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THE FUNCTIONAL ANALYSIS OF MAIZE PRODUCTION AND THE EFFECT OF LAND CONSOLIDATION ON THE PRODUCTIVITY IN RWANDA

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ABSTRACT

The main objective of this research was to evaluate the impact of land consolidation on the productivity of smallholder maize farmers in Rwanda. The research was conducted in Musanze District with a sample size of 67 farmers known to be adopting Land Consolidation in two sectors namely Cyuve and Nyange whereby the maize crop was grown due to favorable climate. The Cobb-Douglass production function model was used to estimate the productivity in maize production. The results showed that the land under maize cultivation, fertilizers and labor have a significant and positive influence on maize farm productivity; maize seed was not significant but has a partial positive influence on maize yield. On the productivity model, the results showed that age, years of schooling, extension access, and cooperative farming have a significant impact on the productivity but farmer's experience was not significant and positively affected the productivity of maize farmers. The most constraints observed were the lack of adequate market, low price given to maize farmers compared to the cost of production, and price unpredictability of agricultural products. This study proposes strategies such as farmer training programs, raising the educational level of farmers, and providing farmers with greater access to credit, adoption contracting farming where farmers could produce on contractual basis with the known potential buyers and encourage cooperative farming which could increase the bargaining power to afford better prices in order to increase the productivityof fragmented maize farms in the region.

Keywords: Land consolidation; Cobb-Douglass, Maize Production; Smallholder farmers.

INTRODUCTION

Rwanda's economy is largely agrarian. More than 80% of the Rwanda's projected populations of 10,718,379 depend on farming (NISR, 2011). The total land area of the country measures 24,700 square kilometers (Kathiresan, 2012). With about 79% of the country's land which is suitable for agriculture, about 11% of that land represents permanent crop land (USAID, 2011). The remaining agricultural lands are covered with forests, marshlands and marginal lands in the hillsides where permanent and routine cultivation of crops are not tenable. Of the total arable land, 1,735,025 ha are cultivated for food and cash crops and the remaining represents pastures and bushes (NISR, 2011). In 2011, food crops were grown over 935,176 ha during the most active season (Kathiresan, 2012).

Food crop production in Rwanda is predominantly dependent on the productivity in small and fragmented farms. Raising productivity levels in smallholder farms therefore represents a vital means to economic growth and poverty reduction in Rwanda. The government of Rwanda is constantly seeking ways and policies to intensify production and raise farmers' income on existing land. Heavy investments are being made to revamp marshlands, improve irrigation systems, facilitate inputs and mechanization to diversify and enhance the level of productivity in small farms (Kathiresan, 2012). The Ministry of Agriculture and Animal Resources (MINAGRI) has embarked on a simplified land use consolidation model whereby farmers in a given area grow the priority food crops (maize, rice, wheat, Irish potato, cassava, soybean and beans) in a synchronized fashion while keeping their land rights intact. Although consolidation is voluntary, it is a pre requisite for availing the benefits such as subsidized inputs under Crop Intensification Program (CIP), a revolutionary flagship program promoting food production (Kathiresan, 2012).

Despite a significant physical expansion (13%) of total cultivated area in the country, the pressure on consolidation of lands for cultivation of priority crops has caused a steady decline in area under cultivation of other (non priority) traditional crops – from 52.6% in 2004 to 42.4% in 2011. Since cultivation of some of the other non-priority crops could provide additional revenues, protect risks from mono cropping and balanced nutrition, the replacement of other crops by priority crops in consolidated areas needs to be justified on such factors as profitability and household food security (Kathiresan, 2012). It is now evident that the aggregate yields of food crops in Rwanda have increased substantially as a result of the increased use of inputs, particularly the improved seeds and fertilizers. Although the subsequent increase in marketing has not yet shown dynamism, the prevalent conditions create a scenario for drawing viable strategies that would sustain the initial momentum gained under the intensification process and take the country further

beyond producing enough food crops for security to producing exportable surpluses (Kathiresan, 2011).

In Rwanda, the land distribution is highly fragmented and skewed. About 36% of the households own 6% of the farm lands, with an average of 0.11 ha. The national average holding of 0.76 ha is generally divided over 4 to 5 small plots, often in multiple locations. Such multiple holdings are valued by farmers since they can diversify their crop production in the different locations and thus provide protection against natural risks (USAID, 2011). Such a risk evasive approach however suffers from low productivity and thus keeps the smallholder farmers within a vicious cycle of subsistence agriculture and poverty (Kathiresan, 2012).The priority food crops in Rwanda include maize, wheat, rice, Irish potato, cassava, soybean and beans. To a great extent, the volumes of production of these food crops determine the levels of food security in Rwanda. Hence the government has adopted a land use consolidation model under the provisions of the Organic Land Law whereby the priority crops are grown in a consolidated manner in identified locations across the country. Based on the adaptability of the priority crops to the various agro climatic zones in the country, farmers are advised to grow crops in a consolidated fashion (Mosley, 2004).

The Rwandan government believes that the cultivation of small fragmented land holdings leads to inefficiencies in agricultural production. Consequently, land reform programs have been introduced and generally include the land law, the land policy adopted in 2004 and the setting up of communal settlements aimed at freeing more land for agriculture. Under article 20 of the new land law, farmers will have to consolidate their land and/or not fragment land holdings below one hectare since it is argued that to be economically productive, a household farm must not be less than 0.9 hectare, a limit set by the Food and Agricultural Organization (Mosley, 2004). In the highlands in general, maize crop meets with several challenges that include long growing cycle, soil fertility and soil acidity in Congo-Nile Crest, less yielding varieties, Maize Streak Virus (MSV) disease, accessibility and availability of improved varieties (i.e. hybrids) and of quality seed. In those areas maize constitutes the main staple food crop and an important source of income and the land reform has come as a response to the need for optimal land use (USAID, 2011). Many farmers are complaining and are almost against this newly adopted policy of land use consolidation by saying that the fluctuation in food price is resulting from the disturbance of the Government to practice the policy which is not suitable according to their land holdings and has led to hunger among small holders and the decline in their income as they were used to be before the implementation of the policy.

This study focused especially on determining whether farm specific characteristics (with a particular focus on land consolidation) have contributed positively on the productivity of maize in Musanze District. Maize was chosen because it is the most important food crop which is grown at the big area of consolidated land in Musanze District. Therefore, this study aims to find out whether the current land consolidation policy has made an improvement on the productivity of smallholder maize farmers, and also find out the reason behind the complaints of many rural farmers about the land use consolidation policy, and make recommendations on how the Government of Rwanda can improve the policy that has been implemented so that farmers can feel more interested and comfortable with the policy. The specific objectives were; to find out the factors associated with land consolidation contributing to the efficient production of maize farms, to assess the levels of productivity of smallholder maize farms in Musanze District, to make a comparative study of maize yield before and after the farmers have consolidated their land, to see if there is an improvement on the living standard of maize farmers from the income generated by maize sales

Hypothesis

- The smaller the land size the lower the level of productivity of smallholder maize farmers.
- The land use consolidation positively increased the productivity among smallholder maize farmers.

MATERIALS AND METHODS

Study Area Description: Musanze District is one of the five Districts of the Northern Province created by the law nº29/2005 of the 23/12/2005, bearing organization of the Administrative Entities of the Republic of Rwanda, relating to the number and the limits of the Districts. The District of Musanze is the result of the fusion of the old following administrative entities such as Busogo, Cyuve, Gacaca, Gashaki, Gataraga, Kimonyi, Kinigi, Muhoza, Muko, Musanze, Nkotsi, Nyange, Remera, Rwaza and Shingiro (Figure 1). Gross surface area of Musanze district is 530.4 km^2 which brings the population to approximately 350,069 inhabitants (Musanze DDP, 2012).

Figure 1: Study area

Musanze District is characterized by two great natural areas, the plane and volcanic area as well as the mountainous area. As a whole, the average altitude of Musanze District is 2000 m including the chain of the volcanoes Kalisimbi (4507 m), Muhabura (4127 m), Bisoke (3711 m), Sabyinyo (3574 m) and Gahinga (3474 m). Musanze District generally has a tropical climate of high altitude with an average temperature of 20ºC; the rains are abundant and annual precipitations vary between 1400 mm and 1800 mm. According to Musanze District report, its population rises with 314242 inhabitants on a surface of 530.4 km^2 that is to say an average density is of 592.6 inhabitants per km^2. The pattern of the settlement according to the kind shows that the manpower of the people of female sex (166 763) is higher than that of the men (147 479).

Sampling Method and Data Collection: The Musanze District was used as case study, two sectors, Nyangeand Cyuve were selected based on the list of maize farmers from which households were randomly sampled using the lists and numbers (given by Agronomists at Sector level) of maize farmers in each sector. The random sampling was used as method of sampling where each maize farmer in the population has the same probability of being selected. The survey was conducted within the maize farmers in Musanze District. Sample size was chosen randomly from the entire population using stratified sampling where the researcher has selected people who are easier to obtain information, the reason why both simple random sampling and stratified sampling were used. According to Grinnell and Williams (1990), if the sample is collected properly, the information collected about the sample can represent the entire population. Therefore the sample size was calculated using the formula of Alain Bouchard (1968) as follow:

$N_O = \frac{t^2 \alpha p(1-p)}{d^2}$ With ns= $\frac{No}{1+\frac{No}{N}}$, Where:

No: Sample size for a finite universe that is to say <100000 which corresponds to 68 individuals, given a magin error of 10%.

t_α : figure from t-student table which corresponds to 1.65; p: estimated frequency of the sample size n (p=0.5); d: error term at 10%; ns:Sample size adjusted to determine a finite universe;

N: size of the population which is equal to 4495 maize farmers

Ns = $\frac{68}{1+\frac{68}{4495}}$ = 67 maize farmers

For determining the sample size at sector level the following formula was used:

$$ni = \frac{Ni \ x \ n}{N}$$

Where ni = the sample size proportion to be determined; Ni= the population proportion in the stratum; n= the sample size; N= the total population

The proportion of population in sector:

1. CYUVE = (2367x 67): 4495=35;
2. NYANGE = (2128 x 67): 4495 =32

There are various methods of data collection and their application usually depends on the nature of the study. In this study, primary data were obtained through visiting and interview schedule. For getting more information, maize farmers were met be interviewed so that they could give the needed information. The survey was conducted in Musanze District, specifically in two sectors in which maize is well grown in consolidated fashion and 67 maize farmers were surveyed randomly, the visiting, questionnaire and interview schedule was the major tools of primary data collection. In order to get secondary data the method of documentations was used.Various documents were consulted before and during execution of this study. The hand book reports, various text books, articles, papers, journals and internet were consulted in order to retrieve relevant information which helped to build well the research topic.

Data Analysis and Model Specification: A Cobb-Douglas stochastic production function was estimated using the single-step procedure suggested by (Kumbhakar *et al*, 1991) that produces maximum likelihood estimates of the stochastic production function.

In economics, The Cobb Douglas functional form of production function is widely used to represent the relationship of output to inputs. It was proposed by Knut Wickell (1851-1926) and tested against statistical evidence by Charles Cobb and Paul Douglas 1928 (Tan, 2008).

An empirical analysis of the relationship between maize farms productivity and production factors on consolidated land in Musanze District was the focus for this study. In this, we tested the hypothesis that maize yield depends mostly on the size of land under maize production, the quantity of maize seeds used, the quantity of fertilizers used mainly mineral fertilizers and labor hired for each growing season. On the productivity side, we tested the hypothesis that productivity in maize production is affected mainly by the experience of farmers in farming practices, age of the farmer, educational level of the farmers which is represented by the years of schooling, the number of extension visit or other training received by farmers and lastly being a cooperative member. These factors are very important and affect farmer's performance in terms of efficiency and allocative effects. The Cobb-Douglas Production function was estimated, because of its simplicity and it provides an adequate representation of the production technology (Nguyen, 1996). Many studies adopt the Cobb-Douglas production function. The non-linear model is widely used to represent the relationship between output and the inputs used as follow:

$P(L, K) = \beta_1 K^{\beta 2} L^{\beta 3} e^{u}$ (Tan, 2008), Where;

P: represents the total production (the monetary value of all goods produced in season

L: Labor inputs (the total number of person-hours worked in a season

K: Capital inputs (the monetary worth of all machinery, equipment, fertilizers and seeds.

β_1: total factor productivity

β_2 and $\beta 3$ are the outputs elasticities of labor and capital respectively. These values are constant determined by available technology. Therefore this functional form was adopted because it fits well our collected data.

This non-linear model was transformed by the natural logarithm (Ln) in order to simplify calculations as follow:

$LnY_i = \ln \beta_1 + \beta_2 \ln X_i + ,\ldots\ldots\ldots + \beta_n \ln X_{in+} \ln u_i ,$

Where Y_i and X_i are observed variables and ui represent unobservable variables or disturbance term. Simply stated, Y_i represent the average maize yield (from 2008-2012) produced by each farmer while X_i represents the four independent variables namely (land, seeds, fertilizers and labor), β_1 is the intercept while from β_2 to β_n are the coefficients of explanatory variables. The variables included in the stochastic production function model are summarized in Table 1.

Table 1. Variables included in the model Cobb-Douglas production function model.

Variables	Type	Definition	Unit of measurement
Maize Yield	Dependent	YIELD	Kgs
Land size	Independent	LSIZE	Hectares
Seeds	Independent	SEED	Kgs
Fertilizers used	Independent	TERT	Kgs
Labor days used	Independent	LAB	Number of days used

Table 2. Variables in the productivity model

Variables	Type	Definition	Unit of measurement
Age	Independent	AG	Years
Education level	Independent	EDUL	Years of schooling
Family size	Independent	FSIZE	Number of persons
Being in cooperative	Dummy	COPME	1=yes 0=no
Extension visit received	Independent	EXVIST	Number
Farmer's experience	Independent	FEXP	Years

Productivity Model:

$$LnYIELD = B_0 + B_1 LnLSIZE + B_2 LnSEED + B_3 LnFERT + B_4 LnLAB + Ui$$

Technical Efficiency Model:

$$Ui = B_{0\,i} B_1 AG + B_2 EDUL + B_3 FSIZE + B_4 COPME + B_5 EXVIST + B_6 FEXP + Vi$$

RESULTS AND DISCUSSION

Characterization of Maize Farmers in Musanze District: The age distribution among maize farmers in Musanze District was asked in order to know the range of the age that the farmers who are more involved in maize farming are (Table 3).These results showed that almost 83.6% of households in Musanze District had 31 years oldor above and only 16.42% have below 31 years old. In the sample of 67 maize farmers in Musanze District more farmers (74.6%) was ranged between 31-65 years old. The implication is that the majority maize farmers in Musanze District attained the level of being more productive because of the experience acquired from farming activities. These results are similar to findings of Battese and Coelli (1995) who has found that the old age had a significant positive effect on technical efficiency, because it provides to farmers with experience in farming activities. However, some literature considers age to have an ambiguous effect (Shuhao, 2005).

The level of education of household head of maize farmers was asked to know the knowledge acquired by maize farmers who are involved in farming activities. Education levels of household heads of Musanze District farmers were high such that those who attained primary school represents 55.2%, secondary represent 22.4%, only 1.5% attained University, while 3% attained vocational trainings and about 17.9% are illiterate (Table 3). This shows that a large number of maize farmers in Musanze District, got education. The strong agricultural education and training systems play an important role for farmers to make their farms more productive as the result of the knowledge and skills acquired from learning environment therefore become technically efficient. This is similar to the findings of (Amos, 2007) who found that education positively influences technical efficiency of farms.

On average, almost 89.6 %of households in Musanze District had the land which is less than one hectare where by only10.4% had the land which lies above one hectare. It has been argued that a plot that is averagely less than one hectare can't be economically productive (Mosley, 2004). Most of Rwandan farmers are smallholders; this explained the reason why the small land holders have less incentive to invest more in small farms believing that the return will also be low. An economically productive farm must not be less than 0.9 ha (Kelly and Murekezi, 2000; Mosley, 2004), which is unattainable to many Rwandans. From these assumptions, there is a need for farmers to consolidate their plots in order to make those scattered plots more productive as it will be easy to find farm inputs provided to farmers in form of subsidy given under Crop Intensification Program.

The question regarding the comparison of farm inputs and the maize yield was asked to know whether maize farmers gain from the investment made on consolidated land (Table 3).The results, showed that about 73.2% made some profit from their investments in farms and the rest 26.8% said they made no profit from their investments, this can be explained by the fact that for those who have made some profits, it was because of improved seeds and fertilizers that are provided to them in form of subsidy (vaucha system) and for those who said that they did not make profit, there are others factors associated with land consolidation which jointly contribute to farms productivity such as: erosion control, conservative farming, respect of planting season, timely harvesting, climate, etc.

Cooperative farming has been thought to be the easy and efficient way of raising the living standard of farmers because they can gain more skills and better access to the market. Therefore it was necessary to see if maize farmers in Musanze District are producing within cooperatives. The number of Maize farmers who are producing within cooperatives in Musanze District was still low such that only 52.2% are cooperative members and the remaining 47.8% are not producing within cooperatives as it is shown in the Table 3.Kalirajan (1981), Kalirajan and Flinn (1983) have found that cooperative increases technical efficiency because cooperatives offers to its members the ability to perceive,

interpret and respond to new events and enhances farmers' managerial skills, including efficient use of agricultural inputs.

Extension visit or other kind of farmer trainings are the best ways for them to adopt the best farming methods (practices) in order to make their farms more productive and more profitable. Access to extension services has been reported to positively influence technical efficiency of farmers especially because farmers acquire information on better farming practices and agricultural technologies (Shuhao, 2005). In Musanze District, access to extension services was not enough to give all maize farmers the best ways of increasing efficiency in their farms. Given that only 79.2% in 67 households received one extension visit or more during the planting season A of 2012/2013 (Table 3). With this there is a need for National Extension Services to provide those extension services or trainings to maize farmers in order to provide for them with better farming technics and skills.

Maize farmers in Musanze District did not produce only for household consumption, instead, they were able to do some additional activities from the profit made from maize production. About 7.5% were able to pay health insurance, 25.4% were able to pay school fees and pay health insurance, 9.0% made investment in small projects which can also contribute to their social welfare, 10.4% were capable to buy household tools from earned income and the rest said that with the earned income, they were capable to purchase foods that they did not produce and purchase inputs (seeds and fertilizers) used in crop rotation (Table 3). The implication is that even if the policy of land consolidation is not perceived by people in the same way, there has been an improvement in living standard of farmers especially those who respected the farming practices as it was required by the Government of Rwanda.

The smallholder maize farmers encountered with a lot of challenges which are hindering the efficiency production and distribution of their produce. Maize farmers faced lots of challenges as it is shown in the Table 3, the most constraints observed were the lack of adequate market and low price given to them compared to the cost of production, price unpredictability (price fluctuation) of agricultural products. As most Rwandan farmers are smallholders, the problem of insufficient land also was other major constraint of maize growers. In general, the larger the household land ownership, the more the diversification particularly in crops and the higher the annual household income. The problem of seeds unavailability for irish potatoes which are supposed to be grown in rotation with maize in next growing season. Nowadays Irish potatoes seeds are too expensive such that is about 400rwf per kg and it is not affordable for every farmers due to the delay of money from maize sales because for those who have IMBARAGA and RAB as their main clients they usually sale their maize on credit (they are not paid at time of delivery). This discouraged many maize farmers and choose to sell to informal buyer or supply on the market which in turn paid discouraging prices to farmers. Lack of active participation by private sector in marketing and trading of farm outputs is a major hurdle in transferring the economic benefits of crop intensification to livelihoods in rural areas.

Table 3. Characterization of maize farmers in Musanze District.

Age Group	Frequency	%
20-30	11	16.4
31-50	36	53.7
51-65	14	20.9
>65	6	9.0
Total	**67**	**100.0**
Education		
Primary	37	55.2
Secondary	15	22.4
University	1	1.5
Vocational	2	3.0
Illiterate	12	17.9
Total	67	**100.0**
Land size		
0.1-0.5Ha	31	46.3
0.5-1Ha	29	43.3
1-1.5Ha	7	10.4
Total	67	**100.0**
Comparison between farm inputs and maize yield in Musanze District		
Very enough	4	6.0
Quite enough	17	25.4
Enough	28	41.8
Not enough	17	25.4
Very few	1	1.5
Total	67	**100.0**
Cooperative farming		
Yes	35	52.2
No	32	47.8
Total	**67**	**100.0**
Extension visit or other training received by maize farmers		
Yes	53	79.1
No	14	20.9
Total	**67**	**100.0**
Investment made by maize farmers		
Buy household tools	7	10.4
Both, food consumption and buy seeds	6	9.0
Invest in projects	4	6.0
Pay school fees	3	4.5
Pay health insurance	5	7.5
Food consumption	4	6.0
Buy seeds and fertilizers	7	10.4
Both, household tools and food consumption	8	11.9
Both, school fees and health insurance	17	25.4
Both, invest in project and pay school fees	6	9.0

Total	**67**	**100.0**
The main challenges of maize farmers in Musanze District		
Insufficient land	18	26.9
Low price	4	6.0
Lack of market	8	11.9
Too expensive potato seeds in rotation	11	16.4
Both, lack of market and low price	26	38.8
Total	**67**	**100.0**

Source: Survey data, 2013

Results of the Stochastic Cobb-Douglas Production Function: As expected, results in Table 4, show that almost all of the farm inputs; land, seeds, fertilizers and labor have a significant positive effect on maize production.

Table 4. Results of the stochastic Cobb-Douglas production function.

Model	B	Std. Error	T	Sig
(Constant)	3.331	.365	9.130	.000*
LnLSIZE	.522	.226	2.306	.024**
LnSEED	.077	.147	.521	.604
LnFERT	.289	.184	2.072	.042**
LnLAB	.455	.344	3.162	.002*
Dependent Variable: LnYIELD				

Source: survey data, 2013,
With *, ** and*** mean significant at 1%, 5% and 10% respectively.
YIELD=3.33+0.52 LSIZE +0.07SEED +0.28 FERT+0.45 LAB + ui

R^2=0.659, this means that about 65% of the variation in maize yield is explained by the land size, seeds, fertilizers and labor used. B_1=0.5, is a partial regression coefficient of land size and tell us the influence of land size on the maize production ceteris paribus. This means that for each 1unit increase in land size, there will be an increase in maize yield by 0.5 kgs. B_2=0.07, is a partial regression coefficient of maize seeds and tell us the influence of maize seeds on the maize production ceteris paribus. The same way for each 1unit increase in maize seed, there will be an increase in maize yield by 0.07 kgs all other things equal. B_3=0.28, is a partial regression coefficient of land size and tell us the influence of land size on the maize production ceteris paribus which means that for each 1unit increase in fertilizers used, there will be an increase in maize yield by 0.28 kgs. B_4=0.45, is a partial regression coefficient of land size and tell us the influence of land size on the maize production ceteris paribus. This means that if labor used increases by 1unit, then the yield will increase by 0.45 kg.

The land size is significant at 5% (p=0.024) and has a positive influence on maize production. This study found out that farm size positively affected the productivity of farms; therefore, the larger the farm size, the more the farm is productive. These results are consistent with some empirical evidence which showed that larger farms are economically more productive than small farms (Kelly and Murekezi, 2000; Mosley, 2004). With these results, the hypothesis stated that the larger the plot size, the more the level of productivity of smallholder maize farm in Musanze District was not rejected. Fertilizers are significant 5% (p=0.042) and has a positive influence on maize yield. This implies that the more fertilizers are efficiently applied in maize farms, the more yield will be obtained at the harvesting time. These results are similar to findings of the former researchers Msuya *et al*. (2008) who found that fertilizers positively affected maize productivity in Tanzania. Labor is significant at 1% (p=0.002) and positively affected the maize yield. This means that for maize farmers who used many labor will be technically efficient than those who used less labor because they spent too much time in land preparation and sow late which will reduce the production.

By estimation of translog production function to analyze the determinants of production in Rwanda, Byiringiro and Reardon (1996) found out that land and labor had positive significant effects on production. Msuya *et al*. (2008) found out that land, expenditure on materials (including maize seed and fertilizers) and family labor positively affectedmaize productivity in Tanzania.

Results from Productivity Model: By analyzing the productivity, we have taken into consideration the following variables: Age of the household heads, years of schooling, experience of the farmers, being a cooperative member, extension visit received or other training (Table 5).

Table 5. Results from productivity model.

Variables of the model	B	S. Err	T	Sig
(Constant)	5.487	.651	8.435	.000*
Age of the household head (AG)	-.022	.007	-3.013	.004*
The family size (FSIZE)	.116	.132	.884	.380
Years of experience in maize farming (FEXP)	.026	.025	1.064	.292
Years spent in school (EDUL)	.225	.108	2.072	.043**
Being a cooperative member (COPME)	-.836	.199	-4.209	.000*
The number of extension visit received (EXVIST)	-.509	.094	-2.597	.003*

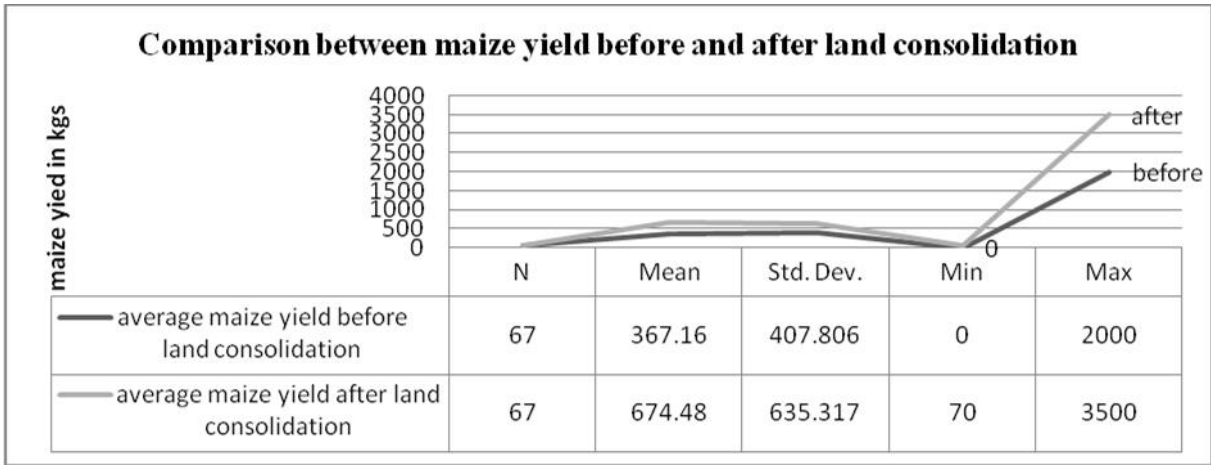
Source: Survey data, 2013,
With *, ** mean significant at 1%, 5% respectively.

In the productivity model, only three variables were significant. A negative sign in the inefficiency model indicates the negative effect on inefficiency or positive effect on efficiency. Variables that reduce inefficiency increase productivity.The age is significant at 1% (p=0.004) and it has a significant negative effect on productivity; this implies that households headed by old people were more efficient than those headed by young ones. This was perhaps due to the fact that older household heads had farming experience and adopted new technologies than young ones. This finding confirmed the results of previous studies conducted by Battese and Coelli, 1995 ; Kibaara, 2005.

The education level (years of schooling) of the household head was significant at 5% (p=0.043) and it is found to have a significant positive effect on productivity means that it reduces productivity. This result is consistent with the finding by Fleming and Lummani (2001) for cocoa smallholders in Papua New Guinea that a higher education is often associated with more off-farm employment that limits the time and attention given to growing crops. Fleming and Lummani (2001) found that this effect outweighs the greater capacity of more educated cocoa smallholders to make better use of information in taking decisions and be more open to improved farming methods.This result contrast with the results of the estimated model for coffee production alone (Overfield and Fleming, 2001), where more years of schooling were found to be associated with lower technical inefficiency, suggesting that it could be misleading to examine efficiency effects on one production activity independently of other activities in the farming system.

Similar results were reported by Kalirajan (1981) in India, Kalirajan and Flinn (1983) in the Philippines that vegetable farming is highly dependent on the experience of farmers. In this study's model, being a cooperative member were found to have a negative effect on the technical inefficiency, cooperative offer to its members the ability to perceive, interpret and respond to new events and enhances farmers' managerial skills, including efficient use of agricultural inputs. Similar results were reported by (Kalirajan, 1981) in India and (Kalirajan and Flinn, 1983) in the Philippines.

Comparison between Maize Production before and after Land Consolidation: This question was asked to know the improvement made in smallholder maize farms after land consolidation as the policy seeks to increase the productivity of farms. The results from descriptive statistics showed that the average maize yield has increased over time such that, the average of maize yield was 367.16 kgs per household before land consolidation and 674.48 kgsafter land consolidation moving from 2008-2012 as represented by X axis in Figure 2. With these results, the rate of change was calculated in order to know at which rate the maize production has increased. We used the difference between the average maize obtained before land consolidation and the average maize obtained after land consolidation. Therefore, the estimated rate of change was 45.48% of the increase in maize yield. This implied that the policy has made a great improvement on the productivity of maize farms such that the maize yield were almost doubled after farmers consolidated their plots. With these results, the second hypothesis was accepted.



	N	Mean	Std. Dev.	Min	Max
average maize yield before land consolidation	67	367.16	407.806	0	2000
average maize yield after land consolidation	67	674.48	635.317	70	3500

Figure 2: Descriptive statistics comparing maize yield before and after land consolidation
Source: Survey data, 2013

Conclusion and Recommendation: This study purposely sampled farmers known to be practicing land consolidation and known to be maize farmers in Musanze District. The Cobb-Douglass function model results showed that land under maize cultivation, fertilizers and labor have a significant and positive influence on maize

farm productivity; even if maize seed was not significant it positively affected the maize yield; this is because of the actual policy of Crop Intensification Program which is providing farm inputs (seeds and fertilizes) to farmers in form of subsidy. On the productivity model, the results showed that age, years of schooling, extension access and cooperative farming have a significant impact on the productivity of maize farmers who consolidated their land; farmer's experience was not significant but positively affected the productivity of maize farmers. Finally, the rate of change in maize yield was estimated to be 83.7% comparing the average maize yield before and after land consolidation, this showed that there has been an improvement in maize production as the result of land consolidation.

There has been a very significant expansion in maize production by adoption of land consolidation in Musanze District; following promotional efforts by the Government of Rwanda aiming to improve food security among vulnerable farmers across the country. The significant yield gains realized from adopting land consolidation also indicated that maize farmers have become more and more adopting new farming methods associated with the farming technology. There were a strong support by both farmer Federation (IMBARAGA) and Public Institutions (RAB) agents through the supply of seeds, fertilizers and extension access increased the likelihood of land consolidation adoption in the research area. The main revealed hindrance of land consolidation within maize farmers is unavailability of farm inputs used when they are rotating maize with Irish potatoes and the misunderstanding between farmers and local leaders who are supposed to implement the policy. The management of crop residues and access to such inputs as seed and inorganic fertilizers need to be improved for farmers to achieve maximum benefits with the policy. Based on the results, this study propose strategies such as providing better extension services, farmer training programs, raising the educational level of farmers, and providing farmers with greater access to credit, encourage cooperative farming which could increase the bargaining power to afford better prices in order to increase the productivity of fragmented maize farms in the region. As most of farmers in the region are the smallholders, it is the tasks of all stakeholders who are involved in agricultural activities to put much efforts in efficiency use improved seeds varieties and fertilizers so that small farms can become more productive.

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REFERENCES

Amos, T. T. (2007). An Analysis of Productivity and Technical Efficiency of Smallholder Cocoa Farmers in Nigeria, J. Social Science, 15 (2): 127 - 133.

Battese, G. E. and T. J. Coelli (1995). A model for Technical Inefficiency Effects in A Stochastic Frontier Production Function for Panel Data. Empirical Economics, 20:325-332

Byiringiro, F. and T. Reardon (1996). Farm Productivity in Rwanda: the Effects of Farm Size, Erosion and Soil Conservation Investments, Agricultural Economics, 15: 132-135.

Fleming, E. and J. Lummani (2001). Analysis of The Technical Efficiency of Cocoa Smallholders in the Gazelle Peninsula, East New Britain Province, Occasional Paper 7, Understanding the Smallholder Cocoa and Coconut Sector in Papua New Guinea, PNG Cocoa and Coconut Research Institute, Keravat.

Grinnell, R. M. and M. Williams (1990). Research in Social Work: A Primer, F.E. Peacock Publishers, New York.

Kalirajan, K. P. (1981). An Econometric Analysis of Yield Variability in Paddy Production, Canadian J. Agricultural Economics, 29: 283-94.

Kalirajan, K.P. and J.C. Flinn (1983). The Measurement of Farm-Specific Technical Efficiency. Pakistan J. Applied Economics, 2: 167-180.

Kathiresan, A. (2012). Farm Land Use Consolidation in Rwanda, Assessment from the Perspectives of Agriculture Sector. Ministry of Agriculture and Animal Resources, Kigali Rwanda.

Kelly, D. and A. Murekezi (2000). Fertilizer Response and Profitability in Rwanda, A Synthesis of Findings from MINAGRI Studies Conducted by The Food Security Research Project (FSRP) and The FAO Soil Fertility Initiative. Republic of Rwanda Ministry of Agriculture, Animal Resources, and Forestry.

Kibaara, B. W (2005). Technical Efficiency in Kenyan's Maize Production: An Application of the Stochastic Frontier Approach. Master of Science Thesis, Colorado State University. Available at: http://fsg.afre.msu.edu/kenya/o_papers/tech_eff_maize.pdf

Kumbhakar, S.C., S. Ghosh and J.T. McGuckin (1991). A Generalized Production Frontier Approach for Estimating Determinants of Inefficiency in U.S. Dairy Farms. J. Business & Economic Statistics, 9(3): 279-286.

Mosley, J. (2004). Land Policy in Rwanda. Issues for UK Policy, APPG Working Paper 3, London.

Msuya, E., S. Hisano and T. Nariu (2008). Explaining Productivity Variation among Smallholder Maize Farmers in Tanzania. Graduate School, Faculty of Economics, Kyoto University. Available at: http://mpra.ub.uni-muenchen.de/14626/. MPRA Paper No. 14626.

Musanze DDP (2012). Musanze District Development Plan, Republic of Rwanda Northern Province.

Nguyen, T., E. Cheng and C. Findlay (1996). Land Fragmentation and Farm Productivity in China in the 1990s. China Economic Review, 7(2): 169-180.

NISR (2011). Rwanda Statistical Yearbook. Rwanda: http://statistics.gov.rw

Overfield, D. and E. Fleming (2001). A Note on the Influence of Gender Relations on the Technical Efficiency of Smallholder Coffee Production in Papua New Guinea. Agicultural Economics, 52(1): 153-156.

Shuhao, T. (2005). Land Fragmentation and Rice Production: A Case Study of Small Farmsin Jiangxi Province, P. R. China. Ph.D. Thesis. Wageningen University.

Tan, B.H., 2008. Cobb Douglas Production Function,http://docentes.fe.unl.pt/~jamador/Macro/ cobb-douglas.pdf.

USAID (2011). Country Profile. Rwanda, Property Rights and Resource Governance Profile. United State Agency for International Development.