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Effects of Water Management Practices on Crop Yields at Insukamini Irrigation Scheme, Lower Gweru, Zimbabwe

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Abstract: ***Food security is a top priority concern on the Zimbabwean socio-political agenda. Zimbabwe's food security is challenged by several physical, socio-political and policy factors, including: population growth; industrialization and urbanization; land and water use changes, water shortage; income changes and nutritional evolution. This paper explores the effects of water management practices on crop yields in smallholder irrigation schemes. CROPWAT was used for data analysis on two convectional cereal crops (maize and sugar beans). Results show that there was a significant difference in the yield of plots with drains and plots without drains for both maize and sugar beans production. This meant that drains had a positive effect on the yields of maize and sugar beans and implies that different water management practices affect crop yields differently. Good drainage practices improved crop yields. The recommended policy action is that food crop farmers on smallholder irrigation schemes should be aided to improve water management of their acreage. The study further recommends that a clear understanding of the issues and trends in agricultural water management practices is essential to support a national development policy that focuses on food security.***

Keywords: Water management, Crop production, Irrigation, Drainage, Insukamini irrigation scheme, Zimbabwe

1. Introduction

Agriculture in Zimbabwe is a source of livelihood for over 70% of the population and is the mainstay of the economy. However agriculture's growth over the past ten years has been declining and becoming inadequate to meet the growing population needs, MAMID (2016). It is thus a key sector in determining food security. While commercial large-scale farmers are contributing to increasing agricultural yields, the smallholder farmers are lagging behind. As such, sustained development in Zimbabwean agriculture is hinged on realizing the potential of smallholder farming. Indeed raising the productivity of smallholder farmers is the most obvious and direct route in a bid to achieve agricultural growth. Irrigation of smallholder farms is one way to aid farmers to increase output, (FAO, 2016).

Water management is an imperative part of irrigated crop production. Effective irrigation systems and water management methods can assist increase crop yields in a period of limited, higher-cost supplies of water. The available water for irrigation in Zimbabwe has become scarce over the last decade and this has been credited to decreasing rainfall, recurrent droughts and urbanization. The situation has been made worse water management knowledge deficiency among small holder farmers, (Makwara, 2015). The scarcity of water is now compromising the underground water recharge and viability of irrigation, (Molden, et al. 2003). It is thus necessary to conserve and more productively use the available water resources.

Irrigation water helps to increase crop output when limited rainfall would otherwise hamper crop growth, (Hunt et al., 2006). Insukamini Surface Irrigation Scheme farmers however have been over applying water volumes with the idea that they can increase their output. Synonymously the irrigation scheme has been facing problems of decline in output from 2009 to 2014, (Makwara, 2015). By boosting crop productivity and producing a range of additional benefits, improving water and land management methods would help to reduce poverty and pressures on water, climate and ecosystems, (Winterbottom, et al. (2013). Advantages of improved water and land management practices to rural communities and farmers include increased yields for the agriculture sector, employment opportunities and increased income, and increased resilience to associated extreme weather events and climate change, (Hongyun and Liange, 2007).

The focus of the paper was therefore to assess farmer practices in water management that directly have an effect on crop production in smallholder irrigation schemes. The specific objective is to determine the effect of different water management practices on the yield of maize and soya bean in smallholder irrigation schemes.

2. Literature Review

Irrigation has various potential benefits for Africa, can significantly initiate rural economic development and contribute towards food security at the household level. Usually, irrigation development also results in general infrastructural improvements, rural electrification, better roads, better health services, as well as housing improvements, (Melvyn, 2003). As large consumers of water, developments in irrigation have intense effects on water use and availability resulting in soil degradation, less water availability and food insecurity are now becoming a common challenge, (Molden et al., 1999). Generous evidence exists that climate change will exacerbate decrease in crop production by increasing water variability because of intense and frequent weather events like major storms, floods and droughts, (Brauman et al., 2013).

Destructive traditional water and land use; and conservation practices have reduced soil fertility levels in Southern Africa which has resulted in crop yields declining, (Okai, 1997). There are several factors responsible for declining crop production, defined by Gretton and Salma (1997) as decline in the biological productivity or usefulness of water and land resources in the predominant intended use, which stem from human activity. These also include too close crop rotation, cultivation of marginal lands, mining agriculture, and mainly the absence of water and land conservation practices (Kufogbe, 1996; Gough and Yankson, 1997).

The effects of bad water management are well documented and widely recognised as undesirable (Altieri & Anderson, 1992; Arden-Clarke & Hodges, 1987; Altieri & Rosset, 1996; Schilling & Wolter, 2001; Hart et al., 2004; Schulz & Liess, 1999; Hunt et al., 2006). Smallholder farming systems based on irrigation are increasingly vulnerable to bad water management practices leading to a global trend towards a decline in crop yields (Altieri & Anderson, 1992; Altieri & Rosset, 1996). In a bid to stop and reverse the undesirable impacts of bad water management practices on smallholder irrigation schemes there has been a move towards more considerate and sustainable farming practices.

Various irrigation technologies and management practices are available to augment applied water in irrigated agriculture efficiency. Irrigation improvements often involve upgrades in physical application systems, with improved field application efficiencies and higher yield potentials. Improved water management methods, such as water-flow measurement and irrigation scheduling, may also be required to achieve physical system maximum potentials. In addition, in many irrigated areas management of drainage flows could be an important concern. In some cases, the effectiveness of improved irrigation practices may be enhanced when implemented in combination with other farming practices such as tillage management, conservation water and nutrient management, (Negri and Hanchar, 1989).

3. Methodology

Quantitative methodology paradigm was used in this research thus forming the base foundation of the paper. 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. 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 20 individuals was drawn from the population under study through a stratified random sampling technique. Stratification was based on plots with drains and those without drains. From the strata a random sample was drawn so as to obtain responses from which judgments could be drawn.

4. Results and Discussions

A sample of 20 farmers of phase 1 at Insukamini irrigation scheme was selected using 2011/ 2012 season. The conventional crops grown have been taken as samples for analysis and these are maize and sugar beans.

4.1 Data presentation on maize yields

The table below shows mean irrigated farming yields with drains against farming yields for the plots without drains for maize. The following is the statistical test of yields between plots with drains and plots without drains of maize production.

H_0: $mean_d = mean_{w.d}$

H_1: $mean_d > mean_{w.d}$

Test Statistic: (t- test) test of difference of means

Table 1: Maize (t/ha)

Farmer	Plots with drains	Farmer	Plots without drains
1	4.5	1	2.5
2	6.0	2	3.5
3	5.0	3	3.5
4	6.5	4	3.2
5	5.8	5	2.8
6	5.0	6	3.2
7	5.5	7	2.5
8	6.0	8	3.5
9	6.5	9	3.4
10	7.5	10	3.2
Total	58	Total	31

CROPWAT computations:
Mean for plots with drains Mean for plots without drains
$\frac{58}{10}$=5.8 $\frac{31}{10}$=3.1

$$t = \frac{mean_d - mean_{w.d}}{\sqrt{\frac{S_d^2}{n_d} + \frac{S_{w.d}^2}{n_{w.d}}}} = \frac{5.38 - 3.13}{\sqrt{\frac{0.88^2}{10} + \frac{0.39^2}{10}}} = 8.837$$

Key: $mean_d$ - mean of plots with drains, S_d - standard deviation of plots with drains
$mean_{wd}$ - mean of plots without drains, S_{wd} - standard deviation of plots without drains

Degrees of freedom = ($n_1 + n_2 - 2$) = (10+10-2) =18

We test at 5% significance level and reject H_0: $t_{cal} > t_{5\%:18}$

$t_{5\%:18}$ =1.73
$t_{cal} > t_{5\%:18}$

Therefore we do not accept H_0

Result**:** t calculated is greater than t tabulated at 5% significance level.

Conclusion: We do not accept H_0

There is a significant difference in the yield of plots with drains and plots without drains maize production. This means that drains have an effect on the yields of maize. The difference between t- values (calculated and tabulated at 5%) is extremely big suggesting that there is an increased yield in maize production through drained plots. This implies that if the government and donors can fund the installation of agricultural drains on irrigation projects maize production would increase.

4.2 Data presentation on sugar beans yields

The table below shows mean irrigated farming yields with drains against farming yields for the plots without drains for sugar beans. The following is the statistical test of yields between plots with drains and plots without drains of dry sugar beans production.

H_0: $mean_d = mean_{w.d}$

H_1: $mean_d > mean_{w.d}$

Test Statistic: (t- test) test of difference of means

Table 2: beans (t/ha)

Farmer	Plots with drains	Farmer	Plots without drains
1	3.00	1	0.90
2	2.50	2	1.30
3	3.00	3	0.80
4	2.90	4	1.40
5	3.20	5	1.20
6	3.00	6	1.20
7	2.50	7	0.70
8	2.40	8	0.90
9	2.70	9	1.20
10	3.00	10	1.10
Total	28.20	Total	10.70

CROPWAT computations:
Mean for plots with drains Mean for plots without drains
$28.2/10 = 2.82$ $10.7/10 = 1.07$

$$t = \frac{mean_d - mean_{wd}}{\sqrt{\frac{S_d^2}{n_d} + \frac{S_{wd}^2}{n_{wd}}}} = \frac{2.82 - 1.07}{\sqrt{\frac{0.274^2}{10} + \frac{0.0.231^2}{10}}} = 15.446$$

Key: Key: $mean_d$ - mean of plots with drains, S_d - standard deviation of plots with drains

$mean_{wd}$ - mean of plots without drains, S_{wd} - standard deviation of plots without drains

Degrees of freedom ($n_d + n_{w.d} - 2$) = (10+10-2) =18

We test at 5% significance level an reject H_0 :
$t_{cal} > t_{5\%:18}$
$t_{5\%:18}$ =1.73

$t_{cal} > t_{5\%:18}$

Result: t-calculated is greater than t-tabulated at 5% significance level.

Conclusion: Therefore do not accept H_0

There is a significant difference in yield between plots with drains and plots without drains of sugar beans production. The difference between t- values (calculated and tabulated) is extreme suggesting that there is a significant increase in sugar beans yield at 5% level through plots with drains. The data on crop yields between plots with drains and plots without drains suggest that there is an improvement in yields on sugar beans at 5% level. This, in essence means that the probability of increasing yields through installation of agricultural drains in ward 8 of Lower Gweru District is more than 95%.

5. Conclusion and Recommendations

The study has shown that proper drainage system improved yields for both maize and sugar beans. This study therefore concludes that proper and prudent water management practices are required in order to have a positive effect on plant growth, increased yields, and enhanced water productivity.

The recommended policy action is that food crop farmers on smallholder irrigation schemes should be aided to improve water management of their acreage. The study recommends that a clear understanding of the issues and trends in agricultural water management practices is essential to support a national development policy that focuses on food security. Improving land and water management can enhance an increase in crop production hence ensuring food security and reducing poverty while helping to adapt to and mitigate climate change. These practices can restore the productivity of degraded agricultural land and boost crop yields. Mitigation measures can also be encouraged as well as adoption of agri-environmental practices that increase soil moisture retention, such as changing cropping systems toward drought resistant crops and the uptake of conservation tillage, as well as providing farm advice and technical guidance to mitigate drought risks.

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