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Determinants and Profitability of Rice production in Cyabayaga Watershed, Eastern Province, Rwanda

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Abstract

The aim of this study was to analyze the determinants of rice production and its financial profitability in the watershed of Cyabayaga, Eastern Province of Rwanda. The study was composed of a stratified sample of 46 rice growers and members of CODERVAM cooperative operating in the same watershed. The Cobb-Douglas production function was adapted and estimated to indicate individual effects of labor, land, and capital on rice production. In addition, a Cost-Benefit Analysis (CBA) approach was opted to compute the financial profitability of rice growing in the study area. Results from the analysis substantiate that cultivated area (land) and labour had significant (5% significance level) contribution to rice yield. However, capital investment in form of inputs (seeds and fertilizers) was not statistically significant even at 15 % significance level, indicating lower contribution to production of rice in the study area, all else equal. Some farmers reported insufficient income to invest in rice production thus making the overall contribution of the investment factor insignificant for this case study. Findings from the Cost Benefit Analysis (CBA) indicated that only one category of farmers, among the three sampled, had positive Net Present Value (NPV). The implication for negative NPVs is that rice growers do not invest appropriately, leading to lower returns. The two analytical approaches led to a similar conclusion that the capital factor represented by investments in seeds and fertilizers does not explain significantly the rice production observed in the Cyabayaga Watershed. It is recommended to support these farmers to have access to inputs and agricultural trainings. These constitute the major area of their investments and constraints for improved and well sustained rice production in the study area.

Key words: *Financial profitability, Rice production, Cyabayaga Watershed, Rwanda*

1. Introduction

Agricultural sector is the backbone of economic development in Rwanda. The sector's share to Gross Domestic Product (GDP) is estimated at 31% and about 82% of the total population depend on this sector for subsistence (NISR, 2012). However, different constraints underpin agricultural development such as limited arable land, poor soil fertility due to land degradation and soil erosion, and use of traditional agricultural techniques (MINAGRI, 2004). Consequently, low agricultural production leads often to importation of additional food for subsistence to complement local production. In addition, the government has opted for intensified agriculture to increase per capita income of farmers in rural areas by promoting certain crops including rice, maize, sorghum, potatoes, and beans (MINAGRI, 2002). Among reasons to promoting rice is that it allows better use of existing additional land in the marshlands and reduce pressure on land located in the hillside. Rice productivity is assumed to be greater in marshland (about 7 tones/ hectare/season) compared to other crops (MINAGRI, 2002; Maganya, 2005). This is likely to stimulate its further consideration by farmers due to increased production and income, not only by the farmers but also to other actors involved in rice production and commercialization (Lagrange,1995). These reasons, among others, make rice easily acceptable by farmers as part of priority food and cash crops.

National needs for rice consumption are not yet met. Estimates from MINAGRI (2004), show that 35000 tones of rice needed to be produced to meet the desired consumption level of Rwandans in 2002 for an area of 4000 hectares. The Rwanda government, in its strategic plan was to transform rice not only as a cash crop but also as a subsistence crop by 2010. Efforts towards this strategic goal are still underway and hence the support to this policy is critical. Institutional arrangements already made can be improved and sustained to materialize the above target. In Watershed of Cyabayaga, Eastern Province, rice occupy the third position compared to maize and beans (ISAR, 2006) and it is the first crop generating income to farmers. This motivated the need for further analysis to examine the profitability of the crop to farmers compared to the extent of investment in its production. Therefore, this paper presents an analysis of determinant factors of rice production and its financial profitability in the watershed of Cyabayaga in the Eastern Province of Rwanda.

2. Materials and Methods

2.1 Study area

The watershed of Cyabayaga is located in the agro ecological zone of the '*Savanes de l' EST*' with 1400 m above the sea level. This watershed comprises of four administrative sectors namely Rukomo, Mimuli, Mukama, and Nyagatare.. The watershed is located near the Muvumba River from which it receives water for its marshland. Three types of soils characterize the watershed: alluvial soils (sols alluvionnaires), vertisols, and carbonates. Normally both vertisols and alluvial soils are appropriate for rice cropping. However, the appropriateness of alluvial soils depends on the texture. Alluvial soils with heavy texture can be used for rice cropping.. With respect to carbonates, their use for rice cropping depends to the extent by which the level of pH can be controlled (Mambani *et al*.1990).

The study was based on the area of 656 hectares covered by the rice plantation (Ntindendereza, 2006). The choice of this watershed was purposely selected among other existing watersheds where rice is potentially cultivated. Data were collected from a stratified sample of 46 rice growers who are at the same time members of CODERVAM cooperative operating in the same watershed in 2007. Three strata were categorized with reference to a joint ranking between the researcher and the cooperative which in turn was based mainly on farm size –this was appropriate compared to other possible criteria such as income level and levels of participation of respondents in various activities of the cooperative. This sample is assumed to be sufficient to providing information related to this study (Usinier *et al*., 1993). Data collection tools include a structured questionnaire and an interview guide. Information from other key informants was useful to shed light on some aspects that needed clarification. The total sample size was composed of 46 rice growers and selected randomly from all members of CODERVAM cooperative. From each stratum, 10 percent of respondents were selected and these provided information on respective quantities of rice produced and relative operating costs in terms of capital, land, and labour used for one agricultural season (2007B). For the measurement of these factors, apart from land, capital and labour were estimated in terms of their related costs in Rwandan currency. Capital factor was viewed as total costs related to seeds and fertilizers. Labour was measured as total man days. Finally, land was measured as farm size owned by farmer respondent in the marshland. The quantity produced was measured in terms of total kilogram.

3. Results and Discussion

Table (3.1) describes the central tendency of factors considered for the analysis per category of farmer respondents. Three categories form the total sample and include the following: first category: farmers with farm size of 60 are and above (10), Secon category: farmers with farm size of between 30 and 60 are (22), and third Category: farmers with farm size less or equal to 30 are (14). Standard deviations are likely to be relatively high suggesting variability of the variables considered between and within farmer categories. On average farmers produce 3.5 tones of rice in the study area compared to 7 tones per hectare envisaged (MINAGRI, 2002). The first category has got greater averages for all variables compared to the other two categories indicating that the former category is likely to gain more profit than the rest (Murekezi, 2003).

Table 1 : Descriptive statistics of model variables

Category	**land area (are)**		**Capital (Costs of Seeds and Fertilizers in FRW)**		**Labour (Human Days)**		**Production (Kg)**	
	Mean	St. Dev	Mean	St. Dev	Mean	St. Dev	Mean	St. Dev
1 (n=10)	96	50.60	227,825	7,7274.85	236,997	112,694.4	3656	1607.94
2 (n=22)	40.45	6.70	92973.35	12353.85	79548.6	19158	1314.09	660.13
3 (n=14)	23.57	3.50	50468.52	7290.77	74384.2	333351.44	780.00	364.77
Total sample (n=46)	47.39	35.52	109352.7	74898.5	112109	86406.49	1660.65	1394.15

Notes: 1 are= 0.01 hectare

To verify if the above mean differences between categories are statistically significant, a multiple comparison was done by considering only the Least Square Difference criteria at 5 percent level of significance. Table 2 shows that most of mean differences are statistically significant. This would imply that the three categories invest differently in operating costs and hence their production levels are also different. Farmers with moreland are assumed to produce averagely more than those with less or equal than 60 ares ; all else equal. Farmers in category one are likely to have better returns compared to those in categories two and three. These results were verified through the Cost-Benefit Analysis of rice enterprise in the study area.

Table 2 : Multiple comparison of mean differences between farmer categories

Dependent Variable	(I) Category	(J) Category	Mean Difference (I-J)	Std. Deviation	Sig.
Capital (Fertilizers and Seeds)	1	2	134851.64745(*)	13963.240210	.000
		3	177356.47557(*)	15158.776979	.000
	2	1	-134851.64745(*)	13963.240210	.000
		3	42504.82812(*)	12516.948133	.001
	3	1	-177356.47557(*)	15158.776979	.000
		2	-42504.82812(*)	12516.948133	.001
Production (KG)	1	2	2341.9091(*)	339.88020	.000
		3	2876.0000(*)	368.98085	.000
	2	1	-2341.9091(*)	339.88020	.000
		3	534.0909	304.67591	.087
	3	1	-2876.0000(*)	368.98085	.000
		2	-534.0909	304.67591	.087
Land (Are)	1	2	55.5455(*)	9.03737	.000
		3	72.4286(*)	9.81115	.000
	2	1	-55.5455(*)	9.03737	.000
		3	16.8831(*)	8.10129	.043
	3	1	-72.4286(*)	9.81115	.000
		2	-16.8831(*)	8.10129	.043
Labour (Man days measured in FRW)	1	2	157648.3636(*)	21485.47637	.000
		3	162612.7143(*)	23325.06923	.000
	2	1	-157648.3636(*)	21485.47637	.000
		3	4964.3506	19260.04203	.798
	3	1	-162612.7143(*)	23325.06923	.000
		2	-4964.3506	19260.04203	.798

* The mean difference is significant at the 0.05 level. FRW.

Financial profitability of Rice production

Financial profitability was performed by applying the Cost -Benefit Analysis (CBA) approach. To compute the net benefit, a comparison of costs and benefits was done at farmer level (de Graaff, 1996, Bizoza and de Graaff, 2010). This is supported by different decision criteria including the Net Present Value (Kuyvenhoven & Menes, 1982) which has been used for this study. The discussion of this approach and its related concepts are well documented (Kuyvenhoven & Menes, 1982, de Graaff, 1996,

Gittinger, 1982, Posthumus & de Graaff, 2005). The discount rate considered for this study was 13 percent equivalent to the market interest rate (applied by the Banque Populaire during the study period). Given that the period of production considered was 7 months (season 2007B); the rate used to compute the Net Present Value (NPV) was 1.08 percent per month. The identification of benefits and costs was done based on costs that are easily quantified in monetary terms by farmers (Pusthumus, 2005). The price of reference wass 140 Rwandan Francs (the price paid by the cooperative before milling). For the Cost Benefit Analysis (CBA), we follow Kuyvenhoven & Menes (1982). A positive NPV implies positive returns and hence profitable rice production and unprofitable when otherwise. The super and subscripts represent respectively future and current time while r stands for the discount rate for time (t).

$$NPV = \sum_{t=1}^{n} \frac{(b-c)_t}{(1+r)^t}; \qquad NPV > 0 \qquad \text{[equ.1]}$$

Table (3) summarizes CBA calculations and respective Net Present Values for the three categories of farmers. Investments in this analysis are viewed as the costs of renting the land area used for production. Land owned by farmers was also valued with reference to those rented. Operating costs include labour, seeds, fertilizers, and other related costs. Results (Table 3) showed that category one (made by farmers with 60 are or above) was the only one that has got a positive NPV (20172.35 Rwf). Other categories had negative NPVs (category two - 940.942 Rwf and three, - 20 792.626 Rwf). Based on the Net Present Value criteria, the implication for negative NPVs for category two and three is lower returns compared to their respective investments. Among reasons for these negative NPVs include lack of sufficient income to invest in operating inputs especially improved seed variety and fertilizers. Secondly, this can be explained by the scale of production which is relatively small compared to farmers of category one. In addition, although it is difficult to increase the farm size, efficient use of existing land through improved skills and access to enough inputs by farmers; is likely to increase the current level of returns. This interpretation is consistent with descriptive statistics of variables considered when comparing farmers of category two and three to those of category one.

Table 3. CBA using farmers' estimations (labour, inputs, yields)_ Season 2007B

Farmer category	Period _2006-2007	Investments (Frw)	Operating Costs	Income	Discount Rate (1.08 %)	Present Values			Net Present Value
						Investment	Operating Costs	Income	
Category 1	December	122 500							20172.35
	January		15033.54		0.99		14883.20		
	February		225231.67		0.98		220727.03		
	March		41918.83		0.97		40661.26		
	April		26884.34		0.96		25808.96		
	May		3184.64		0.95		3025.41		
	June		26884.34		0.94		25271.28		
	July		3184.64	511 840	0.93		2961.71	476011.2	
Totals		122 500	342 322	511 840	-	122 500	333,338.85	476011.2	
Category 2	December	50 568.182							- 940.942
	January		5068.55		0.99		5017.86		
	February		86173.10		0.98		84449.64		
	March		13310.68		0.97		12911.36		
	April		947.48		0.96		909.58		
	May		9189.62		0.95		8730.14		
	June		947.48		0.94		890.63		
	July		9189.62	183 960	0.93		8546.35	171082.8	
Totals		50 568.182	124826.55	183 960	-	50568.182	121455.56	171082.8	
Category 3	December	29 464.286							- 20792.626
	January		4493.91		0.99		4448.97		
	February		60985.12		0.98		59767.19		
	March		11932.64		0.97		11574.66		
	April		775		0.96		744		
	May		8213.43		0.95		7802.76		
	June		775		0.94		744		
	July		8213.43	109200	0.93		7802.76	101556	
Totals		29 464.286	95.388,53	109200		29 464.286		101556	

Estimating the Rice Production function in Cyabayaga Watershed

An empirical analysis of the relationship between rice production and production factors is the focus for this section .The hypothesis that rice production in the watershed of Cyabayaga requires more investments in improved varieties and fertilizers by farmers for them to have better and positive return was tested. The assumption was that the profit gained by rice growers as results of their production depend mostly on labour and area cultivated and less to investments made in terms of fertilizers and seeds. To verify this assumption, a Cobb-Douglas function (Gujarati, 2003) was adapted to estimate the relationship between rice production and operating costs of traditional factors that are likely to have a direct impact: seeds and fertilizers, labour, and land. Personal characteristics such as education level (formal and informal) and gender were not considered due to their indirect impact. These factors are important and affect farmer's performance in the form of efficiency and allocative effects (Vegard, 2003; Due & Gladuin, 1991; Admassie & Asfaw, 2004; Huffman, 2001). However, given that farmer respondents operates and produce through farmer cooperative; this leads to strong assumption of little variability in education (mostly informal) as chances of access to information are somewhat equal and gender effects are more less the same among sample respondents. This explains partly why these two characteristics were not considered for the model specification although they are theoretically assumed to affect farmer's production (Bizoza *et al*, 2007; Musemwa and Mushunje, 2012). Information obtained during the survey on estimates of costs of the above factors and production levels of farmers was based mainly on respondents' recall as they did not keep records. The first equation used for estimatation is presented as below. (presented below vs as presented below)

$$y_i = x_i\beta + \varepsilon_i \qquad \text{[Equ.2]}$$

Where y_i and x_i are observable variables and ε_i represent unobservable variables or a disturbance term. Simply stated, y_i represent quantity of rice produced for each farmer while x_i represent the three independent variables namely capital (seeds and fertilizers), labour, and land used by the same farmer to producing reported quantities of rice. Presented in Table 4 are Ordinary Least Square (OLS) estimates of model 2 after natural log transformation obtained using STATA. Performing individual significance test (*t* -test), coefficients of labour and land are statistically significant at 5 percent level of significance $(\alpha = 0.05)$. This implies significant and individual contribution to variation of rice production, *ceteris paribus.*

Likewise, the estimate of capital measured by the costs of seeds and fertilizers is not statistically significant (even at 15% significance level). This would imply no statistically significant effect of capital on rice production of the sample population. However, for the overall significance test, all coefficients are statistical significant even at 1 percent level of significance. Stated in terms of elasticity, the rice production was labour, land, and capital inelastic. This means that rice production in the study area is likely to respondent less proportionate to unit change in use of labour, land, and capital, respectively.

Given that the problem of endogeneity was suspected due to possible reverse causality between production and capital (operating inputs), the OLS estimate of the capital is likely to be biased and inconsistent (Verbeek, 2008). The endogeneity problem was tested by applying Durbin –Wu-Hausman procedure (Verbeek, 2008). Results from the test show the contrary to expectation that capital is heterogeneous (Table 4-Column 3). This implies that the OLS estimate of capital previously obtained, although not statistically significant, it is not biased and hence can be reliable. Alternatively, assumed reverse causality between the two variables does not apply to this study sample, *ceteris paribus*. This can be explained by the use of cross sectional data. Further analysis can be done when panel or time series are collected to the same sample for a given time period.

The Two- Stage Least Square procedure (2SLS) was used to estimate the relationship between production and capital by considering land and labour as its instrumental variables. These two variables were strongly correlated with the capital (Adj. R-squared= 83.9%). Results are presented in Table 3.6, and confirm a statistically significant and positive relationship between rice production and capital (Adj.R-squared = 60.%). This information suggested that land and labour are the main contributing factor to current rice production in the watershed of Cyabayaga. Stated differently, capital has got an indirect and positive impact on rice production. This is consistent with expectations as farmers reported insufficient income to invest in improved rice varieties and fertilizers. Therefore, this finding could be considered as part of information to promote rice production in the watershed of Cyabayaga, Eastern province of Rwanda.

Table 4 : OLS and 2-SLS estimates of rice production in Cyabayaga Watershed

Estimation option	OLS Estimator		OLS –Test for Endogeneity		2-SLS estimator	
Variables/Equation	Coefficients	*t*-ratios	Coefficients	*t*-ratios	Coefficients	*t*-ratios
(i) Endogenous variables						
LN Production						
(ii) Explanatory variables						
Land (Ln)	0.5473741	2.30 **	0.7435343	5.82***		
Labour (Ln)	0.325364	2.17 **	0.4056456	3.23***		
Capital (Ln)	0.3083793	0.98	-	-	1.263832	8.69***
Residuals (estimated)			0.3083793	0.98		
Constant	-2.127609	-0.92	-0.2358399	-0.19	-7.334027	-4.4***
Regression siagnostics						
F-Value		29.97		29.97		75.52
Probability > Prob>F		0.0000		0.0000		0.0000
R-Square		0.6816		0.6816		0.6089
Adj R-square		0.6588		0.6588		0.6000
Sample size (*n*)		49		46		46

Significant levels : * P $\prec$ 0.1, ** P $\prec$ 0.05, *** P $\prec$ 0.01 , Ln= Natural Logarithm

4. Conclusion

The main objective of this study was to analyze the determinants of rice production and its profitability in Cyabayaga Watershed, Eastern province of Rwanda. Information used for the analysis was obtained among a stratified sample of 46 farmers who are producers of rice. This paper concludes that the average production of rice in the watershed is yet insufficient compared to theoretical bench mark of 7 tons per hectare. This is partly explained by lower productivity of production factors used by farmers for rice production that is mostly capital measured as investment in seeds and fertilizers. Labor and land have significant effects on rice production in Cyabayaga watershed and are the main factors determining the profit gained by farmers in rice production.. Support to farmers to have access credit facilities or other institutional arrangements would enable them have access to agricultural inputs for improved profit and well sustained rice production. Training of farmers in use of inputs and management of credits obtained is critical for better running of activities in their cooperatives so that to avoid any sort of free rider problem. Finally, to improve benefits from the farmer cooperative, the management of cooperatives can be improved to reduce other possible related transactions costs.

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