*Research article*

# An Evaluation of Water Demand and Supply for a Small-scale Irrigation Scheme in Zimbabwe

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**Abstract** Previous studies have shown that most smallholder irrigation schemes in developing countries in Africa, have proved to be unsustainable beyond external assistance. The low performance of most smallholder irrigation schemes is largely attributable to unreliable and inadequate water delivery. This research assessed the on-farm water management performance for Fuve-Panganai irrigation scheme in Zaka District of Zimbabwe. The objective of this study is to assess the on-farm water management performance for the irrigation scheme in terms of water demand and supply. The irrigation water demand for 204 ha of dry beans for the winter irrigation season (April to August) was estimated using the FAO CROPWAT. The seasonal water supply was calculated using the 2012 to 2016 recorded canal water depths. The Relative Water Supply (RWS) index was calculated from the water demand and supply. 38 randomly selected farmers, members of the waters user's association and relevant agencies were interviewed to understand the decision-making process and the overall performance of the scheme. The results showed a stable water supply for the five years with a coefficient of variation of 0.2. The water supply was greater than water demand during the winter mid-irrigation period (May to July) with an average RWS of 1.59. The results correspond with results from the interview survey in which more than 90 percent of the farmers were satisfied with the irrigation management performance. However, 37 percent reported to have experienced water shortages. This is due to the heavy distribution losses by damaged pipes and leaking water valves. The irrigation system is in dire need for rehabilitation to minimize water losses.

**Keywords** performance assessment, water demand, water supply, relative water supply

## INTRODUCTION

Irrigated agriculture is the most effective way of reducing crop failure, hunger and malnutrition in Africa and has the potential to increase the competitiveness of smallholder farming in most parts of Africa (World Bank, 2008). Despite these potential benefits of irrigation, smallholder irrigation schemes in most developing countries, including Zimbabwe have proved to be unsustainable beyond external assistance (Mutambara and Munodawafa, 2014). They showed that the sustainability of small-holder irrigation schemes in Zimbabwe was being affected by a complex interaction of a variety of factors which include; limited access to agricultural inputs, low educational level and/or lack of training in appropriate farming skills, lack of collateral which enables farmers to access loans or working capital and erratic irrigation water supply.

To achieve higher crop yields from irrigated agriculture it is necessary to supply the amount of water required by the crops. The amount of water required by the crops is determined by the area under cultivation, the crop water requirements and any inevitable losses incurred during the application of the water to the field (DFID, 1997).

According to Sakthivadivel et al., (1993), the two most crucial factors in irrigation planning, design and operation are the available water supply and the water demand. The two authors defined Relative Water Supply (RWS) as the ratio of water supply to the water demand associated with crops grown with the cultural practices used, and for the actual irrigated area. They underscored the usefulness of the RWS as a tool for understanding the performance of irrigation systems.

## OBJECTIVES

The objective of this study is quantitatively and qualitatively assess the on-farm water management performance to identify the current problems for the small irrigation scheme, Fuve-Panganai Irrigation Scheme, Zimbabwe.

## METHODOLOGY

### Study Site

Fuve-Panganai irrigation scheme is in ward 15 of Zaka district, 131 km south of Masvingo City, Zimbabwe. The nearest meteorological station; Buffalo Range Airport, records a minimum temp of 8.7 ºC in July and a maximum of 32.9 ºC in January. Average annual rainfall received is 584 mm.

The irrigation Scheme is 283 hectares in extent comprising of four blocks, designated, A, B, C and D each with 9; 70; 54 and 150 hectares respectively. Irrigation water is conveyed by gravity from Siya dam by a 14.5 km conveyance canal that discharges into Murerezi stream and ultimately to Chiredzi River and Manjirenji Dam through a water catchment transfer. The design capacity of the main canal is 3.5 $m^3/s$. There is an off-take to blocks C and D at 11.5 km from the dam and it is from this off-take that a branch canal with a design capacity of 0.25 $m^3/s$ supplies water to blocks C and D. Both the main and branch canals are lined in concrete. The off-take to block C regulation pond is 3.5 km along the branch canal. The branch canal eventually discharges into block D regulation pond at 7.5 km from the main off-take and there other two regulation ponds for the other subsections of block D. Figure 1 shows the layout of the irrigation system.

The regulation ponds receive water from the branch canal for 24 hours and store it overnight, since irrigation is practiced during the day time. Water is conveyed from the regulation pond to the field by an underground pipeline system. Farmers take water from the field hydrants using hose pipes and direct it into furrows. Each farmer is entitled to one hectare of irrigated land.

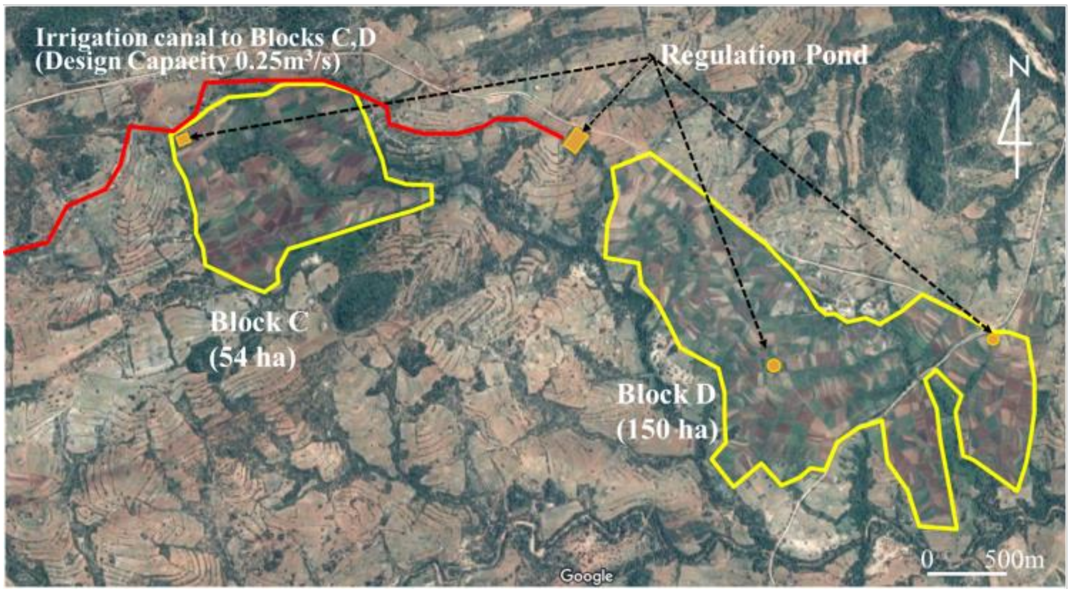


**Fig. 1 Layout map of blocks C and D of Fuve Panganai Irrigation Scheme**

Sections C and D with a total area of 204 ha were purposely selected as the study site because they share the same branch canal. Maize, groundnuts and sugar beans are the main crops grown. Maize and groundnuts are grown in the summer whilst sugar beans is grown in winter. It was therefore assumed that sugar beans was continuously grown in winter for the period under consideration.

### Water Demand and Supply

The irrigation water demand for 204 ha of dry beans for the winter irrigation season was calculated using the FAO CROPWAT 8.0 for Windows which is a computer program for the calculation of crop water requirements and irrigation requirements based on soil, climate and crop data.

The average monthly climate data for Buffalo Range Airport was accessed from FAO CLIMWAT 2.0 which is a climatic database to be used in combination with the computer program CROPWAT. The average monthly water supply for April to August which is the winter/dry season was calculated from daily irrigation water supply data for 5 years (2012-2016). The Relative Water Supply (RWS) index was calculated for dry season using the formula;

$$RWS = S/D \tag{1}$$

Where, $S$ is an amount of water supply and $D$ is an amount of water demand

### Quessionaire Survey

A sample of 38 randomly selected farmers were interviewed to get their perception on the water management performance with 80 percent confidence interval and 10 percent margin error. The waters user's association members and key informants from Zimbabwe National Water Authority (ZINWA), Department of Irrigation (DOI) and Agricultural Research and Extension Services (AGRITEX) department were also interviewed to understand the decision-making and water allocation process.

## RESULTS AND DISCUSSION

### Stakeholders

There are five key stakeholders in the irrigation scheme; the farmers, the Water Users Association (WUA), ZINWA, DOI and the AGRITEX department. Their roles and responsibilities are in shown in Table 1.

### The Water Allocation and Irrigation Practice

The water allocation process is in three stages; the planning stage, the negotiation stage and the implementation stage.

During the planning stage the farmers make the irrigation season plan; i.e. they come out with crop(s), the total hectarage, the planting dates, the tentative water requirements and amount of money needed to buy the water from ZINWA, etc. The WUA coordinates this process and they may also consult the AGRITEX and or the DOI officers for technical advice.

The WUA on behalf of the farmers engage the ZINWA in the negotiation stage to agree on the water contract. The water contract includes the crop, the total hectarage, the irrigation season, the amount of water needed and the payment plan amongst other factors.

During the implementation stage ZINWA supplies irrigation water to the farmers throughout the irrigation season as per the agreement in the water contract. The farmers order water as per demand by calling the ZINWA offices, the ZINWA through its resident technician, who stays in the farm, supplies a canal water depth for a certain number of hours and or days to meet the farmers water requirements. The process of ordering and receiving water is 24 hours.

**Table 1 The roles and responsibilities of key stakeholders**

| Name of stakeholder | Roles and responsibilities |
|---|---|
| Farmers | The main beneficiaries of the irrigation scheme. They are autonomous, and run the scheme independently. They are responsible for the operation and maintenance of the branch canal and other farm level irrigation facilities |
| WUA | The farmers' committee which coordinates the irrigation activities on behalf of the farmers e.g. making contract with ZINWA, collecting water fees from the farmers and holding meetings. |
| ZINWA | A quasi-government body managing irrigation facilities such as dams and the main canal. They supply the farmers with water based on the contract with WUAs. |
| DOI | A government department responsible for the supervision of irrigation projects including the operation and maintenance of the irrigation structures. |
| AGRITEX | The government department responsible for extension services; such as advising farmers on the best agronomic practices including irrigation scheduling |

The farmers are charged by ZINWA 4.36 USD/hectare/month. Of the 4.36, 1 USD is taken by the Save Water Catchment Council and the remaining 3.36 USD is for ZINWA. This means that each farmer on average pays 22 USD per irrigation season per hectare.

As seen from the water allocation process ZINWA water supply is not limiting; the farmers can order as much as they need and since this can be done within 24 hours there is less risk of water shortage. The farmers can irrigate during the day from 0800 hours to 1600 hours, there is no strict time table hence all the farmers can irrigate whenever they need but in practice in sections where the water pressure is low, they follow a flexible irrigation time table.

## The Water Supply and Demand

Fig. 2 shows the annual branch canal water discharge for the five years. The highest amount of water supply was observed in 2013 and the least amount in 2014. There is a relatively stable water supply with a coefficient of variation (CV) of 0.2. This means the ZINWA's water supply to the farmers is reliable.

The RWS for the mid-irrigation period (May, June and July) was shown in Fig. 3. It ranges from 1.28 to 2.12 with an average of 1.59. Although the irrigation season is five months from April to August, the first and last months of the irrigation season were not included in the analysis to avoid the error margin.

The RWS values at different locations of a system are closely linked to the management behavior of water managers and farmers (Sakthivadivel and Merry, 1993). Levine (1991) gave general recommendations (based on observations) that for a RWS of approximately 2.0, monitoring and control to secondary channels, daytime monitoring, limited communication between the system managers and farmers would still permit relatively high yields. Levine recommended that for a RWS of 2.5 or greater, minimal operational control at the main distribution level is enough to ensure that water will not be the limiting factor in crop production. However, considering the pipe line system is installed in the study scheme, this RWS is very high since the conveyance and distribution efficiency is theoretically very low under pipe line system.

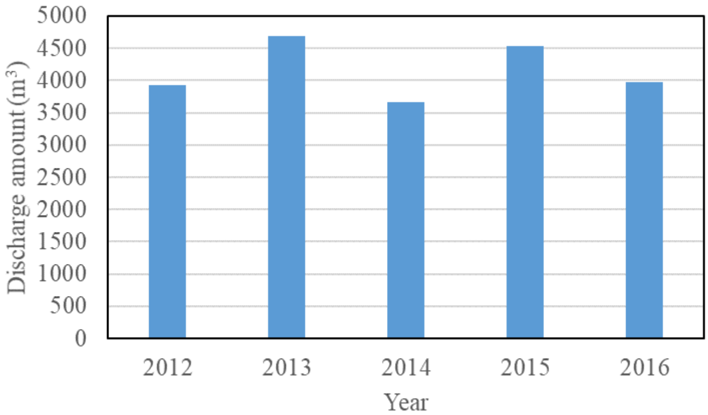


**Fig. 2 Annual canal water discharge**

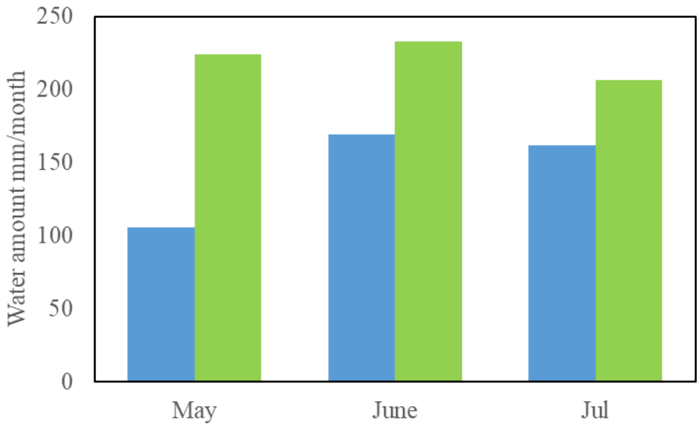


**Fig. 3 Water demand and supply during mid-irrigation period**

**Farmers' Perceptions on Irrigation Performance**

Fig. 4 shows the farmers perceptions as far as irrigation performance is concerned. Over 90 percent of the farmers are generally satisfied with the water delivery service by ZINWA. Although most of the farmers are satisfied, about 37 percent of the farmers have experienced periodical water shortages. Field observations revealed water leakages from damaged hydrants and pipes which might be the major reason for the water shortage. The high value of RWS are caused by the damaged hydrants and pipes in the study irrigation scheme. The rehabilitation of these will go a long way in improving the availability of water to all farmers.

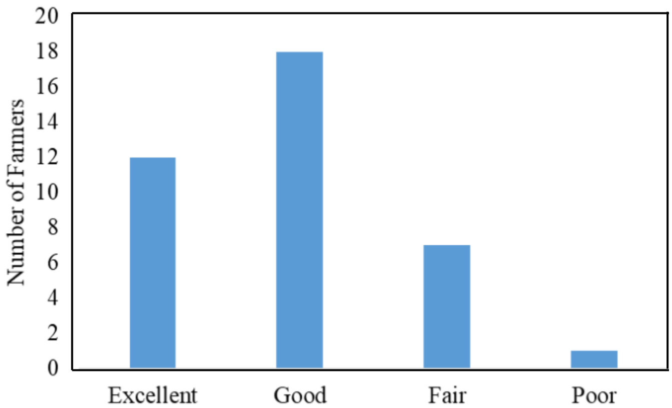


**Fig. 4 Farmers' perception on irrigation performance**

## CONCLUSIONS

The analysis of water demand and supply revealed that the water supply from ZINWA is reliably stable as shown by a CV of 0.2. The scheme received more water than the IWR as shown by the RWS of 1.6. The water allocation system is efficient with the farmers being able to order and receive water within 24 hours. Although more than 90 percent of the farmers are generally satisfied with the water delivery performance, 37 percent are experiencing some water shortages. There are water losses due to damaged hydrants and pipes. The results of this study can contribute to the overall evaluation of the performance of the irrigation scheme and therefore help in making the necessary recommendations for improvement e.g. increasing the water supply and or rehabilitation.

## ACKNOWLEDGEMENTS

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