Deviation of Planned Water Demand from Actual on Farm Water Usage and Suggestions for Improvements: A Case Study from Uda Walawe Irrigation Scheme, Sri Lanka

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Abstract

Water managers' seasonal water allocation plans deviates from the actual water usage in the field due to many factors. Temporal and spatial variations that vary dramatically will affect the Field Irrigation Requirement (FIR) which is calculated. Therefore, the main objective of this paper is to see how planned FIR deviates from the actual on farm water usage in Uda Walawe Irrigation Scheme. The study proposes suggestions for improvements in meeting and balancing the water demands. Irrigation issues and the interviews with farmers and officials were used for the analysis.

Results show that actual water usage is always higher than the FIR and water manager's planned. There are various factors contributes for these discrepancy. Two lines of improvement are outlined. One is adjustment of the volumes allocated to each D. The second possibility of improvement points to greater involvement of farmers at the scheme and branch levels. A way to tackle this is to devise a transparent process of allocation at the scheme level whereby representatives from the different branch canals would participate in the definition of sharing arrangements. MASL's role would be to ensure bulk allocation at the head of canal. FOs are responsible for finding ways to distribute this volume within their area.

Introduction

Irrigation water management is a critical issue in this millennium as available water is to be allocated for various other uses. Competition for water has been increased and the share for agriculture has reduced. Intensive planning and management is necessary to overcome the frequent crop failures. Water managers calculate on farm water demand using various assumption and methodologies but some time they cannot achieve their target and there are various reasons for that. Udawalwe Irrigation scheme (UWIS) is a good site to understand these reasons. This paper highlights difference between water managers planning and the actual implementation at the ground.

Uda Walawe development scheme is one of the major multipurpose development projects implemented by government of Sri Lanka after the independence. The Uda Walawe reservoir is located on the boundary of the Wet and Dry Zones of Sri Lanka (Figure 01), around 200 km southeast of Colombo (Hussain *et al.* 2003).

This reservoir is built across the Walawe Ganga, which is the fifth largest river in Sri Lanka. The river is 136 Km long and has a catchment area of 1200 square kilometers. The Uda Walawe reservoir was constructed during the period 1963 – 1967, as part of a plan to develop irrigation infrastructure in 32,000 ha of land in the dry zone of southern Sri Lanka (ADB 1969). It is an earth fill dam, with a live storage capacity of 240 Million Cubic Meters (MCM). There are two main canals, the Right Bank Main Canal (RBMC), and the Left Bank Main Canal (LBMC). The original plan was to develop 20,000 hectares of land for irrigation under the project (Nippon Koei 1996). Command area was planned to irrigate with a net work of canals based on 42 km long RBMC and 31 km long LBMC. Even though the construction of tank was completed in 1967 development of downstream area has taken place in steps (Nippon Koei 2005). Right bank was given the first priority in development agenda and left bank has been given the second priority. The total area actually developed up to the end of 1997 was about 12,900 ha, comprising 8,500 ha under RBMC and 4,400 ha under LBMC. By 2000, the area irrigated has increased to 11,000 ha in the RBMC and 6400 ha in the LBMC.

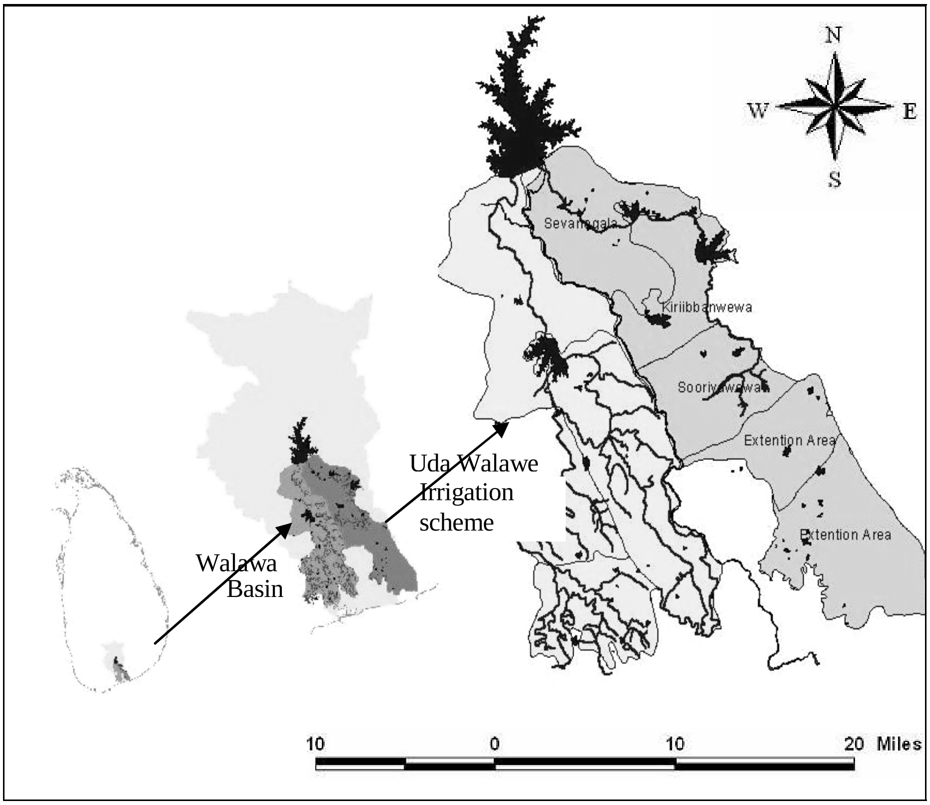

Figure 01: Location of Uda Walawe bank irrigation system

Seasonal water allocation for the irrigation at the beginning of the season deviates from the actual on farm water allocation at the end of the season. Seasonal allocation predicted by using various assumptions and referring past experience and the indices such as seepage and percolation rates. Therefore, the main objective of this paper is to see how seasonal planning deviate from the actual on farm water usage in a selected irrigation scheme in Sri Lanka. The study proposes suggestions for improvements of on farm water management.

Methodology

During the study period, gauge heights of the flumes of two Distributor canals and the Field canals were measured continuously and these heights were converted in to volumes using rating curves for the flumes. The drainage canals were observed to investigate the availability of excess drainage water and this was a qualitative measurement. Several transect walks were made through the selected canals with the frequency of once in every two weeks. Farmers and the officials were interviewed during the transect walk to obtain the farmers and officials perception on water management and problems.

Study Area

Udawalawe Irrigation Scheme (UWIS) is a 18,000 ha irrigation area located in southern Sri Lanka. It is supplied by Udawalawe reservoirs through two main canals (Right Bank Main Canal: RBMC, and Left Bank Main Canal: LBMC), as indicated in Figure 02. Overall management of the UWIS is done by the Mahaweli Authority of Sri Lanka (MASL). The reservoir was constructed in 1969 and the irrigation network went through several phases of development and rehabilitation (Molle and Renwick 2004). Currently the LBMC is being extended and a last block of 5,000 ha is under construction. The scheme has been rehabilitated in the 1980s and hydraulic structures of the distributary and the field canals (FC) are in a reasonable state. Allotments were generally conserved at rehabilitation but all the plots inlets were made dependent of a FC canal, and no direct off take from a D canal is being allowed. Each FC is given a design discharge of 28-32 l/s.

Average annual rainfall in the study area, which is part of the South-East dry zone, is less than 1500 mm. Soil types are Low Humic Gley soils that are often associated with RBE, and alluvial soils which are especially suited for paddy. Annual potential evapotranspiration is estimated to be 1700 mm (Jayatillake 2002).

Two Distributary canals (D canals) have been selected in different areas of the RBMC command area: D7 in Moraketiya Block (MKD7) is typical of head-end areas, with good water supply and high rate of diversification to banana cultivation. D8 canal, in Chandrika Block (CWD8), is also on an average receiving area and has a large area planted to banana, although to a lesser extent than D7 (Figure 03 &04). It is supplied through the Chandrika Branch canal that is supplied directly by the Chandrika reservoir.

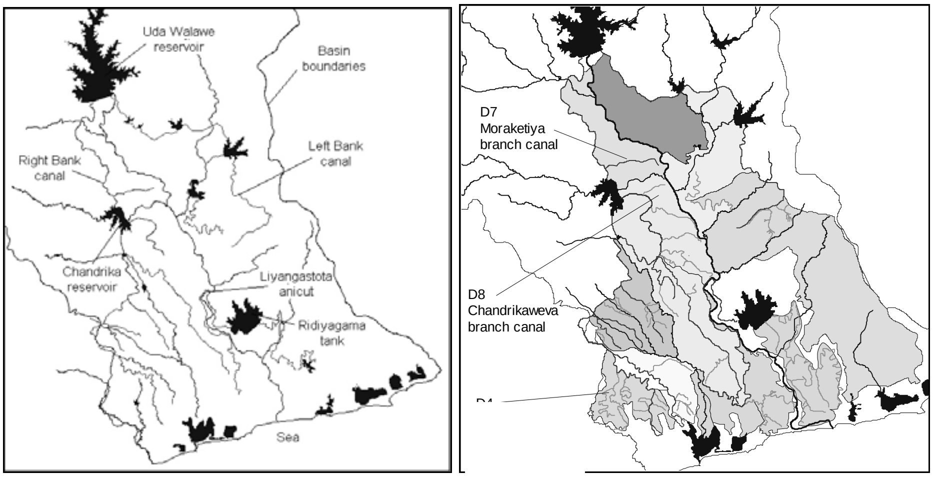

Figure 02: General layout of the UWIS in Walawe river basin and location of study blocks and D-canals studied

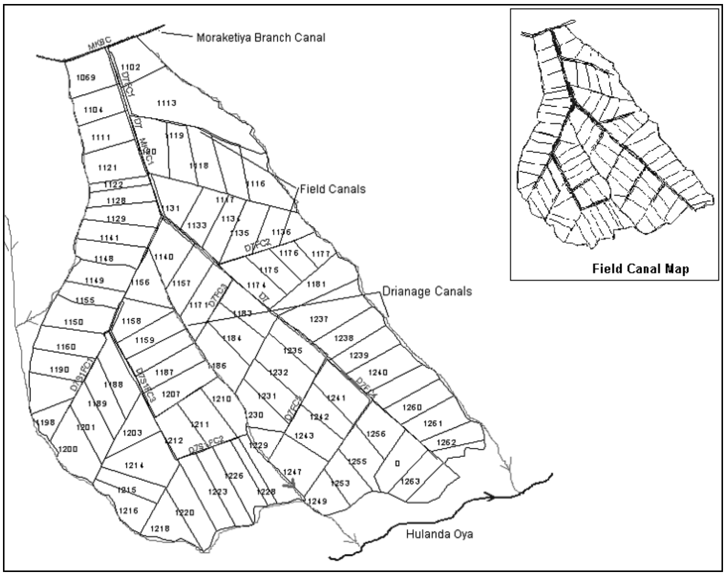

Figure 03: Layout of the MKD7

Figure 04: Layout of the Chandrikawewa D8 distributor canal

Study Period

April 2003 to August 2003

Results and Discussion

Irrigation and water management

Irrigation supply is divided in to two seasons, *maha* (October-February) and *yala*, (April to July). In theory, the water delivery schedule for each season is decided at the "kanna meeting" at the inception of each season and this schedule is conveyed to farmers through their representatives and various other means such as posters. It is said that prior to the season starts MASL collects the land use data for each canals and based on that they calculate the water requirement for the season. In theory this is a demand oriented water management, but in some dry years, they practice supply oriented water management that is governed by the available water in the reservoir. So it is worth to say that the water management in UWIS is in between demand oriented and supply oriented.

Plot Level Water Management

Both canals are cropped with a mix of paddy and banana and the plot level water management is different according to the crop type. There are three crop combinations, only paddy, only banana, paddy and banana mix. Table 01 shows the land extents and land uses in the study area.

Table 01: Area and land use in studied canals

FC Canal ID	No of plots	Total plot area (ha)	% of banana	% of paddy	% of other	Number of FC
MKD7	91	83.4	88	4.4	7.6	9
CWD8	117	136	46	51	3	14

Only Paddy: When a plot consists of paddy only, farmers are more concerned about water management and they put more effort in avoiding lengthy periods without standing water in their fields. Normally farmers let the water flow from plot to plot, and excess passes to the drainage canals from the lowest plots. No rotations were found within the FC; hence farmers leave their farm inlet open throughout the season allowing water to flow to the drains continuously. This is an indication that the supply is in excess.

Only Banana: Water management practices in banana plots mainly depend on the leveling status of the land. Normally in paddy cultivation farmers have to level their land before sowing, but in banana cultivation this is not necessary. Some farmers have maintained the earlier leveling of the paddy fields and can manage water more easily at the plot level. They open the inlet and allow flood irrigation same as in paddy plots. If the land is not leveled farmers have to stay to guide water to the plant and the process consumes a lot of water.

Paddy and Banana: When banana and paddy share the same plot, farmers give priority to their paddy plots. When the paddy plots are located in the upper part of the plots, they directly receive water from farm inlets. After feeding the paddy plots, water spills to the banana plots. When the banana plot is in the upper part of the land, furrows direct water through banana plantation to paddy plots.

Rotation

As irrigation water is inadequate for continuous supply, UWIS practices rotations. During the irrigation period each farmer is given a time schedule to irrigate their plots. Normally, rotation period start at the end of the land preparation period. Table 02 shows the starting and finishing dates of the rotation periods for the selected D canals.

Table 02: Starting and end dates of the rotation period

FC Canal ID	Irrigation started	Irrigation finished	Number of Rotations
Moreketiya D7	26/5/03	25/8/03	12
Chandrikawewa D8	16/5/03	25/8/03	15

There are two different rotations practicing in each MKD7 and CWD8. First two rotations in MKD7 are allocated only for paddy irrigation and third rotation is for the whole paddy and the banana. This pattern goes until the season finished. MASL adjust the gates according to the types of rotations. In CWD8 paddy and banana both significant compared to the paddy and banana in MKD7. So, rotation applies for the CWD8 are same through out the year as shown in Table 03.

Table 03: Type of rotation in the study area (Two tables are merged to one)

D Canal	PR (days)		PB (days)		Rotation within D canal	Within FC	Comments
	On	Off	On	Off			
MKD7	3	3	5	3	No	Yes	Two PR followed by one PB (occur once in every 15 days)
CWD8	5	2	5	2	Yes	No	FC 1 to FC8 in first half and rest in second half

PR: Paddy only rotation; PB: Paddy Banana mix rotation

Crop Water Requirement

The paddy crop is established in the filed during April to May. Net agronomic requirements or evapotranspiration are estimated using Penman method (FAO Paper 24) and relevant Crop co-efficient (Kc) values.

Crop water requirement, KTc=ETo *Kc

ETo=Reference crop evapo-transpiration

The duration of the paddy cop is 105 days. Water supply to banana, though it is a perennial crop, is also considered for 105 days. Kc for paddy and banana are changing between 1 to 0.9 and 0.4 to 1.3 respectively based on the crop stage. In this study Kc for banana was taken as 0.85 assuming all the banana plots are in a matured state. Table 03 shows the estimates of total crop water requirements (net agronomic requirements), with values of 520 mm and 411 mm/ season for paddy and banana, respectively.

Table 03: Calculation of crop water requirement according to IWMI climatic atlas and Ponarajah's (1984) specifications (land preparation not included)

				Paddy		Banana	
Month	50% prob. RF mm/month	Penman ETo (mm/day)	Days	Kc Paddy	Total mm	Kc banana	Total mm
May	146.38	4.41	20	1	88	0.85	75
Jun	110.34	4.52	30	1.15	156	0.85	115
Jul	84.34	4.67	30	1.2	168	0.85	119
Aug	91.96	4.78	25	0.9	108	0.85	102
Total					520		411

Field Irrigation Requirement (FIR)

Water is lost through evapotranspiration and runoff. Seepage and percolation vary with the edaphic environment which could be partially controlled through proper management. However, evapotranspiration is determined mainly by the vapor pressure deficit and the canopy size which is beyond the control of a farmer. Bund leakages and spill over from the field is totally under the farmer's control. Therefore, the Field Irrigation Requrenment (FIR) (Ponrajah 1982) is the addition of evapotranspiration (ET), seepage (S) and percolation (P) rates (Farmers take water directly form the field canal hence conveyance efficiency wasn't considered). A combined seepage and percolation rate in the study area is 9 mm/day (MMP consultant report 1992). It is note worthy to mention here that the seepage and percolation assumptions are critical in estimating water requirement. In case of Udawalwe, various consultants show various figures varying between 5 mm/day to 20 mm/day. These figures were also generated by testing few sample locations and not a single consultant has critically looked at the seepage and percolation values. Seepage and percolation is much important because of the prevailing high soil heterogeneity in the dry zone due to its undulated land terrain.

Effective Rainfall

The rainfall for the study area amounted to 315 mm (IWMI Data) during yala season and data wasn't showed that officials utilize this rainfall during their water management program.

MASL Planning for the Season

The MASL standards for calculation of overall requirements at the block level are different but quite simple and they follows the MMP consultant guide lines (Project office hand book 1992). The overall target is 1,067 mm (3.5 feet)/season; this roughly corresponds to targets of 5 inches per week during land preparation (3 or 4 weeks) and 76 mm (3 inches)/week during the remaining part of the cycle. In these calculations, the MASL considers that the conveyance losses correspond to 8% of flow. Other Field Crops such as banana are sometimes considered to be equivalent to 0.6 of paddy and targets attributed to 38 mm (1.5 feet)/week.

Actual Water Usage

MKD7

According to the Table 04 MASL planned allocation for MKD7 is quite low. They planned 0.47 MCM (Million Cubic meter) but delivered 1.2 MCM which is much closer to the FIR. This implies that the management was done according to the demand or request form the farmer or according to the past experience. It is worth mentioning here the FIR should also be lower than the current estimation as big portion contributed as seepage. In reality we cannot expect 9 mm of seepage throughout the season from the banana plots where farmers don't keep impounding water. Large volume of drainage water from the farmers field were observed during the study period explaining the above situation and this indicate that farmers in the MKD7 area are in a comfortable situation with regard to water management i.e they have excess water to irrigate their lands.

CWD8

MASL planned allocation was lower than the actual volumes delivered through FC and it indicates complexity of seasonal planning. Actual usage of the canal was 2.2 MCM against planned 1.18 MCM imply the seriousness of the problem (Table 04). Reasons for such variations are discussed in the discussion part of this paper.

Table 04: Comparison of various estimation with actual delivery

Canal	Crop	Area Ha	S and P ($1000m^3$ / season)	Total water requirement ($1000m^3$/season)			
				Crop water requirement	FIR	MASL planned	MASL delivered *
MKD7	Paddy	6.3	60	33	92	72	1216
	Banana	70	662	288	949	400	
CWD8	Paddy	70	662	364	1026	800	2218
	Banana	66	624	271	895	377	

* Amount delivered through FC to the plots

Relative Water Supply

Relative water supply (RWS) is defined here as the ratio between target volumes and actual supply. If the ratio is one the actual almost equal to planned which is unlikely to happen in Uda Walawe irrigation scheme. RW for the canal MKD7 is 2.6 and this indicates an excess usage of canal water. RWS for CWD8 is 1.9 and this is due to planning of water demand being difficult because of the paddy banana mix cropping and heterogeneous soil types.

Reasons for the Imbalances

In large irrigation schemes water sharing is complicated due to various factors involving it such as water availability, farmers, officials, soil, crop etc. In reality water mangers plans are not implemented in the field always due to this complexity but good managers able to reduce the gap between planned and actual usage. There are many reasons for these imbalances among the actual volume supplied, FIR and the MASL seasonal plan. Some of these causes are listed below.

- In MKD7, improper alignment of furrows, blockage of furrows and absence of farmers during water issues lead to loss of water to drains or lower plots due to overflow hence actual water usage is high.

- In CWD8, farmers from one FC have distinct water rights as they lived in this area before the implementation of UWIS. Therefore, they can get water at will and they get a continuous supply too.

- Some FC canals in the CWD8 are very long and farm-turn-outs in the lower part of most of these FC's are at a higher elevation so that larger flows are needed to reach the downstream ends. These lead to loss of water from CWD8 command area.

- In both canals, drainage observations clearly indicate these losses are due to the duration of supply, topography/layout of the irrigated area and soil types, and some times lack of concern from farmers.

- Land tenure and land fragmentation also have an effect on poor water management in the study area. Regular operations such as (canal clearing and rotation) are difficult due to the poor cooperation of tenant farmers. A survey on 24 plots revealed that on an average there were over two farmers for a plot. A higher number of farmers may turn water management more difficult.

Discussion

Rotations and Water Management

In MKD7 the most important feature is the attempt to enforce a rotation with two three-day periods devoted to rice and one five-day period for the irrigation of both paddy and banana (these three "on" periods being separated by three-day "off" periods). Water supplied during the land preparation and the rice-only turns were found to be far above the requirements of rice, which is grown only in 4% of the area. This schedule had been designed several years back, when banana was not so overwhelmingly dominant. Further, the irrigation of scattered rice plots incurs significant conveyance losses due to lack of coordination between paddy-growers. Some banana growers were found to use water during the paddy-only turns, which is desirable given the amount of water supplied to the area in these turns. The recent increase in small paddy patches within banana areas can be interpreted as a means of grain production for self-consumption and a strategy to obtain the right to receive water during the "paddy-only" rotation that is once in six days.

Figure 05 show that paddy-cum-banana plots use a higher amount of water in MKD7 of all rotations, when compared with banana-only plots. This is normal when the higher water requirement for paddy is considered. However, if the total amount of "paddy only" water issued during the season was to be used by paddy plots only, these plots would have received approximately 7,515 mm of water, which is unacceptably high. Therefore, it can be argued that under the present water issue conditions, it is acceptable and even desirable to irrigate a mix of paddy and banana plots during the paddy-only rotations, which minimizes wastage.

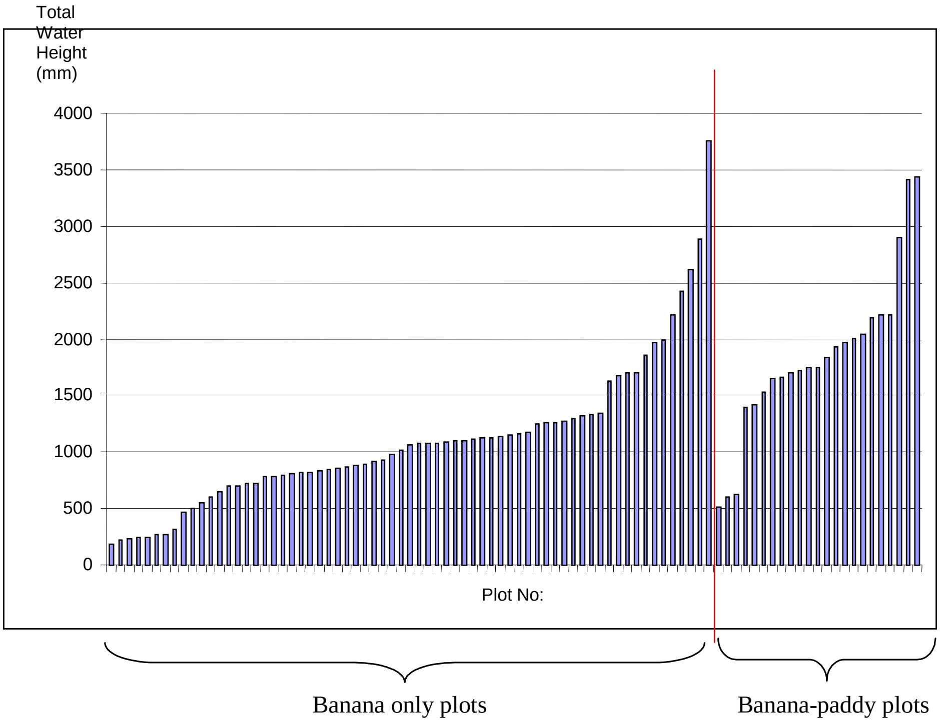

Figure 05: Volume of water (expressed as water depth) diverted to the plots (whole season in MKD7)

In CWD8, the area could roughly be divided into two equivalent parts of paddy and banana/OFCs. The rotation adopted is simpler than in MKD7 and consists in a succession of 2 days 'off' and 5 days 'on' periods. The total water depth applied is 2,055 mm, with conveyance losses in the D canal estimated at 20%. Monitoring the drainage system confirmed that drainage starts on the second day of supply and often continues after supply is interrupted. Since a large part of the area has rather permeable Reddish Brown Earth soils, the plots may dry up within one or a few days. Therefore, percolation and direct overflow to the drains are quite high.

RWS and Water Management

A high RWS is not a problem in UWIS per se. A lingering perception of irrigation practitioners view is that surface irrigation with low efficiencies is a wasteful activity and that a low efficiency is necessarily a bad thing. In the case of UWIS Walawe, this is shown by 40 years of consultant and ADB's reports (1984) deploring the very high water duties and the permanence of very high water duties. This viewpoint overlooks the fact that Uda Walawe system is provided with a small reservoir that does not allow significant regulation of storage across seasons, and that there are no alternative users for its waters. In that sense a high RWS is desirable because it brings 'comfort' and flexibility in management. What is generally poorly understood is that water is a substitute to labour and capital and that in situations of relative abundance using it in excess allows the decrease of input in terms of capital (e.g. more sophisticated structures that would be needed to ensure fine-tuning of supply) and labour (from both managers and farmers).

Conclusion and Recommendations

As mentioned above the rather high level of supply must not be seen as a problem, nor does it have necessarily something to do with local instances of poor supply. However, the prospect of the forthcoming completion of the Left Bank Extension area means that the overall allocation pattern within Uda Walawe Irrigation Scheme will have to be revised. This increase by 25% of the area served will roughly entail a decrease of allocations to the Right bank canal by 25%. Even though the remaining volumes will still be above requirement targets, this may have far-reaching implications on the actual pattern of management, especially in dry years. Accommodating this drop in available water will need stricter management and definition of water duties.

Two lines of improvement can be outlined. The first area where there is scope for improvement is a better adjustment of the volumes allocated to each D canal. This can be done by better tailoring the number of days ‘on’ of each rotation to the time it effectively takes to serve all the plots. It is not rare to see the fields irrigated in three days and water flowing throughout to the drain during the last one or two days of the rotation. However, it must be understood that the crucial factor in RBE soils is not so much the duration of the inflow (‘on’), but the duration of the ‘off’ period, because many plots dry up in a few days. Therefore, while intermittent non-standing water conditions are not necessarily a problem, this ‘off’ period must be limited in order to avoid low soil moisture and resulting stress. This shows that fine tuning of supply is a delicate issue because the reasoning of the optimal duration of ‘on’ and ‘off’ periods must consider soil characteristics, topography, layout, farmers’ readiness to enforce stricter rotations and to accept the burden of improved coordination, etc.

While these adjustments can be largely designed or experimented with by MASL, a second possibility of improvement points to greater involvement of farmers at the scheme and branch levels. The redefinition of allocation made necessary by the extension of the left bank is likely to trigger complaints from farmers who will see their share reduced without having understood the consequences and thought of the possible remedies. A way to tackle this is to devise a transparent process of allocation at the scheme level whereby representatives from the different branch canals would participate in the definition of sharing arrangements, similarly to what happened in Kirindi Oya (a river basin adjoining to Walawe) ten years ago. MASL’s role would be to ensure bulk allocation at the head of the canal and FOs within the branch canal would be responsible for finding a way to distribute this volume within their area. By doing so one would allow the crucial information on local conditions that is only known by the farmers to be factored in the definition of rotations of course this cannot be done overnight and probably needs substantial guidance from MASL but can be achieved gradually. This perspective may seem a bit farfetched because the role of FOs has unfortunately always been confined to the D canal and FC canal levels. Their role must be shifted "upstream", where the crucial process of water sharing eventually determines the share they get and the evenness of its supply.

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