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# *An Assessment of Water Management Practices on Smallholder Surface Irrigation Schemes: Case study of Insukamini Irrigation Scheme, Lower Gweru, Zimbabwe*

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*Abstract* – **The aim of the paper was to assess the water management practices on smallholder surface irrigation schemes (A case study of Insukamini irrigation scheme). A case study type of design in which phenomenology will be at the center stage was adopted. Positivism was used as a complementary approach to make the study adopt triangulation. Results indicated that the irrigation scheduling was not according to the recommended or designed. There was a significant difference in the yield of plots with drains and plots without drains. A few farmers had drains on their plots and a larger number of farmers had not installed drains on their plots. Furthermore, most farmers had a portion of their plots that was water logged and a few plots had no signs of water logging. The paper recommends that water management practices on smallholder irrigation schemes that use surface irrigation must be improved so that sustainable yields can be attained and productive land may not be lost due to water logging. Regulation of irrigation scheduling to avoid either over watering or under watering is essential. Installation and maintaining an adequate surface drainage system is critical. Irrigation schemes should strive for improved planning, operation and sustainable; and integrated water resources management. It is also imperative to improve farmers' knowledge of water management. There is indeed a need in developing countries for capacity building in drainage in all its aspects: design, construction, integration with water management, the environment and health.**

***Keywords* – *Agriculture; Water management; Irrigation; Drainage; Insukamini irrigation scheme; Zimbabwe.***

## *I. Introduction And Background*

This study aimed to assess the effects of water management practices on smallholder surface irrigation schemes. Irrigated agriculture accounts for two-thirds of the water withdrawn from the earth's rivers, lakes, and aquifers and produces approximately 40% of total food production [4]. Demand for water to satisfy the needs of industry and a population is increasing. On a global scale, agriculture will be obliged to give up water for higher-value uses in cities and industries. Water to satisfy agriculture demands can be found by irrigated agriculture becoming more efficient, therefore water management practices should be properly planned. The challenge is to sustain irrigated food production with less water.

Water management is the activity of planning, developing, distributing and managing the optimum use of water [7]. Water resource management planning has regard to all the competing demands for water and seeks to allocate water on an equitable basis to satisfy all uses and demands. Using an integrated approach method to water resources planning, a framework is offered for formulating strategies to ensure adequate water supply. Grafton and Hussey highlighted that Integrated Water Resource (IWR) planning is elaborated covering policy issues, cost-benefit analyses and environmental issues. Water management practices determine the yields and environmental effects such as water logging and salinity issues.

Effect of water management practices on yields and income of a small holder irrigation scheme need clarification. Water management practices deserve more recognition than it has received. Water-use efficiency in smallholder irrigation schemes is in the range 30% to 60%, leaving substantial room for improvement [2]. As irrigation development is crucial to ensuring food security in both the short and long terms, and small-scale irrigated production will have to supply an increased amount of food with less water in the future.

Insukamini irrigation scheme was first established by the Government of Zimbabwe in 1988 benefiting forty five families each with 0.25ha of land. Insukamini dam has a capacity of 38x106 cubic meters and has an irrigation water allocation of 600 megalitres per year. The available water can support the development of 50 hactares under irrigation at an allocation of 12 megalitres per hectare per year. The area is generally flat with a slope of approximately 2.5% making it ideal for any type of irrigation system. The soils are clay loam soils, moderately deep with inherent soil fertility. The scheme draws water from Insukamini dam and uses the canal system. It is communally owned and is located in region three of the Midlands province about twenty five kilometres from the city of Gweru, in the Lower Gweru area. Insukamini irrigation lies within two wards which are eight and sixteen of Vungu District. The surrounding area is dry but the irrigation scheme is a green oasis of life visible for miles.

The Insukamini irrigation scheme have problems of water logging, water shortages, salinity, loss of land due to water weeds and decrease in yields in some plots. This paper assesses the effect of water management practices on productivity on smallholder irrigation schemes with Insukamini scheme as a case study. The community of Vungu District will benefit immensely from the positive adoption of recommendations from this paper. The recommendations might ultimately result in proper water management resulting in overall improvement in yields and ultimately incomes of beneficiaries of the Insukamini Irrigation Scheme. The study may provoke further researches that will enhance the yields of the irrigation scheme. The overall objective of this study thus is to assess the effect of water management practices on smallholder surface irrigation schemes.

## *II. Literature Review*

Better water supply, sustainability of the water source, improved crop yields, efficient water uses which facilitate equitable distribution of water, lower water charges, saving in time and energy, reuse and safe disposal of water and the reduction of pollution to the environment which all contribute to an improved quality of life for the rural and peri-urban communities [5]. They must be equitable and sustainable utilization of water for social, environmental justice, and economic benefit for present and future generations.

To improve water management people have to improve the conveyance efficiency, field canal efficiency, field application efficiency, distribution system efficiency and farm irrigation efficiency. Surface irrigation schemes are designed and operated to satisfy the irrigation water requirements of each field while controlling deep percolation, runoff, evaporation and operational losses. The performance of the system is determined by the efficiency with which water is conveyed to the scheme from the head works, distributed within the scheme and applied to the field, and by the adequacy and uniformity of application in each field [3].

Some authors have questioned the economic viability of smallholder irrigation schemes in Zimbabwe. They pointed out that certain smallholder schemes have failed and are under-utilized. This was attributed to poor water management practices, lack of inputs and irrigation experience by farmers [9]. In the same report Mupawose advocated for the reduction of subsidies on smallholder irrigation and indicated that irrigation development had become expensive.

However, effectiveness of smallholder irrigation agriculture as a poverty alleviating strategy has long been recognized by many developing countries. The more farmers produce with the same amount of water, the less the need for infrastructure development, the less the competition for water, the greater the local food security and the more water for agriculture, household and industrial uses and the more that remains in nature. To achieve more crop per drop, either production must be increased, keeping water constant or the same amount of production must be maintained while using less water [8].

Irrigation engineers have traditionally depended mainly on engineering measures to meet water saving targets. The future will require modernization of irrigation and drainage, which means not only modernizing the infrastructure, but includes improving the water management practices of the scheme [1]. Water is seen as a strategic input in food security policy and in poverty reduction strategies. Water is also seen as a key environmental resource. In addition, water is an input to other sectors and has to be managed within an integrated framework, especially where it is scarce. Increased water scarcity has shifted the focus from exploitation of water resources and building infrastructure to improvement of water use efficiency [11].

Planning, consultation between the public and the ministries involving appropriate legislation and funding agreements are essential if irrigation projects are to be economically efficient and socially and environmentally acceptable. If every party concerned is involved from the planning to the implementation phase everyone would benefit even through spinoff effects [10].

### *III. Methodology*

Phenomenology and positivism were used as complementary approaches to make the study adopt triangulation. In easiness the two approaches (phenomenology normally known as qualitative; and positivism, also known as quantitative approach) will be used. This is the Quan-Qual model, a model in which the researcher uses two or more methods in an attempt to confirm and corroborate findings within a single study [6]. CROPWAT is a decision support system developed by the Land and Water Development Division of FAO for planning and management of irrigation. CROPWAT is meant as a practical tool to carry out standard calculations for reference evapotranspiration, crop water requirements and crop irrigation requirements, and more specifically the design and management of irrigation schemes and will be used for data analysis.

A population is all possible observations of the random variable understudy [12]. In this case it refers to all 121 farmers at Insukamini irrigation scheme. Stratified random sampling was used to identify the primary participants. A sample of 30 individuals was drawn from the population under study through a stratified random sampling technique. Stratification was based on proper book-keeping and non-book-keeping of beneficiaries as well as diarization of events. From the strata a random sample was drawn so as to obtain responses from which judgments could be drawn.

### *IV. Results And Discussion*

The table below shows the crop water requirements and evapotranspiration for each month from the CROPWAT model.

*Table 1: Crop Water Requirements*

| | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **June** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** | **Total** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **ETo mm/day** | 4.1 | 3.9 | 4 | 3.6 | 3.1 | 2.7 | 2.8 | 3.6 | 4.6 | 5.2 | 4.4 | 4 | 46 |
| **Effective rainfall mm/month** | 130.6 | 118.1 | 83.3 | 42.6 | 12.7 | 6.9 | 1.0 | 3.0 | 9.8 | 36.6 | 93.2 | 134.9 | 672.7 |
| **ET crop mm/month** | | | | | | | | | | | | | |
| Grain Maize | 137.2 | 100.4 | 84.1 | | | | | | | 38.2 | 75.7 | 126.1 | 561.7 |
| Groundnuts | 91.3 | 103.3 | 115.4 | 71.4 | | | | | | | 23.2 | 64.4 | 469.0 |
| Tomatoes | 102.5 | 112.8 | 128.1 | 100.1 | 7.7 | | | | | | | 62.0 | 513.2 |
| Dry Beans | 88.8 | 109.5 | 118.9 | 60.8 | | | | | | | | 32.8 | 410.8 |
| Green Mealies | | | | | | | | 83.1 | 129.9 | 173.7 | 137.2 | | 523.9 |
| Onion | | | | | 60.3 | 79.0 | 98.3 | 118.9 | 125.6 | | | | 482.1 |
| Cabbage | | | | | 17.8 | 44.6 | 81.3 | 123.9 | 137.1 | 4.4 | | | 409.1 |
| Wheat | | | | | 20.5 | 61.0 | 98.3 | 122.9 | 120.5 | 20.1 | | | 443.3 |

Source: Author computations

The table above shows the brief irrigation design for the Insukamini irrigation scheme.

*TABLE 2: BRIEF DESIGN REPORT*

| Item | Design Maturity | Symbol | Value |
|---|---|---|---|
| 1 | Soil Type | $S_t$ | Sandy loam |
| 2 | Available Moisture Content | AWC | 120mm/m |
| 3 | Allowable Moisture Depletion | MAD | 48% |
| 4 | Design Crop | Mz | Maize |
| 5 | Root Zone Depth | RZD | 0.75m |
| 6 | Field Application Efficiency | $E_a$ | 60% |
| 7 | Field Canal Efficiency | $E_b$ | 92% |
| 8 | Water Conveyance Efficiency | $E_c$ | 92% |
| 9 | Farm Irrigation Efficiency (EbxEa) | $E_f$ | 55% |
| 10 | Distribution System Efficiency (EcxEb) | $E_d$ | 86% |
| 11 | Overall Irrigation Efficiency (EcxEbxEa) | $E_p$ | 50% |
| 12 | Peak Crop Water Use | $ET_c$ | 7.5 |
| 13 | Net Depth of Irrigation | $D_{net}$ | 45mm |
| 14 | Irrigation Frequency | IF | 7 days |
| 15 | Gross Depth of Irrigation | $D_{gross}$ | 90mm |
| 16 | Irrigation Cycle | IC | 6days |
| 17 | Total Area | At | 36.5Ha |
| 18 | Area to be irrigated per day | A | 6.08Ha |
| 19 | Volume of water to be abstracted per day | V | 5472$m^3$/hr |
| 20 | Irrigation time per day | IT | 10hrs |
| 21 | System Capacity | Q | 547.2$m^3$/hr |

*TABLE 3: PEAK NET IRRIGATION REQUIREMENTS FOR DIFFERENT CROPS*

| Crop | mm/month | mm/day |
|---|---|---|
| Grain maize | 138 | 4.7 |
| Green maize | 225 | 7.5 |
| Groundnuts | 125 | 4.2 |
| Beans | 143 | 4.8 |
| Wheat | 174 | 5.8 |
| Onion | 163 | 5.4 |
| Tomatoes | 122 | 4.3 |
| Cabbage | 122 | 4.3 |

In the design of the irrigation scheme the peak water requirement of green maize (7.5mm/day) has been used. This ensures that the irrigation schedule caters for all other crops since maize have the highest water requirement.With an irrigation frequency of 7days. Net depth of irrigation is 45mm and an irrigation efficiency of 55%.

*TABLE 4: IRRIGATION SCHEDULING PRACTICED AT INSUKAMINI IRRIGATION SCHEME*

| | |
|---|---|
| Butternut | Twice a week in the early stages, Once per week in the late stages, (0,25ha/45min) 2 siphons per furrow. |
| Sugar beans | Twice a week in the early stages, Once per week in the late stages, (0,25ha/45min) 2 siphons per furrow. |
| Cabbage | Twice a week , (0,25ha/45min) 2 siphons per furrow |
| Peas | Once a week in the early stages, Twice per week in the late stages (0,25ha/45min) 2 siphons per furrow |
| King onions | Once per week, (0,25ha/45min) 2 siphons per furrow |
| Maize | Once in a week (0.25ha/45min) |

Mean $ET_o$ = 3,83mm/day from the cropwat
Irrigation frequency =7days.
50mm siphon size is used.

From designed 6ha is irrigated per hour therefore 0.608ha=1hr
$0{,}456\text{ha}=\frac{3}{4}\text{hr}$.
$0{,}456\times10000\text{m}^2=4560\text{m}^2$
$410{,}4\text{m}^3$ per $\frac{3}{4}$hr.
$\frac{410{,}4\text{m3}}{4560\text{m2}}=0.0912\text{m}= D_{gross}$
$91.2\text{mm}=D_{gross}$

$ET_c = ET_o \times K_c$
$\frac{45\text{mm}}{\text{ETc}} = 7\text{days}$
$45\text{mm}\div( ET_o \times K_c) = 7\text{days} = 45\text{mm}\div (3.83K_c) = 7$

Therefore $K_c=1.68$
$D_{net} = D_{gross}\times\text{Efficiency}$
$D_{net}=91.2\text{mm}\times0.55=50.16\text{mm}$
50.16mm – 45mm=5.16mm
$0.00516\text{m}\times 10000\text{m}^2=\mathbf{51.6m^3}$

The irrigation scheduling is not according to the recommended or designed. In the design of the irrigation Dnet=45mm and Dnet for the practised irrigation scheduling is 50.16mm.Therefore the farmers are over irrigating by 5.16mm.

The challenge was that the scheme had no water management committee (IMC) and irrigation management supervisors for a very long time to help monitor irrigation scheduling. The farmers used to over irrigate because they was no supervision. Farmers used to have disputes over water allocation and siphons. In 2012 that is when proper water allocation, irrigation scheduling and irrigation practices in line with design recommendations had been adhered to because of the Water Management Committee and Water Management Supervisors who thoroughly monitored the irrigation schedule and water allocation according to blocks.

Covering of infield drains by mealies stalks clearly shows that farmers do not really know the importance of drainage systems and some farmers are ignorant. Poor maintenance of these drains is caused by poor management.

The figure below shows the extent to which farmers have drains in their plots.

90 % of farmers did not have drains on their plots and 10% of farmers had drains on their plots. A few farmers have drains on their plots and a larger number of farmers have not installed drains on their plots. Where drainage has been maintained yields have been increasing. There is reduced water logging. With drainage, there is a chance possibly that yields are maintained and improved, rapidly at first, then more slowly until the system reaches a consistent, sustainable level.

93% of farmers had plots affected by water logging and only 7% were not affected. This indicates that most farmers had a portion of their plots water logged and a few plots have no signs of water logging at the moment. This can be attributed to poor water management system due to lack of proper drainage system.


*Figure 1: Drains Covered With Mealie Stalks*

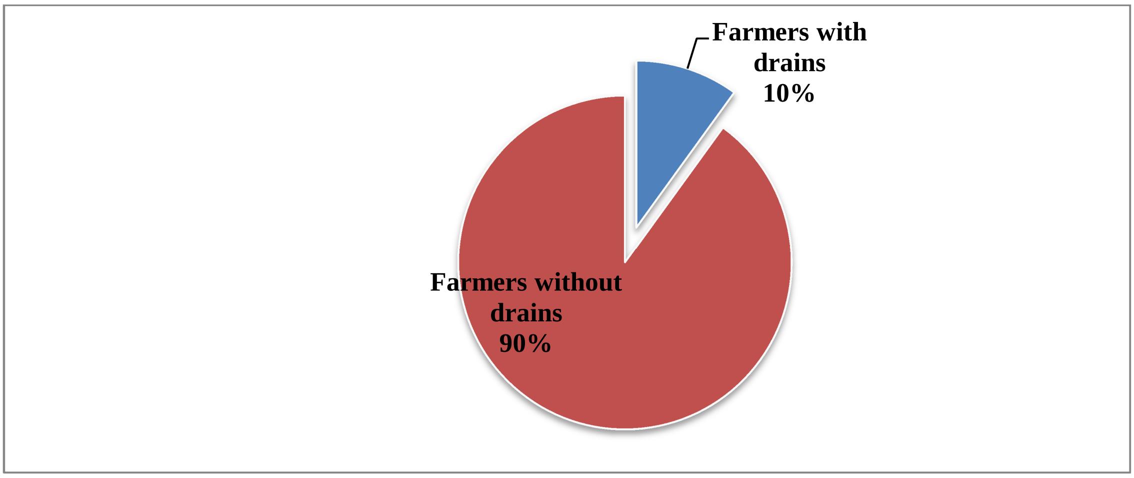


*Figure 2: Presence Of Agricultural Drains In Farmer's Plots*

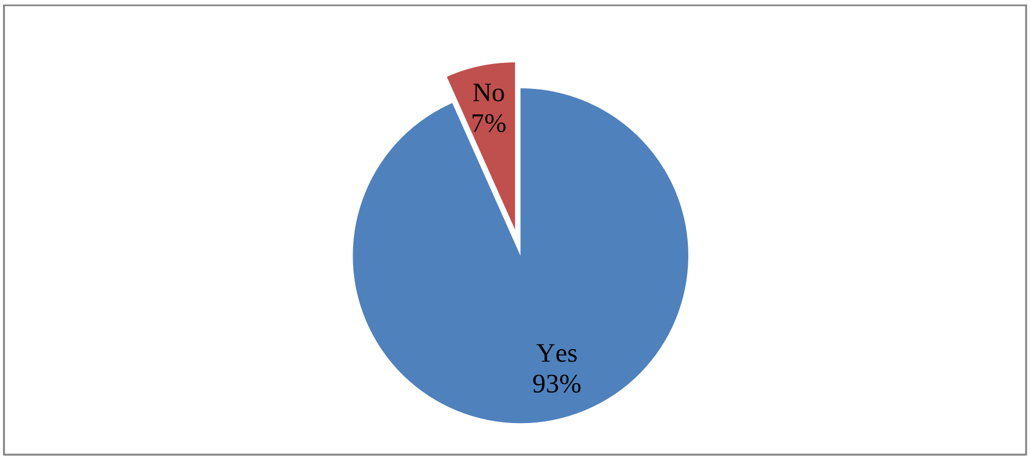


*Figure 3: Water Logging In Plots*

Pictures below show some of the waterlogged areas.

*Figure 4: Waterlogged Areas*

## V. CONCLUSION AND RECOMMENDATIONS

The paper concludes that Insukamini irrigation scheme has poor water management practices. The irrigation scheduling was not according to the recommended or designed. Drains were covered by mealies stalks showing that farmers do not really know the importance of drainage systems on smallholder irrigation schemes that use surface irrigation. Most farmers did not have drains on their plots and most plots were affected by water logging. From the statistical analysis of the data from Insukamini irrigation scheme results indicated that often importance of installation of land drains is neglected in achieving sustainable yields and preventing loss of productive land due to water logging and salinity.

The significant importance of proper water management practices can be more pronounced and realized in the long run. Investments in the installation of water management facilities in irrigation schemes take time to yield results. This suggests that irrigation can be sustainable by adopting proper water management strategies and productive agricultural land will not be lost as a result of water logging and salinity. Agriculture in irrigation schemes that use surface irrigation must pay more attention to water management practices, because this is important for agricultural sustainability.

Governments and NGOs must be informed about the contribution proper water management makes to sustainability, in order to mobilize investments for proper water management facilities in agricultural areas. Overall planning, designing, construction, sustainable operation and maintenance, management of irrigation schemes, irrigation research, and provision of irrigation engineering, advisory and regulatory services to irrigation clientele for viability and sustainability of irrigation schemes must be achieved. The threat of water logging and salinization hangs over nearly every irrigation scheme: apparently excellent irrigation schemes have failed because of lack of proper water management strategies. There are pressing needs for more investment for proper water management systems to maintain current production levels in existing agricultural systems around the world and to drain degraded and abandoned agricultural land.

Regulation of irrigation scheduling to avoid over watering and under watering is also critical. Installation and maintaining an adequate surface drainage system, including installing a subsurface drainage system where the need arises. Using proper irrigation schedules with leaching requirements incorporated is important. Adjusting cropping patterns through the cultivation of crops with salinity tolerance and avoiding mono cropping. Incorporating soil ameliorates, such as incorporating gypsum in irrigation water to reduce sodium content of soils**.**

Land levelling reduces water logging and as well as salinity**.** Strive for improved planning, operation and sustainable and integrated water resources management. Improve farmers' knowledge of water and salt management. Address the essential needs relating to water management;

training and improvement of WMC and IMC staff. There is a need in developing countries for capacity building in drainage in all its aspects: design, construction, O&M, integration with water management, the environment and health. It is important to give authorities sufficient means and executive power to promote installation of drainage systems. They should be aware of the various water management solutions available for specific problems. Farmer beneficiaries need to be made aware of what drainage can contribute to their well-being.

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