International Journal of Agriculture Innovations and Research
Volume 3, Issue 3, ISSN (Online) 2319-1473
Manuscript Processing Details (dd/mm/yyyy) :
Received : 18/10/2013 | Accepted on : 31/10/2013 | Published : 07/11/2014

Analysis of Economic Efficiency of Maize Production in Huye District in Rwanda

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***Abstract* – This study presents the analysis economic efficiency of maize production In Huye District, Rwanda by using stochastic frontier cost function. The primary data were collected from 65 maize farmers in the study area during February–March 2013 for the cropping year 2012–2013. Result of the total revenue (TR), Gross margin, net farm income (NFI) and return on Rwandan francs invested (ROI) per hectare were 2,611,000 Rwf, 492,830 Rwf, 475,830Rwf and 0.22 Rwf respectively. The results shows that maize farming in the study area is not profitable and Diseconomics of Scale was obtained as 0.99 (ES<1), hence diseconomics of scale exists. Results of the stochastic frontier cost function showed that Parameter of estimate indicated positive relationship and significance at 10% level for fertilizer and labour except maize output have negative relationship but significant at 10%. While improved seed have positive relationship but insignificant at 10%. Further, quantitative estimates obtained from the cost function shows Mean cost efficiency index was 1.026, slightly above frontier cost indicating that an average maize farms from the study incurred about 2.6% costs above the frontier cost-an indication of inefficiency. Some constraint to maize farmers in the study area is inadequate credit, inadequate contact with extension agents and lack of improved seeds. The study recommended that the work of extension agents should be intensified in the study area.**

***Keywords* – Economics Efficiency, Stochastic Frontier, Cost Function, Net Farm Income, Maize Production.**

Introduction

Rwanda is a landlocked, resource-poor country. The population is about 10.7 million, and 87 per cent of Rwandans live in rural areas (NISR, 2011). Population density in the country is the highest in Africa, with about 379persons/km². The annual demographic growth rate is 2.7 per cent, and the population is expected to increase to about 12 million by 2015. (IFAD, December 2011) Rwanda's total arable land is about 1.4 million hectares (ha) which is 52 per cent of the total surface area of the country. There is potential for arable land expansion through the use of irrigation. (Rwanda, September 2011)

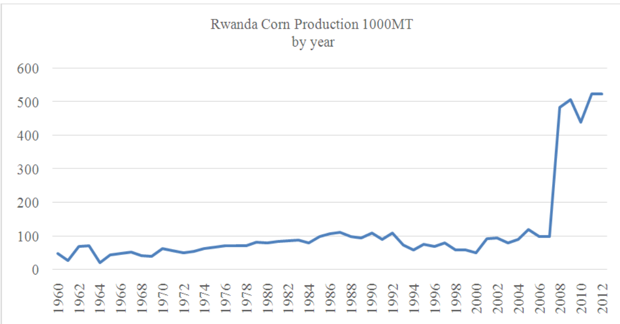
Like many other African economies, Rwanda's economy largely depends on agriculture. It has contributed an average of about 36 per cent of total GDP between 2001 and 2008, and it employs more than 80 per cent of the population. But the sector is very fragile. Rough terrain, erosion and climatic hazards combine with geography and the lack of modern technology to create serious constraints to agricultural development. (IFAD, December 2011) The major food crops in Rwanda are maize, rice, banana, Irish potatoes, sweet potatoes and cassava.

Overview of the Maize in Rwanda

Maize (Zea mays L.) is one of the major crops in Rwanda. It ranks second to sorghum among cereals and third to all crops, covering 10% of the total cultivated land after beans (25%) and banana (22%). It is produced on approximately 100,000 ha with a grain yield of 1.2 t/ha. It is currently grown in all Rwandan ecologies that include semi-arid mid-altitudes (900-1450 masl), moist mid-altitudes (1450-1700masl) and highlands (>1700masl) and is essentially intercropped with beans. (ISAR, 2009)

As a staple, it is consumed in several traditional food preparations, their consumption has been increasing and maize is becoming important cash crop for small-scale farmers especially in the maize growing regions. (Kelly Wanda et al, 2002) The national production of maize is stable from 2004. However, annual production is often short of demand and grain has to be imported. In 2006, a total of 91,813 tons of grain was produced from approximately 114,836 ha and 29,076 tons had to be imported to supplement domestic production. Farm productivity is therefore low, averaging about 0.8 t ha-1. Improving productivity will require adoption of improved cultivars and appropriate crop management practices by growers (Sallah *et al.*, 2007). Maize supplies a high quantity of carbohydrates to the population. The crop has become popular especially in urban areas amongst manual laborers and is targeted by MINAGRI to contribute to the nutritional status of the population. Maize has multiple uses than any other cereals. It is used mainly as a food for human consumption. It is also the number-one feed grain in the country, being the main source of calories in animal feeding and feed formulation.

Evolution of Maize production in Rwanda from 1960 to 2012



Source: indexmundi, 2013

The national production of maize is stable from 1960. It has been increasing and a boom is observed in 2008 with a result of regional crop intensification. Its production is valued at between 80,000 to 170,000 metric tons per year.

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PROBLEM STATEMENT

Empirical studies suggest that most under developed and developing countries are still facing the problem of high poverty levels. In addition to poverty, Rwanda's population growth rate is at 2.751%, very high; yet agricultural resources are limited, e.g. arable land. This calls for improving yields of major staples, such as maize for better food security & livelihoods of rural households. Thus, resources need to be used in the most efficient way to achieve this objective. Further, improved efficiency is expected to improve food security by cutting hunger halfway in 2015 (Amos, 2007).

Most farmers in Rwanda practice subsistence farming with low productivity. This may be attributed to high inefficiencies (technical and allocative) because of Low capitalization, price fluctuation, disease and pest, poor storage facilities and inefficiency of resources utilization are the identified problem in maize production. In order to realize increased production and efficiency, small-scale farmers in developing countries need to efficiently utilize the limited resources accessed for improved food security and farm income generation.

In Rwanda maize is the most important cereal crop, so the Rwandan government adopted different agricultural program and policies aimed at raising productivity and efficiency of agricultural sector. These programs and policies placed the smallholder farmers in central focus. This was due to the fact that the nation's agriculture has always been dominated by the smallholder farmers. In view of this production efficiency of smallholder farms has important implication for the development strategies adopted in many developing countries where the primary sector is still dominant.

An improvement in the understanding of the level of production efficiency and its relationship with host of farm level methods can greatly aid policy makers in creating efficiency, enhancing policies as well as judging the efficacy of the present and past government reforms in the agricultural sector. The research is thus intended to find out the maize farming in the study area is profitable and economics of scale exist.

Research question

- What is the profitability of maize farming in study area
- Are there cost efficiency in this study area
- Are there economics of scale of maize farming exit in study area

RESEARCH OBJECTIVE

Main objective

The broad objective of this study is to examine the economic efficiency in small scale maize production in Huye district.

Specific objective

The specific objectives are to:

- Determine the cost efficiency of the farmers in the study area.
- Determine the profitability and economics of scale of maize farming in the study area.

Hypothesis of the study

- There is no significant relationship between maize input and the output used by the farmers.
- There is significant relationship between maize input and the output used by the farmers.

Significance of the study

This work was showed if there was the economic efficiency in small scale maize production in Rwanda, especially in Huye district. It was proved that maize production is still an untapped opportunity that can bring its important role in poverty alleviation and food security in Rwandan rural areas. In addition agricultural institutions such as ministry of agriculture and animal husbandry, international NGO's should use the obtained result in order to bring their valuable contribution to the development of rural areas.

Scope of the Research

The study was limited to determine the cost efficiency of the farmers in study area. In addition, the study determined the profitability and economics scale of the above mentioned farmers. Geographically the study was carried out in Huye district, the study was collected demographic information, production information and market information for only maize crop.

LITERATURE REVIEW

Literature suggests many factors which affect the efficiency of farmers. These are classified into conventional and non-conventional factors. Non-conventional factors capture the impacts of macroeconomic variables such as public investment and agro-ecological variables. Conventional factors are traditional choice variables in the farmers‟ production decision process.

According to Frisvold and Ingram (1994), the conventional inputs include labor intensity, fertilizer usage, tractor use intensity and stock of livestock. On the other hand, non-convectional inputs include land quality, irrigation, agricultural research, calorie availability, agricultural export and instability. Deininger and Olinto (2000) and Pender et al. (2004) also identified fertilizer, cattle ownership, access to credit, supply of extension, human capital (education, age, and gender of house head), family size and proportions of dependants as explanatory variables to efficiency. The plot level factors such as the size of the farm, tenure, distance of the field from the residence in one way or another affects productivity (Xu et al., 2009).

Ownership of livestock especially oxen is likely to help framers prepare their fields early and also allows them to increase the area of land cultivated. Furthermore livestock acts as buffer zone and improves farmers‟ access to credit and fertilizer markets. In an effort to identify strategies to increase agricultural productivity and reduce land degradation, Pender et al. (2004) used econometric analysis on cross sectional data in Uganda. The study findings showed that ownership of livestock (especially oxen), agro- climatic zones, primary sources of income, age of house head, ownership of land and participation in agricultural extension activities positively affected productivity. This study also shows that investments such as fertilizer facilities are more likely to improve productivity. Population density has a bearing on the way farmers employ their inputs. Studies show that farmers in high density populated areas tend to use intensive methods of crop production. For example Frisvold and Ingram (1994) and Pender et al. (2004) show that households in more densely populated areas were found to adopt some labor intensive land management practices which enabled them to increase crop production per hectare. Farm size also affects the productivity. Pender et al (2004) showed that farm size was negatively related to productivity in Uganda. In Zambia, Brambilla et al. (2009) used cross-sectional postharvest survey data to investigate the dynamic impacts of cotton marketing reforms on farm output. This study showed that small farms are more efficient. Frisvold and Ingram (1994) also agree that for small fields the production is normally small but in terms of productivity or production per hectare they perform better than larger plots.

Recent studies estimating cost efficiency using stochastic frontier model

Some studies carried out to estimate cost efficiency include the following:

P. Paudel *et al* (2009), carried out the study to analyze the cost efficiency of maize production in the Chitwan district. The estimated cost efficiency of production resources employed were 0.065, 0.016, 0.027, 0.015, 0.014, 0.092, 0.130 and 0.210 respectively for Cost of tractor, Cost of animal power, Cost of labor, Cost of fertilizer, Cost of pesticides, Cost of manure, Cost of seed and Maize output positive coefficients and were significant at 5% level. From the analysis of scale effect among maize farms, it was revealed that the maize farms experienced an increasing return to scale, that is, the output increased more proportionately than the total production cost.

Zalkuwi, (2008), carried out the study to examine economic efficiency of maize production in Ganye local government in Adamawa state, Nigeria. Results of the stochastic frontier cost function showed that variance parameter gamma (γ) and sigma (δ^2) are both significant at 1% level. Parameter of estimate indicated positive relationship and significance at 1% level for fertilizer, herbicides, seeds and hired labor. Mean cost efficiency index was 1.04, slightly above frontier cost indicating that they are efficient in allocating their scarce resources.

Reasons for Choosing Stochastic Frontier Production Model

The stochastic parametric method decomposes random errors into error of farmer's uncontrollable factors, dependent variable as well as farm specific inefficiencies. While Deterministic and non-parametric methods have drawbacks since it forces all outputs to a frontier yet sensitive to outliers if large, it distorts efficiency measurements (Ogundele et al., 2006).

METHODOLOGY

Field Methods

The Study Area

Geographical characteristics

According GoR (2008), Huye is one of the 8 districts which make the Province of the South; it is has 14 sectors: Mbazi, Kinazi, Simbi, Maraba, Rwaniro, Rusatira, Huye, Gishamvu, Mukura, Ruhashya, Tumba, Kigoma, Ngoma, and Karama. The Map below shows the Sectors of Huyedistrict and specify where the study carried on precisely in marshland of KOAIRWA.

Sampling Procedure and Sample Size

Maize farmers are the target respondents for the study. The total population concerned under study was 1945 farmers. so the researcher selected 65 respondents among the total maize farmers of KOAIRWA by using formula below:

$$n = \frac{N}{1+(\frac{N_o}{N})}$$

Where

n=sample size (65)

N=population size (1945)

No=sample size of the defined population

$$N_o = \frac{t^2 p(1-P)^2}{d^2}$$

Where

P=estimated frequency of population sample with size n

d=error term which equal to 10%

p=is not well known like our case, p equal to 0.5 estimate.

t=confidence interval 90% with t statistic equal to 1.65

$$N_o = \frac{(1.65)^2 * 0.5 * (1-0.5)}{10\%^2} = 68$$

$$n = \frac{68}{1+\frac{68}{1945}} = 65$$

The sampling technique employ was the multistage stratified random sampling technique. The first stage was involved purposive selection of the rural areas. The second stage involved simple random sampling through random selection of 65 maize farmers in the study area.

Data Collection

Data collection is the process of gathering and measuring information on variables of interest, in an established systematic fashion that enables one to answer stated research questions, test hypotheses, and evaluate outcomes. During this study Primary data were collected from farmers using a survey method involving a structured questionnaire. The socio-economic data collected included sex of respondent, age, marital status and formal education levels. Production information collected included size of farmland owned, land tenure system, size of land under maize production, type of labor used in production, varieties of seed planted, amount of seed planted, fertilizer application, and seasonal yields. Amount of credit, access to extension services were also among production information (number of visits), amount of fertilizers used. Market information was also collected which included prices of seeds, seasonal quantities produced, incomes earned from maize farm sales. Data about constraints faced by maize farmers and suggestions to increase their outputs was also collected.

Model Specification

Net farm income (NFI) analysis

The net farm income analysis was used to determine the profitability of maize production in the study area. The net farm income analysis is given by

NFI = GM – TFC

GM = TR – TVC

Where

GM = Gross margin (Rwf)

TR = Total revenue (Rwf)

TVC = Total variable cost (Rwf)

TR = Total Revenue = Output x Unit price

$TR=P_y.\ Y$

Where

P_y = Price per unit output (Rwf)

Y = Total quantity of output (Kg)

$TVC=\sum P_{xi}.X_i$

Where

P_{xi} =Price per unit of output (Rwf)

Xi =Quantity of i^{th} input used per unit

Net Return (NR)

NR = GM – TFC

Profit (Net returns) = Total Revenue – Total cost

Where TC = Total cost of production per hectare (Rwf)

Total cost = Total variable cost + Total fixed cost

$$\text{IRR} = \frac{\text{Net returns}}{\text{Total Cost}}$$

Internal rate of return (IRR) is the amount of money that would be generated on a Rwandan francs invested in business. A high rate of return signifies a profitable enterprise.

Stochastic frontier model specification

In this study Battese and Coelli (1995) model, as used by Ogundari et al (2006), was used to specify a stochastic frontier cost function with behavior inefficiency component and to estimate all parameters together in ordinary least square estimation. This model implicitly expressed as

$\text{Ln } ci = g\ (P_i, y_{i,}\beta) + (V_i – U_i)$

Where

C_i = the total production cost

g = suitable functional form such as Cobb Douglas

Pi = vector variable input prices (fertilizer, labor and seed)

Yi = the valve of maize produce in kg

Vi = the systematic component which represents random disturbance cost due to factors outside the scope of the farmers.

Ui = the one sided disturbance farm used to represent cost efficiency and is independent of Vi.

β= the parameter of the estimate

It is assumed to be identically and normally distributed mean zero and constant variance

As N (0, δ^2v). Ui is the one-sided disturbance form used to represent cost inefficiency and is independent of V_i. Thus, Ui = 0 for a farm whose costs lie on the frontier, Ui >0 for farms whose cost is above the frontier, Ui <0 for farm identically and independently distributed as N (0, δ^2v). The two error terms are proceeded by positive signs because inefficiencies are always assumed to increase cost.

Moreover for the study the cost efficiency of an individual farm is define in terms of the ratio of the observed cost (C^b) to the corresponding minimum cost (C^{min}) given the available technology. That is cost efficiency (C^{EE}).

$$\frac{C^b}{C^{min}} = \frac{g(P_i, Y_i, \beta) + (V_i + U_i)}{g(P_i, Y_i + \beta) + (V_i)} = \exp\text{ (Ui)}$$

Where

C^b = the observed cost represents the actual total production cost

C^{min} = minimum cost and represents the frontier total production cost or least cost total production level.

C^{EE} = exp (Ui)

CEI = exp (ln TC| Ui) / exp (ln TC| Ui=0) = exp (Ui)

C^{EE} takes the values of 1 or higher with 1definig cost efficient farm. And following the adoption of Battese and Coelli (1995) framework for the analysis of data, the explicit Cobb Douglas functional form for maize farm in the study area is therefore specified as follows;

$$\text{Ln}\quad c_i = \beta_0 + \beta_1 \text{LnP}_{1i} + \beta_2 \text{LnP}_{2i} + \beta_3 \text{LnP}_{3i} + \beta_7 \text{LnY}_i + (V_i + U_i)$$

Where

C_i =Total production cost

P_1=Cost of fertilizer

P_2=Cost of seeds

P_3=Cost of labor

Y_i=Output of maize (kg/ha)

The choice of Cobb Douglas is based on the fact that the methodology requires that the function be self-dual as in the case of cost function in which the analysis is based on.

The inefficiency model U_i is define by

$U_i = \delta_0 + \delta_1 Z_{1i} + \delta_2 Z_{2i} + \delta_3 Z_{3i} + \delta_4 Z_{4i}$

Where Z_1, Z_2, Z_3, Z_4 represents age, farming experience, farm size and literacy level.

These socio-economic variables are included in the model to indicate their possible influence on the cost efficiency of the farmer.

The analysis of the economies of scale

Economics of scale (E_s) - Economics of scale may be defined in term of elasticity of cost with respect to output. Economics of scale can be measured by the inverse of the sum of all cost elasticities with respect to all output included in the regression.

$$\text{cost elasticities} = \sum\left(\frac{\partial \ln \text{Tc}}{\partial \ln \text{Y}} + \frac{\partial \ln \text{Tc}}{\partial \ln \text{P}_{1i}} + \frac{\partial \ln \text{Tc}}{\partial \ln \text{P}_{2i}} + \frac{\partial \ln \text{Tc}}{\partial \ln \text{P}_{3i}}\right)$$

$$E_s = \frac{1}{\left(\frac{\partial \ln Tc}{\partial \ln Y} + \frac{\partial \ln Tc}{\partial \ln P_{1i}} + \frac{\partial \ln Tc}{\partial \ln P_{2i}} + \frac{\partial \ln Tc}{\partial \ln P_{3i}}\right)}$$

The cost function parameter estimated most especially the coefficients of the output for the Cobb-Douglas model suggests the presence of Economic of scale (Es) in the production process.

Economics of scale is mathematically equivalent to the inverse of the sum of all the elasticizes of total production cost with respect to all output (Ogundari et al, 2006). Economics of scale or Positive economies of scale prevail exist, if the Economic of scale is greater than 1 (E_s>1) defined as the reduction in cost of production of the given output level while holding all other input prices constant, conversely, the Diseconomies of scale exist when the economics of scale is less than 1 (E_s<1) this case where E_s=1 no economies of scale or diseconomies of scale exist. However in multiproduct setting, economies of scale (E_s) is defined on those reduction on average cost when all output are increased proportionally holding all other input prices constant.

The return-to-scale and economics of scale are equivalent measures if and only if the product is homothetic, an assumption that applies to and is implicit in the Cobb-Douglas function structures (Chambers, 1988). If costs increase proportionately with output, there are no economies of scale meaning that there is a constant return-to-scale. If costs increase by a greater amount than output, there are diseconomies of scale meaning that there is a decreasing return-to-scale if costs increase by a lesser amount than the output, there are positive economies of scale which is sometimes referred to simply as economies of scale meaning increasing return-to-scale. Here, since the Cobb-Douglas function was used, this assumption is imposed.

Results and Discussions

Socio-economic Characteristics of the Farmers

The descriptive statistics of maize farmers' characteristics is shown in Table 2 below. Such characteristics include: age, level of formal education in years spent in school, farm experience in years and farm size are systematically discussed below.

Socio-Demographic Variables

Table 2: Demographic Characteristics of Maize Farmers in Huye Districts

Characteristics	Mean=65	Standard Deviation
Age (years)	48.74	11.56
Education level (years)	1.51	0.50
Farming experience (years)	2.42	1.14
Farm size (m^2)	313.83	1739.29

Source: field survey 2013

The summary of the descriptive analysis of the farmers' socio-demographic characteristics are shown in Table 2. In general, the mean age for the sampled farmers was 48.74 years meaning that the farmers are in their middle age (i.e. relatively active). This portrays that most of the maize farmers are in their active and productive age when they can put in their best for optimum productivity. Results in Table 2 indicate that the average years in school in the study area were 1.51 years. This implies that the education level of the farmers was very low. Education of the farmer plays an important role in decision making and accessing crucial production information. It helps farmers in gaining skills and adapt new technologies. The average farming experience was 2.42 years, implying the maize farmers has few years of experience and so shouldn't produce high output. The mean maize area of the households was 313.83 meter square per farmer and it indicates that most of the farmers have operated a small-scale of land. This could be as a result of low accessibility to land.

The Profitability analysis of the farmers

Table 3: Average cost and returns on maize production

Variable	Value (Rwf/Ha)
Total Variable Cost (TVC)	2,118,170
Total Fixed Cost (TFC)	17,000
Total Cost of Production (TC)	2,135,170
Total Average Output (kg/ha)	10,444
Average Cost per Kilogram	204.44
Average Revenue per Kilogram	250
Total Revenue (TR)	2,611,000
Gross margin (GM = TR – TVC)	492,830
NFI (GM – TFC)	475,830
Return on Rwf invested (ROI)	0.22

Source: field survey 2013

The finding on the costs and returns of maize production in the study area revealed that the total variable cost was 2,118,170 Rwf which represents about 99.2% of the total cost of production while fixed cost was 17,000 Rwf representing about 0.8% of the total cost. Hence the total cost (TC) of farming per hectare was 2,135,170 Rwf (TVC + TFC). Total revenue, gross margin and farm income were 2,611,000 Rwf, 492,830 Rwf and 475,830Rwf respectively. The average cost per kilogram shown that 204.44 Rwf was used to produce 1kg maize while the average revenue per kilogram shows that 250 Rwf was generated as revenue from selling 1kg of the maize produced. Return on Rwandan francs invested by the Maize farmer's shows that for every one Rwandan franc invested, 0.22 was gained. This means that 22% profit was made. From this result, one can conclude that maize farmers in the study area were poorly rewarded for their efforts.

Cost efficiencies analysis of the sampled maize farmers

Stochastic Frontier Cost Estimation

Table 4: Summary statistics of the variables in stochastic frontier model

Variable	Mean	Standard Deviation	% of TC
Total production cost (Rwf)	32,848.77	45,383.87	
Cost of fertilizer (Rwf)	8,725.31	16,145.13	26.56
Cost of seed (Rwf)	848.08	1,365.22	2.58
Cost of labor (Rwf)	23,013.85	33,474.73	70.06
fixed cost (Rwf)	261.54	1,302.36	0.79
Maize output (kg/hectare)	2,698.03	5,935.43	
Age of the farmers (Years)	48.74	11.56	
Farming experience (Years)	2.42	1.14	

Farm size (m^2)	313.83	1739.29
Literacy level (rating: 0 –2)	1.51	0.504

Source: Field Survey 2013

The summary statistics of the variables for the frontier estimation in table 4 presents the sample mean and standard deviation for each of the variables. The mean value of 32,848.77 Rwf as total cost of producing 2,698.03 kg of maize was obtained from the data analysis with a standard deviation of 45,383.87Rwf. The large standard deviation conforms to the fact that most of the farmers operate at different scale of operation and most of the farm operates at the different level of cost of production.

Analysis of the cost variables of the farmers showed that labor accounts for about 70.06 % of the total cost due that may be due to the higher use of family labor for maize cultivation. Most farmers in the study area were of the small scale, did not have enough capital to hire labor and as a consequence, they relied on family labor for most of the operations. The total labor used for maize production, about 51% of the labor is fulfilled by their own family labor. Cost of fertilizer account for 26.56% of total cost which shows that the farmers are adopting the comparatively modern technology like a higher reliance on the use of fertilizer for the maize production finally cost of seed 2.58% of the total cost respectively. While fixed cost account for 0.79% of the total cost respectively.

Variables representing the demographic characteristics of the farmers employed in the analysis of the determinant of cost efficiency include age of the farmers, farming experience and farm size and literacy level. The average age of the farmers was 48.74 meaning that the farmers are in their middle age (i.e. relatively active).

The average farming experience was 2.423 years, implying the maize farmers has few years of experience and so should produce low output. Literacy level was rated 1.52 meaning that most of the farmers didn't attended primary school and others attended a bit of primary education (i.e. relatively uneducated).

Estimates of the stochastic frontier cost function parameters

Table 5: The ordinary least square (OLS) estimates of parameters of the Cobb Douglas frontier function for maize farmers in the study area.

Variables	**Parameter**	**Estimated Coefficient**	**(t-ratio)**	**Sig.**
General model				
constant	β_0	0.563	1.322	0.094
Ln improved seeds cost (Rwf)	β_1	0.028	0.976	0.335
Ln fertilizer (Rwf)	β_2	0.330	8.319***	0.000
Ln Maize output Kg/are	β_4	-0.050	-1.283***	0.020
Ln labor cost (Rwf)	β_5	0.700	15.362***	0.000

Dependent variable: ln total cost, source: Field Survey 2013, *** = significance levels at 10%.

The ordinary least square (OLS) estimates of the parameters of the stochastic cost frontier models were obtained using the computer program SPSS. These results are presented in Table 5. The result revealed that all independent variables confirm with a prior expectation as all the estimated coefficients of the cost of labor, fertilizer and seed gave the positive coefficients while and maize output gave the negative coefficient. The parameter estimates of the frontier cost function as reported in Table 5 show the statistical significance at 10% level on fertilizer and labor coefficients except the coefficient of cost of improved seeds. Hence these variables are the important determinants of maize production in the study area. The reason for the cost of improved seeds being an insignificant factor might be due to its lesser contribution to the total cost of maize production because government gave him for nothing except fifty for transportation. .

Since the cost function is a function of all input prices, the percentage increase in the total production is based on the interpretation of the coefficient of the Cobb-Douglas function, Hence, 1% increase in the cost of improved seed will increase the total production cost by approximately 0.03%, 1% increase in the cost of fertilizer will increase the total production cost by approximately 0.336%, 1% increase in the cost of labor will increase the total production cost by approximately 0.708%, 1% increase in the maize output will decrease the production cost by approximately 0.054%.

Cost inefficiency analysis

Table 6: the ordinary least square (OLS) estimates of parameters of inefficiency model

Inefficiency model	**Parameter**	**Estimated coefficient**	**(t-ratio)**
Constant	δ_o	-1.299***	-1.327
Age farmers (years)	δ_1	0.013	0.357
Farmers experiences(years)	δ_2	0.157***	0.274
Farm size (ha)	δ_3	-4.342E-5	-0.446
Literacy level (rating 0 – 2)	δ_4	0.188	0.537

Source: Field Survey 2013, *** = significance levels at 10%.

The analysis of the inefficiency model is depicted in the Table 6 The explanatory variables in the model show that the signs and significance of the estimated coefficients in the inefficiency model have important implications on the cost efficiency of the maize production in the study area.

The positive coefficient of the age of the farmers implies that farmers of older age tend to be less cost efficient i.e. the decrease in cost efficiency tends to increase with the farmers age for maize production in the study area. This is in conformity with the assumption that the farmers of younger age have a greater access to the extension services and have a better knowledge about the cost of production since they are comparatively more educated than the households of older age. However, this variable is not significant in influencing the level of cost efficiency.

The positive coefficient of literacy level indicates that farmers' level of cost efficiency tend to decline with education. This is in contradiction with the assumption that educational level of the farmers will have positive effect on the level of efficiency as the embody skill that can improve their overall efficiency. Moreover, the negative and insignificant coefficient for farm size which also represents the scale of operation indicates that as the farm size increases, the farmers become more cost efficient in the allocation of resources. This is an indication that the level of cost inefficiency of an average maize farmer in the sampled farmers tends to decrease as the farm size moved from a small to a large area thereby making the maize farmers to enjoy the economics of scale as the cost per unit output decrease in the long run.

Cost efficiency scores for the maize farmers in the study area

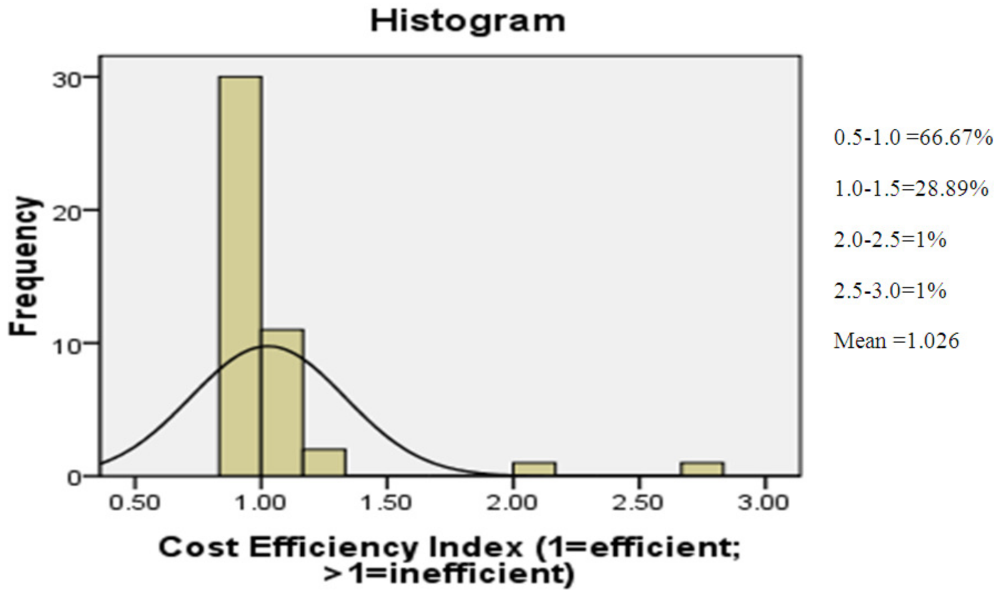

Fig.6. Cost efficiencies of the sampled maize farmers

Cost efficiency scores for the maize farms in the study area are presented in Graph 1. The predicted cost efficiencies (C_{EE}) ranged from 0.5 to 3.0. Cost efficiency is estimated as C_{EE} =EXP U_i ,The mean cost efficiency of an average maize farm was estimated as 1.026, meaning that an average maize farms in the study area incurred costs that are about 2.6 % above the minimum cost defined by the frontier. In other words That is, over 2.6% of the maize farms costs are wasted in comparison to the best practice firms producing the same output and facing the same technology. The higher value of cost efficiency represents the more inefficient farm during the course of maize production in the study area. However of frequencies of occurrence of the predicted cost efficiency between 1.0 and 1.5 representing about 28.89% of the sampled farmers implies that implying that few farmers are fairly efficient in producing at the given level of output using the cost minimizing input ratios. This indicates that the majority of farms in the study area need to minimize the waste of resources associated with maize production process.

Correlation coefficient between maize output and input used by the farmers

Table 7: Correlation coefficient between maize output and input

Input	Correlation coefficient	sig	Decision rule
hired labor	0.681**	0.000	Reject H_O
Family labor	0.005	0.484	Accept H_O
Cost of improved seeds	0.572**	0.000	Reject H_O
Cost of Fertilizer	0.536**	0.000	Reject H_O

Source: Field Survey 2013, **. Correlation is significant at the 1% level (1-tailed).

International Journal of Agriculture Innovations and Research
Volume 3, Issue 3, ISSN (Online) 2319-1473

The result of the hypothesis as given by correlation coefficient showed that fertilizer, improved seeds and hired labor are highly significant at 1% level and positively related to maize output while family labor are not significant. This implies that increase in the amount used to these variables will lead to increase in maize output.

Analysis of economies of scale of maize farming in the study area

In order to achieve second part of the second objective of this study of analysis of economies of scale, elasticities (βi) need to be calculated. Determination of elasticities is necessary for the estimation of responsiveness of yield to inputs.

Table 8: Cost Elasticity

Variable	Coefficient	Elasticity
Ln cost of Fertilizer	0.330	0.330
Ln maize output	-0.05	-0.05
Ln cost of Seed	0.028	0.028
Ln cost of Labor	0.700	0.700

Source: Field Survey 2013, Dependent variable total cost of production

Cost elasticizes with respect to all input variables used in the production analysis is are positive and imply that an increase in the cost of fertilizer, increases total production cost by 0.330%, 1% increase in the cost of seeds will increase total cost by 0.028%, 1% increase in the cost of labor will increase total production cost by 0.700%. However, labor cost, cost of fertilizer and cost of seed are positive implying that the cost function monotonically increases in input prices (i.e. increasing input prices in the same proportion).

Summation of the partial elasticity of production give cost elasticities which is 1.008. The scale effect among the maize farms in the study area was computed as the inverse coefficient of cost elasticities with respect to the maize output in kg as the only output in the analysis that shows that scale effects among the sampled farmers. This is because the computed value of the Scale effect is 0.99 (i.e., 1/1.008 =0.99) which confirms that there is a negative economy of scale or diseconomies of scale meaning that there is a decreasing return-to-scale imply that costs increase by a lesser amount than the output.

The analysis of the constraint faced by farmers in maize production

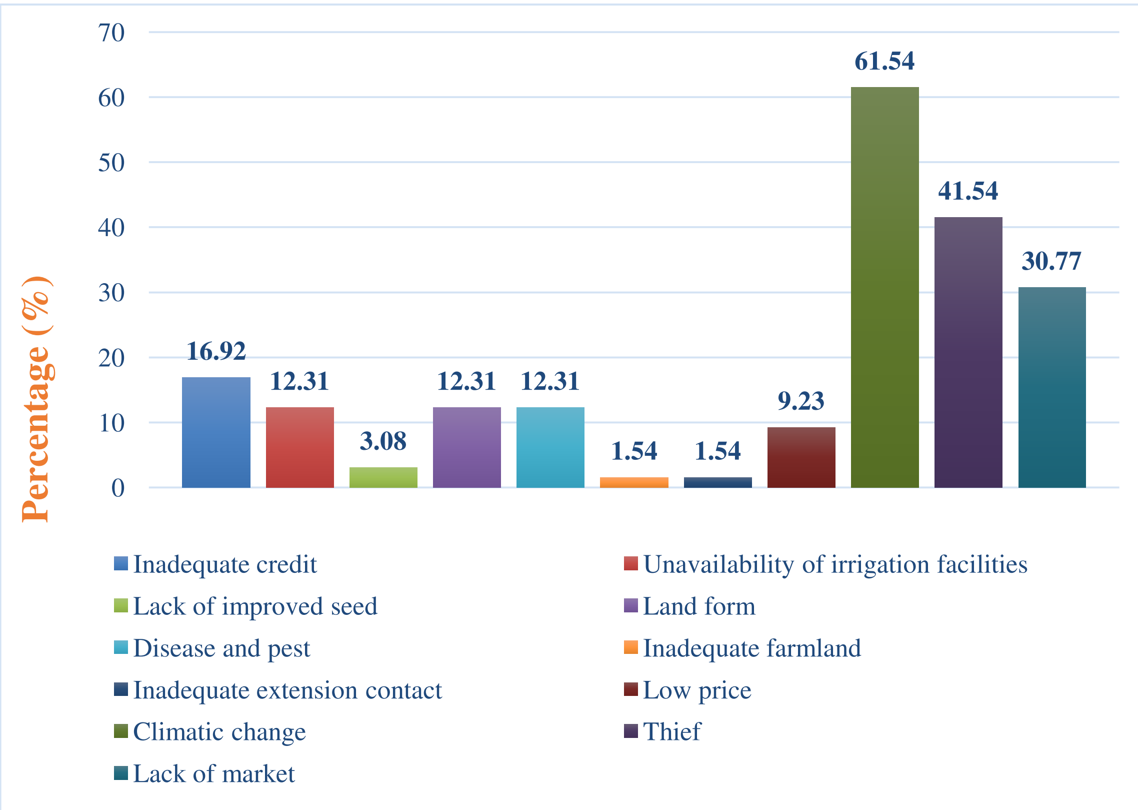

Fig.7. Distribution of farmers based on constraint s faced in maize production.
Source: Field Survey 2013

The constraint identified militating against maize production in the study area were in graph 2.

The study revealed that 61.54% of the farmers were confronted with the problem of climatic change which causes damage to the crops, 3.08% of the farmers could not use improved seed either because of lack of funds or they do not have access to it, 12.31% could not afford irrigation facilities either to complement for rain in time of drought or during dry season farming. Landform post constraint to 12.31% of the farmers which causes flooding and water logging giving room to water to cause damage to crops, 41.54% of the farmers are faced with the problem of thief this is due to insecurity in the study area. Lastly only 21% of the farmers have contact with extension agent occasionally.

Summary of the Findings

This study aimed at establishing the economic efficiency of maize Production in Huye district especially Mbazi sector. This overall objective was achieved by analyzing cost efficiency and profitability of maize farmers. Also economics of scale of maize farmers were estimated. In additional to the set specific objectives, the study first characterized categories of maize farmers in terms of social demographic factors. The characterization was established using descriptive statistics generated by Statistical Package for Social Scientists (SPSS) computer software.

Descriptive statistics indicated that the mean age for the sampled farmers was 48.74 years meaning that the farmers are relatively active. The average years in school in the study area were 1.51 years which implies that the education level of the farmers was very low. The average farming experience was 2.42 years, the mean maize area of the households was 313.83 meter square per farmer and it indicates that most of the farmers have operated a small-scale of land.

About determine of the profitability of the farmers in the study area, Result of the net farm income (NFI) and return on Rwandan francs invested (ROI) per hectare were 475,830 Rwf; 31, 098.79; and 0.22 Rwf respectively. Using the ordinary least square methods (OLS) estimates of the parameters of the stochastic cost frontier models were obtained using the computer program SPSS result show that all independent variables confirm with a prior expectation as all the estimated coefficients of the cost of labor, fertilizer and seed gave the positive coefficients while and maize output gave the negative coefficient and are significance at 10% level on fertilizer and labor coefficients except the coefficient of cost of improved seeds. The mean cost efficiency of an average maize farm was estimated as 1.026, meaning that an average maize farms in the study area incurred costs that are about 2.6 % above the minimum cost defined by the frontier.

The scale effect among the maize farms in the study area is 0.99. This confirms that there is a negative economy of scale.

Conclusion

In conclusion maize farming in the study area is not profitable and diseconomies of scale exist. The closeness of the average cost efficiency (C_{EE}) of 1.026 to unity is an indication that although farmers are small scale resource poor, they are efficient in the use of their resources and that any expansion in their present level of production will bring down the cost of production per output. The prevailing economics of scale obtained for the study is in accordance with result of Ogundari et al (2006) that indicated higher relative efficiency for small farms.

Recommendation

Despite continued government investment in the agriculture sector through Agricultural input subsides, extension services and promotion of new technology, small scale maize farming has remained cost inefficient. Based on the finding in the study area, the following are recommended. More effort should be intensified on the part of extension agent in educating the farmers so as to boast their efficiencies in maize production. The farmers should be encouraged to keep records also, they should be thought the recommended quantities of agrochemicals and improved seed to use on their farms in order to achieve optimum yield. This will help the farmers to make better farm plans in the future so as to increase output as well as profit. The useful policy recommendations made by agricultural researchers should be implemented by the government. This will go a long way in contributing towards the achievement of self-sufficiency in the nation.

Further Research

Considering that low productivity is a serious national issue for Rwanda, it is important the research on productivity and efficiency of maize production continues. There is need for a follow up study. Such a study should include all the relevant variables important in explaining economic efficiency. Variables to be considered include among others; access to credit, land tenure, access to market information.

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