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Cost Benefit Analysis of Rice (Oryza Sativa, L.) And Maize (Zea Mays, L.) Production. A Comparison Study in Rwangingo Marshland, Nyagatare and Gatsibo Districts

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Abstract – The marshlands in Rwanda have been developed to increase production by contributing to the reduction of agricultural products imports. To analyze the cost benefit ratio between rice and maize production in Rwangingo Marshland aimed to see the crop that can give maximum returns through profitability analysis. The research was designed as analytical study which worked as comparison between CBR of rice and maize production. Stochastic production function was used to estimate the impact of drivers' cost of production to the production and CBR for profitability comparison analysis. Data were collected from 271 respondents and randomly selected using multistage sampling techniques. Stochastic production function results indicated that, rice production: capital and labor were statistically significant at 1%. Maize production: labor was statistically significant at 1% and positively affecting production, capital had inverse relationship to the production, the capital and labor (α+β) indicated the CRTS of 1. Profitability analysis was based on three measures of CBR, NPV. Rice and maize production gave CBR of 1.9 and 1.5, NPV of 1,103,684Rwf and 1,011,970Rwf and IRR of 7% for rice and maize respectively. The results recommended that, rice production should be the one to cultivate in this marshland because it indicated the maximum return, or both crops could be taken into consideration under the measures that could maximize the outputs.

Keywords – CRTS, CBR, NPV, IRR, Production, Profitability, rice, Maize.

I. INTRODUCTION

1.1 Background of the study

Rice and maize are beneficial as staple and income generating crops in Rwanda. The above 55% rice producers sell more than a half of their harvest (Leopold & Karl, 2018). During 2020, maize farmers' cooperatives of 128 in 24 districts were selected for maize cultivation and 62000 rice farmers combined in 60 rice farmers' cooperative, the production yield earned was 4.45 and 5.2 t/ha for maize and rice respectively. In 2011, over 200Mln US $ were gained from 525,679 T of maize (NISR, 2015).

Marshland under rice production was invested more cost to increase rice production (Leopold & Karl, 2018) . Above 12,400 ha of marchlands can make around 80000 MT/year (JICA, 2020). Rice requires more investment than other cereal crops in Rwanda and by focusing on the cost of production, rice is more expensive to produce and the market price has a significant effect on the gross revenue and net profit earned by the farmer (Kilimo.T, 2012). Also maize is the most dominant crop in Rwandan people because the high production of maize is used to measure food availability. Any shortages of maize in the country may increase high number of people that suffer from hanger due to the minimum level of dietary energy consumption. Rice and maize are supported by government and their seeds are locally produced through the intensive efforts of the Rwanda Agriculture Board

(RAB) which led to increase the quantity of high-quality seeds, there are also subsidies to promote the cultivation of rice and maize includes especially on seed, fertilizers, micro-nutrients (Mikhail , Glenn , & David , 2020).

Rwangingo marshland in Gatsibo and Nyagatare produce both rice and maize crops, where maize farmers were initially produce rice when this marshland prepared in 2017 but nowadays they no involve in rice production. The previous studies indicated positive relationship between production and the drivers' cost of production. This paper has two specific objectives: To estimate the return on each driving cost of production marshland and. To analyze the profitability based on cost benefit ratio of rice and maize production in Rwangingo marshland. The purpose of this research was to analyze cost benefit of the two crops to indicate the crop that gives high return on investment in Rwangingo marshland using CBR through the profitability comparison analysis between the production of rice and maize.

II. RESEARCH METHODOLOGY

2.1. Study area

Rwangingo marshland located in Gatsibo and Nyagatare districts in Eastern Province of Rwanda. Agriculture production and livestock are the principle economic activities in the two Districts (www.minaloc.gov.rw, n.d.) The marshland has more than 900 hectares across the districts of Nyagatare and Gatsibo and each district is benefiting from it. The marshland on Nyagatare side is located in sectors of Karangazi and Katabagemu. On the side of Gatsibo District, Rwangingo located in sectors of Ngarama, Gatsibo, Gitoki and Kabarore. The marshland was prepared in 2017. Initially, farmers were designed to grow rice, but farmers located on the side of Nyagatare decided to grow maize on 615 ha of land by Rice Growers' cooperative (seed multipliers) and the rest 245 ha was reserved to grow rice on the side of Gatsibo district by Ubumwe cooperative (Author's survey. 2023).

2.2. Research design of the study

This research was designed as an analytical study which worked as comparison between CBR of rice and maize production. It was comparing the driverrs of cost of production, cost of inputs and benefit from both rice and maize. Ubumwe cooperative which grow rice and Rwangingo rice growers' cooperative which grow maize intended to provide research information using data collection tool of structured questionnaire for both quantitative and qualitative data. After that, provided research answers were helped to compute CBR, NPV and IRR as it was used to compare the benefit between rice and maize production.

2.3. Sampling strategy, data collection and analysis

The sample size calculation, multi-stage sampling technique has been used in different six steps: first step used Raosoft sample size calculator gave rice growers 200/1054 respondents and maize growers 71/98 respondent with the marginal error of 5%, confidence interval of 95% and 80% of response distribution. Second step used cluster sampling technique, for rice growers 5/9 were selected using quincunx and maize growers due to few farmers 3/3 clusters selected. The third step used purposive sampling technique to find farmers who grow rice and maize. The fourth step used probability sampling technique to give every farmer the chance to be selected. The fifth step used random sampling technique by using sampling interval and give 5 and 1 for rice and maize farmers respectively. And the sixth step, the sampled farmers were stratified by quota to have both participations of male and female, female of 30.5 % and male of 59.5% rice growers were selected from sampled farmers in Ubumwe cooperative while female of 14% and male of 86% were chosen to represent maize Growers from Rice growers' cooperative. On the data collection methods; questionnaire responded individually with open-ended questions and closed-ended questions. Data analysis methods; this paper has two objectives. For the first objective, stochastic production function was used in order to examine the influence and significance of each driver's cost of production used to the marginal output as it aims to estimate the return of each. And for the second objective; cost benefit analysis template used to compute cost benefit ratio as the main measure of profitability analysis in this research as far as other measures of profitability were concerned (Net Present Value and Internal Rate of Return). For the second objective, also sensitivity analysis performed to see the sustainability of rice and maize production project.

2.4. Data analysis method

Table 1: data analysis methods

Objectives	Data analysis methods
Return of driving factors of production	Regression analysis using Stochastic production function by examining the contribution and significant impact of each input to the marginal output
Profitability analysis	Cost benefit ratio using Cost Benefit Analysis scheme

2.5. Econometric models

Stochastic production function

Estimation of the contribution and significant impact of each input to the marginal output. The Cobb–Douglas production function is a particular functional form of the production function, widely used to represent the technological relationship between the amounts of two or more inputs (particularly physical capital and labor) and the amount of output that produced by those inputs (Cobb & Douglas, 1928). $y = AL^{\beta}K^{\alpha}e^{vi}$. **Y**: total production (the real value of all yield produced), **L**: labor input (person-hours worked). And labor is an essential resource in production and is the most significant item in rice production (S, Inpong, & Krailert, 2012), **K** :capital input (a measure of all machinery, equipment, and buildings; the value of capital input divided by the price of capital), **A**:total factor productivity, **α** and β are the output elasticities of capital and labor, respectively. These values are constants determined by available technology.

e: error term. Before performing regression analysis exponential function transformed into linear by using natural logarithm as follow: $\boldsymbol{Ln\ Y_{\mathrm{i}} = B_0 + \alpha\ ln\ K_1 + \beta\ ln\ Labor_2 + V_{\mathrm{i}}}$**.** K which is capital used includes different variables which as the cost of drivers of production, and production is depending on them. The final formula to verify stated objective, Capital linearized into different variables and it became $\boldsymbol{Ln\ Y_{\mathrm{i}} = A_0 + \alpha\ ln\ Seeds_1 + \alpha\ ln\ Land_2 + \alpha\ ln\ Fertilizers_3 + \alpha\ ln\ Chemicals_4 + \alpha\ ln\ Irrigation_5 + \beta\ ln\ Labor_6 + \alpha\ ln_{\mathrm{n}} + V_{\mathrm{i}}}$**.**

Profitability analysis

Decision measures:

1. CBR

$$\pi(P) = \mathrm{TR} - \mathrm{TC},\ CBR = \frac{TR}{TC}, \text{ or } CBR = \frac{\sum_{t=0}^{n}\frac{(b)_t}{(1+r)^t}}{\sum_{t=0}^{n}\frac{(c)_t}{(1+r)^t}}$$

π: Profit, TR(b): Total revenue, TC(c): Total cost, CBR: Cost-Benefit Ratio

2. NPV, $NPV = \sum_{t=1}^{n}\frac{(b-c)_t}{(1+r)^t}$

NPV: Net Present Value, b: benefit, c: cost, r: discount rate, t: period of time

3. IRR: $\sum_{t=1}^{n}\frac{(b-c)_t}{(1+IRR)^t} = 0$ IRR: Internal Rate of Return, when IRR ›r, NPV›0

4. Sensitivity analysis: four scenarios proposed.

III. RESULTS AND DISCUSSIONS

To estimate the return on each driving cost of production for both rice and maize production in Rwangingo

Regression analysis requires transformed exponential function into linear function using natural logarithm. The presence of multicollinearity was tested using pairwise correlation and corrected by linear combination of similar independent variables. Regression analysis performed at the level pairwise correlation below to 40% of correlation among the independent variables with VIF below to 10 at each variable.

Rice production regression analysis (OLS)

Table 2: Production regression analysis of rice production using OLS

				Number of obs = 200
Source	SS	df	MS	F (6, 193) = 1276.02
Model	102.237494	6	17.0395823	Prob > F = 0.0000
Residual	2.5772687	193	0.013353724	R-squared = 0.9754
Total	104.814762	199	0.526707349	Adj R-squared = 0.9746
Ln_production_kg	**Coef.**	**t**	**P>|t|**	**[95% Conf. Interval]**
Ln_Fertilizer	0.0502182	2.00	0.046	0.0008022 0.0996342
Ln_Seed	1.428343	7.65	0.000	1.059972 1.796713
Ln_Land	-0.1943847	-1.08	0.280	-0.5482573 0.1594879
Ln_Labor	-2.055007	-8.86	0.000	-2.512459 -1.597555
Ln_Irrigation	0.2769025	9.93	0.000	0.2219064 0.3318986
Ln_Chemical	0.1478354	3.34	0.001	0.0605123 0.2351584
_cons	14.07786	10.75	0.000	11.49575 16.65997

Source: Author's survey 2023

The results from regression analysis indicated that 97% of the variation of rice production explained by the above inputs used. Seed, chemicals, irrigation and labor were statistically significant at 1% and positively affected rice production in the study area except labor which indicated negative influence to the rice production, it appears that the employed labors were more than necessary to be used and some of them are useless because may cause negative externality. Fertilizers used also indicated positive influence and it was statistically significant at 5% level of significant. Land showed an unexpected sign because if there is an increase of one unit of land can decrease 19% to the marginal output. This negative influence caused by: land did not provide the expected yield because there are high harvest losses, which means that the increment of land would be useless because it would lead the farmer to loss. Or the land has another reason especially as you move from cluster 9 to cluster 1, there is large land which is not used due to land is in high risk zone and it can be the reason why land it affecting production negatively. Another reason, the other required inputs used may be not efficiently to provide maximum production compared to cultivated land, this may also affect marginal output negatively. The theory of regression analysis supported by the determinants of rice production in Cyabayaga watershed and determinant of crop production in Rwanda (Bizoza & al., Determinants and Profitability of Rice production in Cyabayaga Watershed, Eastern Province, Rwanda, 2013), (Maniriho & Bizoza, 2018).

Due to the regression, analysis using OLS (Ordinary Least Square) method was suspecting to generate variables with the presence of endogeneity and the estimates were likely to be biased and inconsistent. The endogeneity issue verified using Durbin-Wu-Hausman, the results from test show that variables are exogenous. This indicates that the results from OLS estimate were not biased and can be reliable and other type of data can be used for further analysis in order to recommend sustainable measures. The

2SLS (Two Stage Least Square) method was performed as to see the relationship between rice production and capital used by taking land and labor as instrumental variables because those variables are powerfully interrelated to the capital with (Adjusted R-squared = 0.9770). The result from 2SLS accept a statistically significant and negative relationship between rice production and capital used (R-squared= 0.9924). Land and labor were the main factors of rice production in study area but they indicated differently as they are negatively affecting the production, it means that they used inefficiently and did not provide the expected outcome at maximum level. The results from 2SLS showed that, 87% of the variation of rice production explained by all explanatory variables in the model. On OLS results, fertilizers and land were not significant at 1% level but using 2SLS; all variables are statistically significant at 1% and have positive influence on rice production except capital used. This may be caused by rice farmer used more labors who were not well managed and the available land did not provide expected production or they both cost more than their efficient. The theory of 2SLS supported by the results from the determinants of rice production in Cyabayaga watershed (Bizoza & al., Determinants and Profitability of Rice production in Cyabayaga Watershed, Eastern Province, Rwanda, 2013).

Maize drivers' cost of production regression analysis (OLS)

Table 3: Regression analysis of maize drivers of production using OLS

Source	SS	df	MS	
Model	44.0223074	7	6.28890106	Number of obs = 71
Residual	0.256206756	63	0.004066774	F (7, 63) = 1546.41
Total	44.2785142	70	0.632550202	Prob > F = 0.0000
				R-squared = 0.9942
				Adj R-squared = 0.9936

Ln_production_kg	**Coef.**	**z**	**P>|z|**	**[95% Conf. Interval]**	
Ln_Seed_Kg	10.02468	2.08	0.041	0.4036289	19.64574
Ln_Land	-10.2469	-2.10	0.040	-19.98915	-0.5046528
Ln_Labor	0.6800916	2.95	0.004	0.2200319	1.140151
Ln_Fertilizer	-0.256229	-0.65	0.521	-0.1049091	0.0536634
Ln_Chemical	-0.0530662	-1.50	0.138	-01236049	0.0174725
Ln_Fuel_Cm^3	0.03228	1.05	0.300	-0.0294267	0.0939867
Ln_Irrigation_Cm^3	-0.0061682	-0.19	0.850	0.0708597	0.0585234
_cons	21.7572	2.29	0.025	2.788074	40.72632

Source: Author's survey, 2023

On maize production $\boldsymbol{Ln\ Y_{\mathrm{i}} = A_0 + \alpha\ ln\ Seeds_1 + \alpha\ ln\ Land_2 + \alpha\ ln\ Fertilizers_3 + \alpha\ ln\ Chemicals_4 + \alpha\ ln\ Fuel_5 + \alpha\ ln\ Irrigation_6 + \beta\ ln\ Labor_7 + V_{\mathrm{i}}}$. Regression analysis indicated that 99% of the variation of the maize production in the study area explained by the above inputs specified in the model. Among the variables, which is significant at 5% level of significant, the increment of unit of seed, and labor can increase 1002% and 68% to the marginal output when other factors remain the same. This highly positive impact to the maize production can be resulted from different factors, but reference made during data collection where a researcher found farmers to be seed multipliers not final seed producers. Seed variety may affect the quantity of production as far as pre and post-harvesting losses are concern. That reasons may be one of the cause why seeds have very highly impact and the increment of seed is affecting maize production positively, and farmers used less seeds that what were they supposed to use, they used seed inefficiently ceteris paribus. The reason why labor also has high positive impact, in this cooperative due to farmers have large land and it is difficult to labor to cover all farming activity during the starting of season, cooperative decided to use digging machine. The tractors replaced many labors in few time that why in case there is no tractor available, the increment of labor should give positive impact to the production of maize in Rwangingo marshland. The increase of labor at a certain proportion should have positive impact. Even though land is significant at 5% level of significance, it has great negative impact on the production of maize. Land did not provide the expected yield because there are high harvest losses, which means that the increment of land would be useless because it would lead the farmer to loss. Another reason why the increase of unit of land should decrease maize production at 1024% and this is high extremely negative impact is that the other required inputs were not been used efficiently to provide maximum production compared to cultivated land. Fertilizers, chemical and water are not significant and the increment of one unit of each variable is affecting production negatively, this is because they used inefficiently or they used unappropriated quality. When other factors remain constant, fuel influences positively to the maize production and the increase of one unit of fuel can increase 3% to the marginal output, but the influence is not statistically significant in the study area and 95 confidence interval. The detailed inputs used last season for maize production: seed, land, and labor, chemical that composed: pesticide and insecticide, fuel that consumed (Profex-supa) is used, water from dam used in irrigation and different fertilizers (NPK, DAP, Urea and Manure) which had added together for the sec of multicollinearity detection among independent variables, which show kind of, similarity. Due to the presence of endogeneity, the estimated results were biased and not reliable, 2SLS applied to see the relationship between maize productions and other variable, land and labor were instrumental variable used because they were strongly influence the capital. The results from 2SLS removed the presence of endogeneity as the p-value was less than 0.05 value. The results from regression analysis of rice and maize production using OLS, 2SLS the results conclude that labor and land as the factor of production influence highly the production negatively or positively on both rice and maize in the study area.

Table 4: Shows the results' summary obtained using regression analysis

Crops			Expected sign	coefficients		P-Vale		Significance		Influence to production	
				Rice	Maize	Rice	Maize	Rice	Maize	Rice	Maize
variables	Capital	Seed	+	1.428343	10.02468	0.000	0.041	***	**	Positive	Positive
		Land	+	-0.1943847	-10.2469	0.280	0.040		**	Negative	Negative
		fertilizers	+	0.0502182	-0.0256229	0.046	0.521	**		Positive	Negative
		chemicals	+	0.1478354	-0.0530662	0.001	0.138	***		Positive	Positive
		Fuel	-	-	0.03228	-	0.300	-		-	Positive
		Irrigation	+	0.2769025	-0.0061682	0.000	0.850	***		Positive	Negative
	Labor		+	-2.055007	0.6800916	0.000	0.004	***	***	Negative	Positive
	Constant			14.07786	21.7572	0.000	0.025				
R-Square				0.9754	0.9942						
2SLS: Tests of endogeneity H0: Variables are exogenous and Durbin (score) chi^2 (1) (p=0.0000), Wu-Hausman F(p=0.0000)				Prob > chi2 = 0.0000	Prob > chi2 = 0.0000						

Note that ***, ** significant at 1% and 5% respectively

Source: Author's survey, 2023

As stated above, 2SLS performed due to the regression analysis using OLS (Ordinary Least Square) method was suspecting to generate variables with the presence of endogeneity and the estimates were likely to be biased and inconsistent. The endogeneity issue verified using Durbin-Wu-Hausman, the results from test show that variables are exogenous. Regression analysis of rice production found the blue estimate using OLS unlike to regression analysis of maize production found to rely on 2SLS estimates.

Profitability analysis: To analyze the profitability based on cost benefit ratio of rice and maize production in Rwangingo

Table 5: The results obtained from CBA Scheme Rice-Maize production Profitability analysis

Variables	*Rice production*	*Maize production*
Infrastructure (ha)	-	-
Investment (Costs)		
Total average land (in Ha)	*0.384*	*7.507*
Total cost for investment (value in RWF)	*477,425*	*16,333,769*

Table 6: CBA Scheme Rice-Maize production Profitability analysis (continues)

Seasonal revenue (RWF)	**906,749**	**24,938,118**
Seed (Kg)/*0.384ha rice and /7.507ha maize*	29.29	187.676
Seed(Frw)	23,432	900,845
Quantity of inorganic and organic fertilizers		
NPK (Kg per ha)	77.68	25.35
DAP (Kg per ha)	-	1,416.197
UREA (Kg per ha)	38.84	741.549
Pesticides (liter per ha)	0.406	21.253
Manure (Kg per ha)	22.5	55,000
DI Grow (Kg per ha)	0.218	-
Bimax 75WP (Kg per ha)	0.294	-
Lime (Kg per ha)	53.175	-
Cost of inorganic and organic fertilizers		
NPK (Frw per ha)	64,319.04	20,991.549
DAP (Frw per ha)	-	1,172,611.268
UREA (Frw per ha)	29,285.36	559,128.169
Pesticides (Frw per ha)	4,045	254,440.845
Manure (Frw per ha)	270	770,000
DI Grow (Kg per ha)	1,859.375	-
Bimax 75WP	4,112.5	-
Lime/Kg	6,912.75	-
Total Seed Value in Rwf	134,236.03	3,678,017
Additional costs		
Labor (Man-days)	194	4,092
Labor (Frw)	1,000	1,000
Equipment		
Tractors (digging machine)(unit per ha)	-	7
Tractors equipment(Frw per ha)	-	583,662
Water engine(spraying machine)(unit per ha)	-	1
Water engine (Frw/machine)	-	338028

Water engine (fuel consumed)/L	-	2627.465
Fuel cost/Frw	-	4203944
Hoe(unit)	3	40
Hoe(Frw)/unit	2000	2000
Pumps (units per ha)	1	2
sheeting (units per ha)	2	35
Sacks (units per ha)	20	320
Pumps Frw per ha	20000	20000
sheeting Frw per ha	20000	20000
Sacks Frw per ha	500	500
Water cost (Frw)	7,112	124,691
Renting cost (Frw)	99,590	2,627,465

Table 7: CBA Scheme Rice-Maize production Profitability analysis (continues)

Utilities (Electricity)	-	-
Bird control cost	38,440	-
Inputs transport cost	5,148	47,415
Salaries	6,000	-
Credit		
Bank	245,221	2,959,770
Interest rate	1.8	1.8
Total interest	4,414	53,276
Maintenance cost (Frw)		
Maintenance costs for secondary pipes	-	-
Maintenance costs for reservoirs and main distribution channels	71,000	71,000
Total Costs for maintenance (ha/ Km)	27,292	532,997
Total Seasonal Operating Costs	*477,425*	*16,333,769*
Total Additional Cost	12,500	230,303
Seasonal depreciation		
Tractor	-	6,167
water engine	-	33,803
Hoe	1,500	13,333
Pump	1,000	2,000
Sheeting	10,000	175,000
Seasonal yield/kg	1,778	31,173
Seasonal price(Frw)	510	800
Gross Margin (per ha)	*906,749*	*24,938,118*
Benefit-Cost Ratio (BCR)	**1.9**	**1.5**

Source: Author's survey, 2023

The determination of rice production CBR (computed using CBA scheme) involved the average data of 200 participants in the study area. The above table 2 shows all the details for the requirements related to what rice farmer used on the average of 0.384 ha of land. The results from investment (477,425 Frw of total cost) found, after farmer harvested shows that on the stated ha, farmer got 1,778 kg of production which present 4630.2 kg/ha of yield. At the price of 510 Frw/kg, farmer earn 906,749 Frw of total revenue. CBR computed from the ratio between gross margin to the total seasonal operational cost, and CBR found to be 1.9 which indicate that rice production in study area give efficient result to the farmer and benefit exceed cost. The empty filled space on infrastructure, it is not that the infrastructures do not exist but it was difficult to count it because the government set them up and gave to the farmers freely. Other unfilled costs, are due to at Ubumwe cooperative did not use the items last season, that is why they could not exist in farmer's operating cost, CBR computed using $CBR = \frac{TR}{TC}$ and $CBR = \frac{\sum_{t=0}^{n} \frac{(b)_t}{(1+r)^t}}{\sum_{t=0}^{n} \frac{(c)_t}{(1+r)^t}}$ formula. The supported theory on this analysis was given on (Cobb & Douglas, 1928), (Graaff & Bizoza, 2010), (S, Inpong, & Krailert, 2012) (Bizoza & al., Determinants and Profitability of Rice production in Cyabayaga Watershed, Eastern Province, Rwanda, 2013), (Ruvuna & Tubanambazi, 2021) , and (Manirere & al., 2022). Based on the data from table 2. Maize production CBR determined by the average data of 71 participants in the study area. The above table shows all the details for the requirements related to what maize farmer used on the average of 7.705 ha of land. The results from investment (16,333,769 Frw of total cost) found, after farmer harvested shows that on the stated ha, farmer got 31,173 kg of production which present 4045.8 kg/ha of yield. At the price of 800 Frw/kg, farmer earns 24,938,118 Frw of total revenue. CBR computed from the ratio between gross margin to the total seasonal operational cost, and CBR found to be 1.5 which indicate that maize production in study area give efficient result to the farmer and benefit exceed cost. The empty filled space on infrastructure is the same as what happened on Ubumwe cooperative, Other unfilled costs, are due to at Rice growers' cooperative did not use the items last season, that is why they could not exist in farmer's operating cost. The supported theory on this analysis was given on (Cobb & Douglas, 1928), (Graaff & Bizoza, 2010), (S, Inpong, & Krailert, 2012) (Bizoza & al., Determinants and Profitability of Rice production in Cyabayaga Watershed, Eastern Province, Rwanda, 2013), (Ruvuna & Tubanambazi, 2021) , and (Manirere & al., 2022) .

Decision measures on profitability analysis

As CBR the main criterion measure that show the crop that give the high profit between rice and maize production in Rwangingo marshland, but it is not the only measure that can take the last decision on which crop to be prioritized in the study area. NPV (Net Present Value) as the linkage of the overall benefits and overall costs in a certain period and discount, NPV takes into consideration the future cost and benefit in the present value by translation of the discount rate that must indicate the opportunity cost of capital invested. Moreover, IRR (Internal Rate of Return) is an alternative decision measure that can show the crop which is profitable than other between rice and maize production in the study area. By applying the below formula, the below results computed. $NPV = \sum_{t=1}^{n} \frac{(b-c)_t}{(1+r)^t}$ NPV>0, and $\sum_{t=1}^{n} \frac{(b-c)_t}{(1+IRR)^t} = \text{NPV} = 0$, then the $IRR = \sqrt[t]{\sum_{t=1}^{n} \frac{(b-c)_t}{\text{NPV}}} - 1$. Where b: revenue at time t for rice or maize production, c: the cost needed to make production at time t, n: number of period (years). n= 1 year, r: discount rate of 7% equivalent from BNR. The data used were from ha on both rice and maize production, the revenue of 2,393,878 Rwf and 3,291,303 Rwf with their related cost of 1,210,742 Rwf and 2,206,484 Rwf for rice and maize production respectively. Using the above formula NPV became 843,559.6 Rwf and 773,461Rwf with the same IRR of 7% for rice and maize production respectively. The results indicated that both rice and maize production investment in Rwangingo marshland would not generate profit to farmers as the agricultural projects within one year. This is because both projects will return less than their discount rate due to negative NPV and the investment is not worthwhile if nothing changes to minimize operational cost. One measure of minimizing or maximizing the cost of capital where necessary by maximizing the profit at the maximum level should be taken, ceteris paribus (risk-free, inflation, financial risk). The financial cost benefit analysis of agriculture production in Musanze and Financial Cost–Benefit Analysis of Bench Terraces in Rwanda support the theory of decision measures on profitability analysis (Graaff & Bizoza, 2010) (Bizoza & al., 2013).

Sensitivity analysis of rice and maize production

Profitability analysis of Rice and maize production in Rwangingo marshland showed that they are profitable agriculture crop production in the study area that farmers can invested-in. In addition, every project must be studied in sustainable way, that why sensitivity analysis was accompanied. Reference made to the previous 5 years when the two cooperatives started. On rice production: the cost of inputs changed each season, since the use of labor, land, production and price found to be the main determinant of profitability analysis and they are available on a certain cost. Once two multiplies the cost of labor as it appeared like previous 5 years, CBR would become 1.4 if in the next 5 years the cost of labor would multiplied at the same rate. Some farmers use the land as their main resources and pay some rate of tax on the profit, but if the one who rent land at the cost mentioned were treated at the same of owing the land CBR become 2.1. CBA. On maize production: the main determinant of profitability is seed, labor, and land, manure, and DAP (Di ammonium Phosphate), production and price. There is no need of undertaking the opportunity cost of the mentioned determinant once they all paid, but farmers should look how to make they own manure because it costly. In the case the cost of labor is multiplied by two, the CBR become 1.2, and once land is rented at lower of CBR will increase at a certain rate of the reduction cost of land, if farmers could be able to produce their own manure, CBR will increase by 0.2 ceteris paribus. On side of post-harvest losses, farmers handled it by their own management as an arrangement. Nevertheless, once CBA consequently started with opportunity costs for post-harvest losses management (10% of capital) would be the best alternative to farmers because they were not aware of the practice they do to fight again losses due to it ended up there is high loss. There is another alternatives scenario on sensitivity analysis as follow:

Firstly, assuming a 15% increase in each operating cost on both rice and maize production, the profitability of the two crops is questionable. The question is, how about the ability of farmers to meet the cost of production and continue profiting from rice and maize production. Under such scenario the results of CBR become 1.28 and 1.26 with the NPV of 451,662 Rwf and 386,750 Rwf, IRR of 5%, and the increment of 15% on each cost of input will result the cost of producing to increase 47% and 20% while the returns remains constant for rice and maize respectively, ceteris paribus. The IRR indicated value which is lower than the equivalent discount rate from BNR, and this results show that rice and maize production in the study area is sensitive to the increase of operational cost, in that case some measures could be taken otherwise the investment could end up in completed losses due to NPV indicated negative relationship.

Secondly, assuming there is a decrease in price of produce by 15%, the sensitivity analysis shows that the average 15% of gross margins diminished, CBRs come to 1.6 and 1.3, and NPVs come to 567,811.9 Rwf and 440,055 Rwf with the IRR of 6% and 5% on both rice and maize respectively. This shows that, as the change happen at the high rate of above to 15% farmers would not provide the profit from production in the study area, when other factors remain the same as indicated by the negative NPV given by the decrease in price.

Thirdly, in case there is a decrease in total production at the same rate of 15%, the revenue decrease on the same rate, CBRs of 1.6 and 1.2, NPVs come to 567,811.9 Rwf and 440,055 Rwf and the IRR of 6% and 5%. If price and production decrease at the same rate of 15%, the result be the same (CBR and IRR), they appear the change at the same rate to, on both rice and maize respectively.

Lastly, suppose that farmers are told to buy the input fertilizers without the support from government (subsidy), according to Rwandan ministerial order in 2022 season B, the government support on NPK: 40%, Urea: 40% and DAP: 42%, farmers paid (828, 764, and 828) Rwf for the mentioned fertilizers respectively. In this scenario, the cost of fertilizers will 100% paid as follow (NPK: 1373, Urea: 1276, and DAP: 1431). The results from sensitivity analysis show, CBRs comes to 1.7 and 1.4, NPVs of 704,101.67Rwf and 747,451.44Rwf, IRR of 7% would be indicated in case the subsidization on inorganic fertilizers removed, ceteris paribus.

According to the all fourth scenarios from sensitivity analysis, the results from them shows the CBRs>1 and NPVs negative, which indicate the negative return from production of rice and maize in coming five years. Moreover, if all scenarios happen at the same time, it appears that farmers could not handle the situations due to IRRs will be less than the equivalent discount rate of 7%. Nevertheless, manure on the profitability of rice and maize production are mostly sensitive to the increase of input costs (labor, land, fertilizers and DAP), the decrease of the production price, the decrease of production quantity and the removal of the subsidy on the inorganic fertilizers. As conclusion on this part of sensitivity analysis, CBR is good measure of profitability but could not be the only measure to rely on when the project is sustainable or looking for profitable project as professional farmer. The theory supported by the determinant and profitability of rice production in Cyabayaga watershed (Bizoza & al., Determinants and Profitability of Rice production in Cyabayaga Watershed, Eastern Province, Rwanda, 2013).

Hypothesis verification

1. First hypothesis (H_{01}): The return of each driver cost of production was the same between rice and maize production in Rwangingo marshland. In addition, the results showed the return of each driver cost of production was not the same between rice and maize production in Rwangingo marshland as the p-value of each variable is differ from each other.
2. Second hypothesis (H_{02}): Rice and maize production in Rwangingo marshland had not equal cost benefit ratio. Moreover, the results from CBA gave CBR of rice production of 1.9 and maize production of 1.5, the results of CBR shows that rice and maize have not equal CBR.

Decision: on the first hypothesis decided to reject null hypothesis (H_0) as it failed to verify the situation of showing how each driver's cost of production give the same return between rice and maize production in Rwangingo marshland as shown by their p-values and decision failed to reject alternative hypothesis (H_1) because it verified the stated situation. On the second hypothesis testing, the study failed to reject the null hypothesis (H_0) because it verified the situation of showing how rice and maize production in Rwangingo marshland have not equal CBR and alternative hypothesis (H_1) rejected due to failing to verify the situation.

IV. CONCLUSION AND RECOMMENDATIONS

Conclusion

Rice and maize are beneficial as staple and income generating crops in Rwanda. It expected that maize production in Rwangingo marshland could give higher profit than rice production. As indicated by CBRs show that benefits exceed costs in study area and the results indicate that both rice and maize production are profitable project in current situation. Total revenues cover 90% and 50% of profit for both rice and maize production respectively. The study of CBA of Rice & Maize Production in Rwangingo marshland aimed to see the crop that can give maximum returns through profitability analysis. Based on obtained CBR as it indicated both rice and maize are profitable crops in the study area on the current situation. Even though maize production expected to give higher profit than rice production on last season in Rwangingo marshland but unfortunately, the drivers of cost of production should not give the same returns and CBR conclude that rice production is more profitable than maize production in the study area when other factors remain constant. However, NPV and IRR indicated that there will no profit in coming 5 years, as current investment is greater than the future investment.

Recommendations

Rwanda Government, Farmers, other partners: Should manage to reconstruct the marshland properly as marshland rearranges into clusters, there is big land locates in very high risk zone from descending, as clusters numbered and the yield become too low due to the marshland was constructed improperly in the way water channels do not serve water at the same level. In addition, there is large areas of exposed soil that easily eroded by erosion. Also by helping the farmers to get machine in charge of bird control and threshing machine in order to minimize pre-harvest losses rather than farmers running to the birds and multiplying the drying station for minimizing post-harvest losses. For the next research, firstly: Soil scientist researchers must carry out the study that shows the soil texture contents in this swamp and which fitted variety that needs low water available and give to the farmers the maximum production. Also, looking if to construct new additional water catchment to re-catch the flow unused water for the next re-use can solve the problem of insufficient water to rice and maize production.

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CONFLICT OF INTEREST:

The author of this article declares no conflict of interest related to this publication manuscript.

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