Kc=1.15			2	5	30 Days Kc=1.2		4	3	25 Days Kc=0.9		1		
2	ET (S_1)	0	0	19.81	23.12	23.12	28.86	29.77	29.77	29.77	30.79	31.39	31.39	31.39	28.03	29.79	29.79	29.79	4.26	0.00
3	ET_c	0.00	0.00	19.81	23.12	23.12	28.86	29.77	29.77	29.77	30.79	31.39	31.39	31.39	28.03	29.79	29.79	29.79	4.26	0.00
4	LP (Land Preparation)	83.07	83.07	11.87																
5	Farm loss	34.32	34.32	34.32	34.32	34.32	34.32	34.32	34.32	34.32	34.32	34.32	34.32	34.32	34.32	34.32	34.32	34.32	4.90	
6	FWR (8+9+10)	117.39	117.39	66.00	57.44	57.44	63.18	64.09	64.09	64.09	65.11	65.71	65.71	65.71	62.35	64.11	64.11	64.11	9.16	0.00
7	ER	0.00	1.88	11.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.35	0.00	0.00	7.63	0.00	0.00	0.00
8	FIR (FWR-ER)	117.39	115.51	54.61	57.44	57.44	63.18	64.09	64.09	64.09	65.11	65.71	65.71	61.36	62.35	64.11	56.48	64.11	9.16	0.00
9	ID	167.70	165.02	78.02	82.06	82.06	90.26	91.56	91.56	91.56	93.01	93.87	93.87	87.66	89.07	91.59	80.69	91.59	13.08	0.00

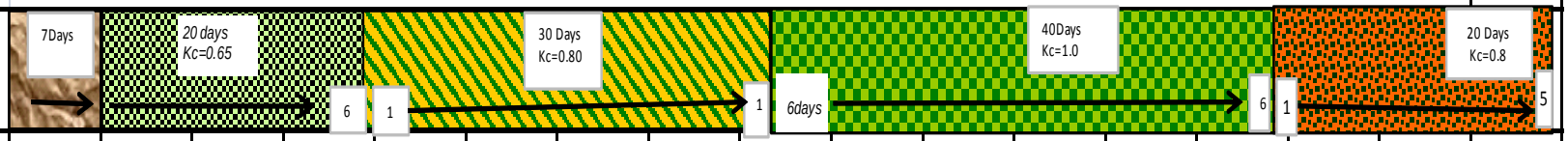
Original in Color

Table 9-4: Cowpea cultivation of Yala season 2008-09

Start time:		15/4/2009	22/4/2009	29/4/2009	6/5/2009	13/5/2009	20/5/2009	27/5/2009	3/6/2009	10/6/2009	17/6/200	24/6/2009	1/7/2009	8/7/2009	15/7/2009	22/7/2009	29/7/2009
End Time :		21/4/2009	28/4/2009	5/5/2009	12/5/2009	19/5/2009	26/5/2009	2/6/2009	9/6/2009	16/6/2008	23/6/200	30/6/2009	7/7/2009	14/7/2009	21/7/2009	28/7/2009	4/8/2009
Pump Discharge																	
	Season																
	Week	29th	30th	31st	32nd	33rd	34th	35th	36th	37th	38th	39th	40th	41st	42nd	43rd	44th
	ET_0	23.12	23.12	25.10	25.89	25.89	25.89	25.97	26.16	26.16	26.16	26.16	33.10	33.10	33.10	33.10	30.26
	Assuming 1 staggers and a 7day for each section land preparation according to field experience																
1	Stagger 1	7 Days	15 days Kc=0.7	1	6 Days	25 Days Kc=0.9	5	2days	35Days Kc=1.10	5	2	15 Days Kc=1	6				
2	ET (S_1)		16.18	17.57	22.38	23.30	23.30	24.85	28.77	28.77	28.77	28.77	35.47	33.10	28.37		
3	ET_c		16.18	17.57	22.38	23.30	23.30	24.85	28.77	28.77	28.77	28.77	35.47	33.10	28.37	-	-
4	LP (Land Preparation)	62.46															
5	Farm loss	8.58	8.58	8.58	8.58	8.58	8.58	8.58	8.58	8.58	8.58	8.58	8.58	8.58	7.35		
6	FWR (8+9+10)	71.04	24.76	26.15	30.96	31.88	31.88	33.43	37.35	37.35	37.35	37.35	44.05	41.68	35.73	-	-
7	ER	-	-	-	-	-	-	-	-	-	4.35	-	-	7.63	-		
8	FIR (FWR-ER)	71.04	24.76	26.15	30.96	31.88	31.88	33.43	37.35	37.35	33.00	37.35	44.05	34.05	35.73	-	-
9	ID	101.49	35.37	37.35	44.22	45.54	45.54	47.76	53.36	53.36	47.15	53.36	62.92	48.64	51.04	-	-

Original in Color

Table 9-5: Groundnut cultivation of Yala season for 2008-09

Start time:		15/4/2009	22/4/2009	29/4/2009	6/5/2009	13/5/2009	20/5/2009	27/5/2009	3/6/2009	10/6/2009	17/6/2009	24/6/2009	1/7/2009	8/7/2009	15/7/2009	22/7/2009	29/7/2009	5/8/2009
End Time :		21/4/2009	28/4/2009	5/5/2009	12/5/2009	19/5/2009	26/5/2009	2/6/2009	9/6/2009	16/6/2008	23/6/2009	30/6/2009	7/7/2009	14/7/2009	21/7/2009	28/7/2009	4/8/2009	11/8/2009
Pump Discharge																		
	Season																	
	Week	29th	30th	31st	32nd	33rd	34th	35th	36th	37th	38th	39th	40th	41st	42nd	43rd	44th	45th
	ET_0	23.12	23.12	25.10	25.89	25.89	25.89	25.97	26.16	26.16	26.16	26.16	33.10	33.10	33.10	33.10	30.26	28.13
		Assuming 1 staggers and a 7day for each section land preparation according to the real practices in Field of Rajangana																
1	Stagger 1																	
2	$ET (S_1)$		15.03	16.31	17.38	20.71	20.71	20.77	20.93	25.41	26.16	26.16	33.10	33.10	32.16	22.70	24.21	16.08
3	ET_c		15.03	16.31	17.38	20.71	20.71	20.77	20.93	25.41	26.16	26.16	33.10	33.10	32.16	22.70	24.21	16.08
4	LP (Land Preparation)	62.46																
5	Farm loss	8.58	8.58	8.58	8.58	8.58	8.58	8.58	8.58	8.58	8.58	8.58	8.58	8.58	8.58	8.58	8.58	6.13
6	FWR (8+9+10)	71.04	23.61	24.89	25.96	29.29	29.29	29.35	29.51	33.99	34.74	34.74	41.68	41.68	40.74	31.28	32.79	22.20
7	ER	-	-	-	-	-	-	-	-	-	4.35	-	-	7.63	-	-	-	-
8	FIR (FWR-ER)	71.04	23.61	24.89	25.96	29.29	29.29	29.35	29.51	33.99	30.39	34.74	41.68	34.05	40.74	31.28	32.79	22.20
9	ID	101.49	33.72	35.56	37.09	41.85	41.85	41.93	42.15	48.56	43.41	49.62	59.55	48.64	58.19	44.68	46.84	31.72

Original in Color

Table 9-6: Pulse (Undu) cultivation of Yala season for 2008-09

Start time:		15/4/2009	22/4/2009	29/4/2009	6/5/2009	13/5/2009	20/5/2009	27/5/2009	3/6/2009	10/6/2009	17/6/2009	24/6/2009	1/7/2009	8/7/2009	15/7/2009
End Time :		21/4/2009	28/4/2009	5/5/2009	12/5/2009	19/5/2009	26/5/2009	2/6/2009	9/6/2009	16/6/2008	23/6/2009	30/6/2009	7/7/2009	14/7/2009	21/7/2009
Pump Discharge															
	Season	Yala													
	Week	29th	30th	31st	32nd	33rd	34th	35th	36th	37th	38th	39th	40th	41st	42nd
	ET_0	23.12	23.12	25.10	25.89	25.89	25.89	25.97	26.16	26.16	26.16	26.16	33.10	33.10	33.10
1	Stagger 1	7 Days	15 days Kc=0.5	1	6 days	20days Kc=0.80				35 days Kc=1.05			15 days Kc=0.7	1	
2	ET (S_1)		11.56	12.55	19.60	20.71	20.71	27.26	27.46	27.46	27.46	27.46	23.17	23.17	3.31
3	ET_c	0	11.56	12.55	19.60	20.71	20.71	27.26	27.46	27.46	27.46	27.46	23.17	23.17	3.31
4	LP (Land Preparation)	62.46													
5	Farm loss	8.58	8.58	8.58	8.58	8.58	8.58	8.58	8.58	8.58	8.58	8.58	8.58	8.58	1.23
6	FWR (8+9+10)	71.04	20.14	21.13	28.18	29.29	29.29	35.84	36.05	36.05	36.05	36.05	31.75	31.75	4.54
7	ER	-	-	-	-	-	-	-	-	-	4.35	-	-	7.63	-
8	FIR (FWR-ER)	71.04	20.14	21.13	28.18	29.29	29.29	35.84	36.05	36.05	31.69	36.05	31.75	24.12	4.54
9	ID	101.49	28.77	30.18	40.26	41.85	41.85	51.21	51.49	51.49	45.28	51.49	45.36	34.45	6.48

Original in Color

Table 9-7: Maize (Irringu) cultivation of Yala season for 2008-09

Start time:		15/4/2009	22/4/2009	29/4/2009	6/5/2009	13/5/2009	20/5/2009	27/5/2009	3/6/2009	10/6/2009	17/6/2009	24/6/2009	1/7/2009	8/7/2009	15/7/2009	22/7/2009	29/7/2009	5/8/2009	12/8/2009	19/8/2009
End Time :		21/4/2009	28/4/2009	5/5/2009	12/5/2009	19/5/2009	26/5/2009	2/6/2009	9/6/2009	16/6/2008	23/6/2009	30/6/2009	7/7/2009	14/7/2009	21/7/2009	28/7/2009	4/8/2009	11/8/2009	18/8/2009	25/8/2009
Pump Discharge																				
	Season																			
	Week	29th	30th	31st	32nd	33rd	34th	35th	36th	37th	38th	39th	40th	41st	42nd	43rd	44th	45th	46th	47th
	ET_0	23.12	23.12	25.10	25.89	25.89	25.89	25.97	26.16	26.16	26.16	26.16	33.10	33.10	33.10	33.10	30.26	28.13	28.13	28.13
	Assuming 1staggers and a 15	1 staggers and a 7 day for each section land preparation which is the real practice of Rajangana																		
1	Stagger 1	7 Days	20 days Kc=0.69		6	1 Days	35 Days Kc=0.87			6	1days	40Days Kc=1.05				4	3	30 Days Kc=0.8		6
2	ET (S_1)		15.95	17.32	18.53	22.52	22.52	22.59	22.76	23.43	27.46	27.46	34.76	34.76	34.76	31.21	24.21	22.51	22.51	19.29
3	ET_c		15.95	17.32	18.53	22.52	22.52	22.59	22.76	23.43	27.46	27.46	34.76	34.76	34.76	31.21	24.21	22.51	22.51	19.29
4	LP (Land Preparation)	62.46																		
5	Farm loss	8.58	8.58	8.58	8.58	8.58	8.58	8.58	8.58	8.58	8.58	8.58	8.58	8.58	8.58	8.58	8.58	8.58	8.58	7.35
6	FWR (8+9+10)	71.04	24.53	25.90	27.11	31.10	31.10	31.17	31.34	32.01	36.05	36.05	43.34	43.34	43.34	39.79	32.79	31.09	31.09	26.65
7	ER	-	-	-	-	-	-	-	-	-	4.35	-	-	7.63	-	-	-	-	-	-
8	FIR (FWR-ER)	71.04	24.53	25.90	27.11	31.10	31.10	31.17	31.34	32.01	31.69	36.05	43.34	35.70	43.34	39.79	32.79	31.09	31.09	26.65
9	ID	101.49	35.04	37.00	38.73	44.43	44.43	44.53	44.77	45.73	45.28	51.49	61.91	51.00	61.91	56.84	46.84	44.41	44.41	38.06

Original in Color

Table 9-8: Irrigation demand (cum) of Tract-1 for Yala season 2008-09

Tract	Total Area	Turnout coverage area	Crop		2009/2010			2010/2011									2011/2012									
				Distribution System	26th	27th	28th	29th	30th	31st	32nd	33rd	34th	35th	36th	37th	38th	39th	40th	41st	42nd	43rd	44th	45th	46th	47th	48th
Tract 1	729.20	75.20	Paddy	FC1	10,858.47	10,543.04	4,984.61	5,242.51	5,242.51	5,766.85	5,849.99	5,849.99	5,849.99	5,942.67	5,997.49	5,997.49	5,600.37	5,690.54	5,851.74	5,154.98	5,851.74	835.96	-	-	-	-	-
				FC2	209,025.45	202,953.52	95,953.66	100,918.24	100,918.24	111,011.83	112,612.40	112,612.40	112,612.40	114,396.38	115,451.64	115,451.64	107,807.09	109,542.94	112,645.97	99,233.28	112,645.97	16,092.28	-	-	-	-	-
		308.00		D1	209,025.45	202,953.52	95,953.66	100,918.24	100,918.24	111,011.83	112,612.40	112,612.40	112,612.40	114,396.38	115,451.64	115,451.64	107,807.09	109,542.94	112,645.97	99,233.28	112,645.97	16,092.28	-	-	-	-	-
		346.00		D2	234,814.31	227,993.24	107,792.10	113,369.19	113,369.19	124,708.09	126,506.14	126,506.14	126,506.14	128,510.22	129,695.67	129,695.67	121,107.96	123,057.98	126,543.85	111,476.35	126,543.85	18,077.69	-	-	-	-	-
			Green Gram	FC1	-	-	-	-	10.29	10.29	4.13	3.11	3.91	4.24	4.26	5.07	4.57	5.20	5.78	3.48	3.93	-	-	-	-	-	-
				FC2	-	-	-	-	38.09	38.09	15.29	11.49	14.45	15.67	15.75	18.75	16.92	19.24	21.37	12.88	14.53	-	-	-	-	-	-
				D1	-	-	-	-	198.15	198.15	79.56	59.79	75.20	81.54	81.96	97.53	88.04	100.12	111.19	66.99	75.60	-	-	-	-	-	-
				D2	-	-	-	-	222.59	222.59	89.37	67.17	84.48	91.59	92.07	109.56	98.90	112.48	124.90	75.26	84.93	-	-	-	-	-	-
			Ground Nut	FC1	-	-	-	5.13	1.70	1.80	1.87	2.11	2.11	2.12	2.13	2.45	2.19	2.51	3.01	2.46	2.94	2.26	2.37	1.60	-	-	-
				FC2	-	-	-	18.96	6.30	6.65	6.93	7.82	7.82	7.84	7.88	9.07	8.11	9.27	11.13	9.09	10.87	8.35	8.75	5.93	-	-	-
				D1	-	-	-	98.67	32.79	34.57	36.06	40.68	40.68	40.77	40.98	47.21	42.20	48.25	57.89	47.29	56.58	43.44	45.54	30.84	-	-	-
				D2	-	-	-	110.84	36.83	38.84	40.51	45.70	45.70	45.80	46.04	53.03	47.41	54.20	65.03	53.12	63.56	48.80	51.16	34.64	-	-	-
			Cow Pea	FC1	-	-	-	20.57	7.17	7.57	8.96	9.23	9.23	9.68	10.81	10.81	9.55	10.81	12.75	9.86	10.34	-	-	-	-	-	-
				FC2	-	-	-	76.10	26.53	28.01	33.16	34.15	34.15	35.81	40.01	40.01	35.35	40.01	47.18	36.47	38.27	-	-	-	-	-	-
				D1	-	-	-	395.93	138.01	145.73	172.53	177.68	177.68	186.33	208.18	208.18	183.93	208.18	245.48	189.76	199.12	-	-	-	-	-	-
				D2	-	-	-	444.78	155.03	163.71	193.81	199.60	199.60	209.32	233.87	233.87	206.62	233.87	275.77	213.17	223.69	-	-	-	-	-	-
			Undu	FC1	-	-	-	5.13	1.45	1.52	2.03	2.11	2.11	2.59	2.60	2.60	2.29	2.60	2.29	1.74	0.33	-	-	-	-	-	-
				FC2	-	-	-	18.96	5.38	5.64	7.52	7.82	7.82	9.57	9.62	9.62	8.46	9.62	8.48	6.44	1.21	-	-	-	-	-	-
				D1	-	-	-	98.67	27.97	29.35	39.14	40.68	40.68	49.78	50.06	50.06	44.02	50.06	44.10	33.50	6.30	-	-	-	-	-	-
				D2	-	-	-	110.84	31.42	32.97	43.97	45.70	45.70	55.93	56.24	56.24	49.45	56.24	49.54	37.63	7.08	-	-	-	-	-	-
			Iringu	FC1	-	-	-	46.20	15.95	16.84	17.63	20.23	20.23	20.27	20.38	20.81	20.61	23.44	28.18	23.22	28.18	25.87	21.32	20.21	20.21	17.33	-
				FC2	-	-	-	170.92	59.02	62.31	65.23	74.84	74.84	75.00	75.40	77.02	76.26	86.72	104.27	85.90	104.27	95.74	78.89	74.79	74.79	64.11	-
				D1	-	-	-	889.26	307.07	324.18	339.35	389.35	389.35	390.18	392.27	400.69	396.74	451.20	542.48	446.92	542.48	498.09	410.46	389.13	389.13	333.54	-
				D2	-	-	-	998.97	344.96	364.17	381.22	437.39	437.39	438.32	440.66	450.12	445.69	506.87	609.41	502.06	609.41	539.54	461.10	437.14	437.14	374.69	-
	Sub Total				663,723.68	644,443.31	304,684.04	323,958.07	322,114.86	354,231.57	359,159.21	359,257.58	359,294.07	365,018.00	368,427.60	368,499.14	344,109.83	349,865.31	360,657.77	316,955.13	359,771.15	52,380.31	1,079.59	994.29	921.28	789.66	-

Table 9-9: Irrigation demand water volume (MCM) for 2008-09

1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	13th	14th	15th	16th	17th	18th	19th
4.46	4.36	2.22	1.88	1.44	1.60	1.68	1.56	1.99	1.83	1.87	1.60	2.05	1.96	1.94	1.94	1.94	2.03	2.05
20th	21st	22nd	23rd	24th	25th	26th	27th	28th	29th	30th	31st	32nd	33rd	34th	35th	36th	37th	38th
1.93	1.93	1.35	0.00	0.00	0.00	4.46	4.33	2.05	2.18	2.17	2.38	2.42	2.42	2.42	2.46	2.48	2.48	2.32
39th	40th	41st	42nd	43rd	44th	45th	46th	47th	48th	49th	50th	51st	52nd					
2.36	2.42	2.13	2.42	0.35	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00					

APPENDIX-10 Pictures of Rajangana Left Bank Canal

Figure4-1: Sluice of Rajangana Irrigation Scheme

Figure4-2: Spillway of L.B Canal System

Figure4-3: Distributory of L.B Canal System

Figure4-4: Field Canal Regulator

Original in Color

Figure4-5: Aqueduct Structure of L.B Canal System

Figure4-6: Spill Comb. Level crossing structure

Figure4-7: Field Canal Drop Structure

Figure4-8 Siphon inlets in L.B canal

Original in Color