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Research Paper

Evaluation of financial performance of Center pivot versus Furrow irrigation systems in sugarcane production at Green Fuel Estate in Chipinge, Zimbabwe

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Abstract
The study was conducted at Green Fuel Chisumbanje Estate in Chipinge, Zimbabwe. The study evaluated financial performance of Center pivot versus Furrow irrigation systems in sugarcane production. Secondary data wereobtained from the Estate, Zimbabwe Electricity Transmission and Distribution Company, Agricultural Bank of Zimbabwe, Commercial Bank of Zimbabwe,First Capital bank, Zimbabwe National Water Authority and FAOSTAT. Cost Benefit Analysis (CBA) was used to assess financial performance. Furthermore, a sensitivity analysis was done to measure the responsiveness of financial performanceto changes in market interest rate. CBA results showed that the Center pivot system is more financially viable [Net Present Value (NPV) =USD36 472; Internal Rate of Return (IRR) =50% and Benefit Cost Ratio (BCR) =1.26] thanFurrowthe system (NPV=USD24 414; IRR=49% and BCR=1.06). Furrow system was found to be less desirable (BCR falling from 1.06 to 0.99) than Center pivot system (BCR falling from 1.26 to 1.17) in case the discount rate increases from 15% (lowest market rate by commercial banks during study period) to 18% (highest market rate charged by commercial banks). The study concluded thatthe Center pivot system is more financially viable for sugarcane production despite having higher investment costs than the Furrow system. The study recommends Green Fuel Estate to invest more onthe Center pivot system thanFurrow system in the long-run.

Keywords: *Sugarcane, Cost Benefit Analysis, Irrigation, Financial performance, Center pivot, Furrow, Zimbabwe*

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I. INTRODUCTION

Sugarcane (*Saccharum Officinarum*) is mainly cultivated in the South East Lowveld of Zimbabwe as the area has an ideal mix of suitable climatic conditions and readily available water supplies from Save and Mwenezi rivers, for irrigation purposes (Chidoko & Chimwai, 2011). The crop contributes 1.4 % to the country's GDP (Annual Action Programme, 2009). There are five major sugarcane estates in Zimbabwe's South-East Lowveld, namely; Hippo Valley, Tongaat Hulett, Mkwasine, Chisumbanje sand Middle Sabi (Sibanda, 2010). The total land area under sugarcane production is over40 000 hectares producing 4.5 million tonnes of raw sugar per annum (Kambanje, 2016).The ever increasing global demand for green fuels coupled with the mandatory blending of gasoline fuel with ethanol by the Zimbabwean government has spurred sugarcane productionin the country (Shumba *et al*.2011).

According to Frenken & Gillet (2012), the Food and Agriculture Organisation (FAO) estimates that 100% of wheat and sugarcane crops in Zimbabwe are irrigated. In the South-East Lowveld of Zimbabwe the rainfall is seasonal, low, erratic and unreliable, making rain-fed sugarcane production not feasible (Chikodzi *et al*. 2013). Sugarcane requires large volumes of water (1500-2000mm) throughout the growing season depending on the variety and intended use of crop (Yohannes, 2016). Thus, sugarcane production has a direct effect on water resources. This calls for a need to conserve the country's already precarious water resources. As a starting point, there is need to examine the performance of the existing irrigation systems. The choice of an irrigation system has a significant direct effect on the cost-effectiveness and overall performance of the farming enterprise. In order for a project to be sustainable all the technical, socio-economic, health and environmental information should be analysed in such a way that the system chosen is technically feasible, economically viable, socially acceptable and environmentally sound (Guerrero *et al*. 2016; Nelson & Hill, 2010).

The Furrowirrigation system (also known as surface system) is the most commonly used type of irrigation technology for sugarcane production in Zimbabwe. This is despite the system's low levels of water use efficiency (35-40%), labor intensiveness and limited environmental soundness. (Narayanamoorthy, 2005; Yonts & Eisenhauer, 2007). Irrigation systems with higher water use efficiencies usually have higher development and operational costs. As such the choice of any one particular irrigation technology over another is a fine balance between the efficiencies that can be achieved as well as the cost. In line with this argument, Magwenzi & Nkambule (2003)suggest that there has been rapid adoption of the Center Pivot irrigation system due to its high water use efficiency, low operational cost per hectare, labour saving advantage and high water distribution uniformity. The fact that water is increasingly becoming precarious and expensive, yet it plays a central role in sugarcane production, calls for an irrigation system which responds to this need. This is an important concern given that Zimbabwe is classified as a water scarce country.

Furrow irrigation is the dominant irrigation system amongst sugarcane farmers in the South-East Lowveld of Zimbabwe despite its low water use efficiency. For instance, at Green Fuel, Furrow irrigation counts for 75% and Center pivot covers the remaining 25%. These irrigation systems differ considerably in terms of water use efficiency, labour requirement, operating and maintenance costs, as well as economic and environmental impacts. Thus, the focus of this study was to assess the financial performance of the Furrow system versus the Center pivot system in sugarcane production at Green Fuel in Chipinge.

II. METHODOLOGY

2.1 Description of the study area

The study was done at Green Fuel Estates (namely Rating and Macdom) in Chipinge, Zimbabwe. The study area was purposively chosen because it is the hub of sugarcane production in the country. Rating and MacdomEstates are located in Middle Sabi and Chisumbanje, respectively. The area is under natural region V. It receives low and erratic rainfall averaging below 450mm per annum with temperature ranging from 17 °C in winter to above 30 °C in summer (Gambiza & Nyama, 2000; Chikodzi *et al*. 2013). South-East lowveld is generally a broad flat peneplain which is approximately 500m above sea level. The valley is characterised with loam fertile soils. Green Fuel Estates use both the Center pivot and Furrow irrigation systems. Irrigation water is drawn from Save and Mwenezi rivers. Green Fuel estates produces an average of 900 000tonnes of sugarcane per annum with an average yield of 110tonnes per hectare. The sugarcane is mainly processed into sugar and ethanol for both domestic and export markets.

2.2 Data collection and analysis

The study used secondary data which was mainly obtained from Green Fuel Estate. In addition, secondary data were also collected from the following sources;Zimbabwe National Water Authority (ZINWA), Zimbabwe Electricity Transmission Distribution Company (ZETDC), Agricultural Bank of Zimbabwe (AGRIBANK), Commercial Bank of Zimbabwe (CBZ) and FAOSTAT. The data consisted ofirrigation development costs, irrigation operation and maintenance costs, water charges, electricity costs, discount rates and water prices.

The data were analysed using a financial Cost Benefit Analysis (CBA). Srivastava & Shar (2007) argued that CBA is a project appraisal tool that analyses the worthiness of a project by valuing all the costs and benefits arising from it. Future benefits and costs are discounted and given a current dollar value so as to counter uncertainties that may arise in the future. The technique takes into account the concept of time value of money to shield the worthiness of money from inflation and other uncertainties that may occur with time (Siddique & Rahim, 2015).

This study used Net Present Value (NPV), Benefit Cost Ratio (BCR) and Internal Rate of Return (IRR) as financial performance indicators for the Furrow and Center pivot systems. NPV measures the financial performance of a project by summing up all the discounted benefits and costs for the project's overall lifespan (Adusumilli *et al*. 2016). Positive NPV means that the project is profitable and is worthy to invest-in as present value benefits will be greater than present value costs. Since this study was comparing two irrigation systems, the one with a higher NPV was preferred. NPV was calculated as follows;

$$NPV = \sum_{t=1}^{t=n} \frac{B_t - C_t}{(1+i)^t} \quad (1)$$

Where: i = discount rate, n = number of years, t = t^{th} year, B_t = benefits, C_t = costs

The study measured IRR for the two aforementioned irrigation systems. IRR is the discount rate or the opportunity cost of capital which equates NPV to zero. IRR is the rate of return that is expected to be received by the business enterprise and is given is expressed as a percentage. A project with a higher IRR is more desirable. IRR is computed as;

$$IRR\ (i) = \left[\sum_{t=1}^{t=n} \frac{B_t - C_t}{(1+i)^t} = 0 \right] \quad (2)$$

Where: i = discount rate, n = number of years, t = t^{th} year, B_t = benefits, C_t = costs

BCR was also calculated for the two irrigation systems. BCR is the proportion of total present value benefits to total present value costs of a project (Scott & Farquharson, 2004). The rule of thumb is to accept a project with BCR which is greater than 1. BCR was calculated as follows;

$$BCR = \sum_{t=1}^{t=n} \frac{\frac{B_t}{(1+i)^t}}{\frac{C_t}{(1+i)^t}} \quad (3)$$

Where: i = discount rate, n = number of years, t = t^{th} year, B_t = benefits, C_t = costs

A sensitivity analysis was also conducted. Sensitivity analysis is a risk measure which is used to compute the responsiveness of dependent variable to changes in independent variables under specific assumptions (Lilburne & Tarantola, 2009).

III. RESULTS AND DISCUSSION

3.1 Capital costs and irrigation efficiency

The differences in irrigation efficiencies for different systems means that more area can be put under irrigation for the same amount of water when systems with higher efficiencies are used. However, it should be noted that irrigation systems with higher water use efficiencies usually have higher development and operational costs (see Table 1). As such the choice of any one particular irrigation technology over another is a fine balance between the efficiencies that can be achieved as well as the cost.

Table 1. Irrigation water requirement, efficiencies, capital costs and O&M costs by irrigation system

Irrigation system	**Irrigation water requirements m^3/ha/year**	**Efficiency (%)**	**Capital costs USD/ha**	**O&M costs (USD/ha/year)**
Furrow	37 000	45	11736.36	125
Center pivot	29 000	90	16929.32	339

Source: FAO (2011), FAOSTAT (2010)

The Center pivot system has high capital costs as compared to the Furrow system. The cost of investment for theCenter pivot system per hectare was found to be higher(USD16929), by 30.7% than the cost of investing in theFurrow system (USD11736). Operation and maintenance (O&M) costs were found to be high for the Center pivot system. The higher initial capital costs plus O&M costs for the Center pivot system could act as a deterrent for farmers to adopt the system. However, the Center pivot system is superior to the Furrow system in terms of water use efficiency.

3.2 Variable costs by irrigation systems

Table 2 shows the distribution of variable costs per hectare for the Center pivot and Furrow irrigation systems at Green Fuel estates.

Table 2: Distribution of variable costs by irrigation system

	Irrigation system	
Variable costs per hectare	**Center pivot**	**Furrow**
Cost of water (USD)	346.59	449.27
Cost of energy (USD)	759.91	443.76
Other irrigation costs (USD)	339	123.5
Other costs (USD)	1850.34	1850.34
Total (USD)	3295.84	2866.90

Irrigation costs comprised of cost of raw water, electricity costs and other irrigation costs (repairs and maintenance costs). Other costs comprised of costs of fertilizers, labour, chemicals, fuel and oil, protective clothing as well as administrative costs. The distribution of variable costs shows that the Center pivot system has higher variable costs per hectare (US3295.84) compared to the Furrow system (USD2866.9). Figure 1 shows the composition of the Total Variable Costs (TVC).

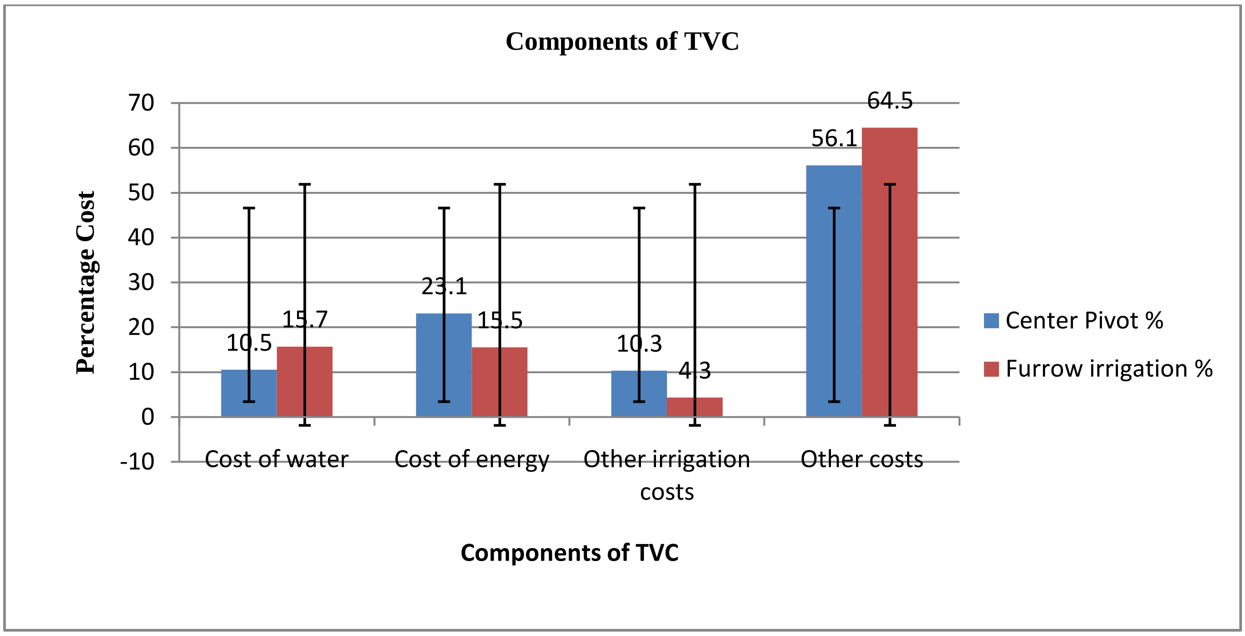

Figure 1. Composition of variable costs by irrigation system

Even though the Center pivot system has higher TVC per hectare, the cost of water component was found to be lower (10.5%) compared to that of the Furrow system (15.7%). Hence, the Center pivot system conserves water more than the Furrow system.

3.3 Gross margin analysis and CBA

The gross margin per hectare were calculated for the Center pivot and Furrow systems (Table 3). Gross incomes were obtained by multiplying the output of raw sugar (Polymetric content) by the market price of raw sugar per tonne.

Table 3: Gross margin by irrigation system

Variables	**Irrigation system**	
	Center pivot	**Furrow irrigation**
Yield (tonnes/ha)	120	100.7
Tonnes of Polymetric content (t/ha)	14.80	10.02
Price per tonne of Polymetric content (USD)	571.67	571.67
Gross Income (USD)	8460.72	5728.13
Total Variable Cost (USD)	3295.84	2866.90
Gross margin (USD/ha)	5164.15	2861.23

The findings in Table 3 show that the Center pivot system is associated with higher yields (120tonnes/ha) when compared to the Furrow system (100.7tonnes/ha). This could be explained by the ability of the Center pivot system to distribute water evenly and effectively to the plant's root zone. The gross margin per hectare was also found to be higher for the Center pivot system (USD5164.15) when compared to the Furrow system (USD2861.23). The Center pivot system was found to be financially more attractive in the short-run despite being associated with higher TVC than the Furrow system.

In order to ascertain the financial worthiness of the Center pivot and Furrow systems in the long-run, a CBA was conducted. Table 4 shows the CBA findings. The indicators of financial performance measured were the NPV, IRR and BCR.

Table 4: Measures of financial worth for Furrow and Center pivot systems at 15% interest rate

Performance measures	Irrigation system	
	Center pivot	**Furrow irrigation**
Net Present Value (USD)	36 472	24 414
Internal rate of return (%)	50	49
Benefit cost ratio (USD)	1.26	1.06

The Center pivot system was found to be financially more desirable in the long-run (with, NPV =USD36 472; IRR =50% and BCR =1.26) than the Furrow system (with, NPV=USD24 414; IRR=49% and BCR=1.06) for sugarcane production. This suggests that Green Fuel Estate should invest in the Center pivot system as its long-term financial benefits tend to outweigh associated costs at market prices. Furthermore, the Center pivot systemalso hasmore environmental benefits than the Furrow system.

In addition, a sensitivity analysis was carried out to evaluate the responsiveness of financial performance indicators to changes in the discount rate. The discount rate which was used in this study was 15% (levied by the AGRIBANK during the period of study). Changes in NPV, BCR and IRR were analysed for scenarios where the discount rate increased to 17% and 18% (the prevailing market interest rates charged by commercial banks CBZ and First Capitalbank respectively). Table 5, shows the study's findings.

Table 5: Measures of financial worth at commercial interest rates

Discount rate	Performance measures	Irrigation system	
		Center pivot	**Furrow irrigation**
CBZ rate (17%)	NPV	30993	20804
	IRR (%)	44.08	43.4
	BCR	1.2	1.02
First Capital bank rate (18%)	NPV	28615	19195
	IRR (%)	39.4	41
	BCR	1.17	0.99

The sensitivity analysis results indicate that both irrigation systems will remain viable if interest rates were to be increased from 15% to 17% or 18%, the rates which were being charged by commercial banks. The Center pivot system will remain more desirable (for example; at 18% discount rate, NPV=28615, IRR=39.4%, BCR=1.17) than the Furrow system (for example; at 18% discount rate, NPV=19195, IRR=41%, BCR=0.99). However, at 18% discount rate, the Furrow irrigation system becomes unattractive if we use BCR as an indicator of financial performance (BCR=0.99). At this discount rate the system's costs will be more than its benefits.

IV. CONCLUSION

Based on the findings, the study recommends that Green Fuel Estate should adopt the Center pivot irrigation system and do away with the Furrow system in the medium to long term. Despite having higher investment costs, the Center pivot system is more financially viable in the long run than the Furrow system. It is also important to note that apart from the financial benefits, the Center pivot is an environmentally friendly system, which conserves water, reduces siltation and saves labour. The Furrow irrigation system is more labour intensive, results in higher water losses and is associated with a higher degree of leaching of valuable nutrients. Thus,given the fine balance in terms of water, energy and labour savings associated with the Center pivot irrigation system,it is justifiable for Green Fuel Estateto convert from the Furrow system to theCenter pivot system for sugarcane production.

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