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CROP PRODUCTION AND FOOD CONSUMPTION FOR FARMERS' WELFARE IN RWANDA

Aristide MANIRIHO[1,2 *], Edouard MUSABANGANJI[2], Philippe LEBAILLY[1]

[1] Unity of Economics and Rural Development, Gembloux Agro-Bio Tech, University de Liège, Gembloux, Belgium.
[2] School of Economics, University of Rwanda, Kigali, Rwanda
*Corresponding author: Aristide.Maniriho@student.uliege.be, manirihoaristide1@gmail.com

Abstract

Agriculture is a source of livelihood for increasing population in the world. It provides mainly food and is expected to avail enough income to farmers and thus improve their livelihood through the increased yield. This study attempted to assess the effects of crop production and food consumption on farmers' welfare. We used secondary data collected at national level during the Fifth Integrated Household Living Conditions from October 2016 to October 2017. For data analysis, Chi-Square test, Pearson's correlation coefficient, t test, and ordinary least-squares (OLS) methods were used. The results revealed that the crop output increased with the increase in inputs (labour, fertilizers, pesticides, and seeds). The return to scale of crop production was 1.06, which implies that the crop production system scored increasing returns to scale. The OLS estimates indicated that food consumption was positively influenced by the age and the marital status of the household head, the household size, farm income, land size, crop production, when bean, maize, potato, rice and soybean were the main crops selected by the farmers, while it was negatively affected by the sex of the household head, when coffee and wheat were the crops chosen by the farmers. The results from Pearson's correlation analysis showed that food consumption was positively and significantly (p=0.00) correlated with family size, farm income, land size, and crop production. With reference to these findings, we recommend that the strategies to increase the crop yield and farm income and thus sustain food consumption and improve farmers' welfare should be enhanced.

Keywords: *crop yield, farm income, food consumption, farmers' welfare, Rwanda*.

Introduction

Crop production should be a primary source of rural development and a cornerstone of farmers' livelihood through the increased yield (Gollin et al., 2002) specifically in less developed economies (Jalan & Ravallion, 2002). It is expected to be a profitable enterprise for it to provide enough income to crop growers (Pender et al., 2004; Maniriho & Bizoza, 2013) and thus to contribute to positive transformation of farmers' welfare (Nyambose & Jumbe, 2013). However, the available resources (mainly land and labour) are not used for high productivity, and this constrains the agriculture to assume appropriately its role in economic development of mainly availing enough food to the population of a country and providing the surplus for exports (Johnston & Mellor, 1961).

In intent to move farmers to the improved level of livelihood, the Government of Rwanda has initiated different anti-poverty programs. As far as the agriculture sector is concerned, the Crop Intensification Program (CIP) was launched in September 2009 to modernise agriculture (MINECOFIN, 2012; Alinda & Abbott, 2012), complemented with "one cow per poor family program" whose main role was to enable the poor to access to protein, and to supply them sustainable organic fertilizers (Kato et al., 2011; Nilsson et al., 2019) that are important for erosion reduction, food security and climate change adaptation (Lal, 2004). Throughout the Economic Development and Poverty Reduction Strategy (EDPRS), agriculture is considered as cornerstone driver for long-term growth and appeals for public efforts in conjunction with

all other development partners to stimulate increasing use of improved inputs and to encourage them to participate in both implementation and monitoring (Government of Rwanda, 2007). Further, the National Decentralized Policy integrates agriculture development in the planning and management of the holistic development process by taking it as the priority area and empowering local populations for them to participate in the initiatives aiming at graduating them out of poverty (Bingen and Munyankusi, 2002).

Previous studies reported the positive effects of some socioeconomic development initiatives on household welfare in Rwanda. With reference to CIP, Maniriho and Bizoza (2013) showed that potato, wheat, maize, tomato, onion, and cabbage are profitable crops that are more likely to improve the farmer's welfare, including nutrition. For one cow per poor family program, Nilsson et al. (2019) found out that the program affected positively the crop production but not the per capita consumption.

Table 1. Comparison of potential yield to current yield of selected CIP crops in Rwanda.

No	Crop	Potential yield (Tones/ha)	Current yield (Tones/ha)	Gap (Tones/ha)
1	Maize	3.79	1.53	2.26
2	Bean	1.60	0.91	0.69
3	Rice	6.69	3.40	3.29
4	Wheat	3.17	1.33	1.84
5	Cassava	38.89	13.54	25.35
6	Potato	20	8.65	11.35
7	Soybean	2.25	0.51	1.74

Note: The information on the potential crop yields are obtained from the technical factsheets published by AFSR (*Appui à la Filière Semencière au Rwanda*) in 2007. The average for different varieties was computed except for the potato where the minimum is considered (the potato average potential crop yield is 29.69 Tones/ha). As for the current crop yield, we considered the statistics of Seasonal Agricultural Survey data, season 2018A, published by National Institute of Statistics of Rwanda. Further, CIP stands for Crop Intensification Program in Rwanda, and ha for hectare.

The current statistics show that the agriculture sector increased at the growth rate of 6% in 2018, while the whole economy increased at 8.6% (NISR, 2018a). Notwithstanding all these efforts and the agriculture development achievements, the malnutrition issues are still crucial among Rwandans especially the stunting cases (World Bank Group, 2018) at the countrywide rate of 35% (NISR, 2018b).

The purpose of this study is to assess the prospects of crop production and food consumption for farmers' welfare. It aims specifically to analyze the relationship between the crop choice and the welfare categories, to compare the mean food consumptions between the growers and non-growers of selected crops, and identify the determinants of crop production and factors influencing food consumption in Rwanda.

Materials and Methods

This study used secondary data collected through the Fifth Integrated Household Living Conditions (EICV 5) survey from October 2016 to October 2017. This is a national level survey conducted on a random sample of 14 580 households, sampled from 245 villages and 2 526 households in urban areas and 1 015 villages and 12 054 households in rural areas. It contained 10 cycles on the whole year to account for seasonality of household incomes and expenditures. Part of the purpose of EICV5 was to avail required statistics to enable the assessment of the anti-poverty initiatives undertaken by the Government of Rwanda (NISR, 2018b). The study variables are well described in Table 2.

Table 2. Descriptive Statistics of the study variables.

Variable	Obs	Mean	Std. Dev.	Min	Max
Age (years)	11801	46.94	15.58	14	105
Mar_status (1=married)	11801	.91	.28	0	1
Sex (1=female)	11801	.26	.44	0	1
Family size	11801	4.58	2.04	1	17
Production (FRW)	11801	393.13	1,250.81	1	58,000
Agri_income (FRW)	11801	5,515.69	47,371.66	0	2,730,000
Food cons. (FRW)	11801	742,000	513,000	8138.57	6,210,000
Land size (ares)	11801	58.64	256.47	.02	13,476
Labour (FRW)	11204	14,365.22	54,472.83	0	1,400,000
Chemical fertilizers (FRW)	11204	5,362.99	31,962.01	0	2,700,000
Organic fertilizers (FRW)	11204	1,590.95	10,888.66	0	575,000
Pesticides (FRW)	11204	1,774.81	14,120.99	0	700,000
Traditional seeds (FRW)	11204	6,312.17	17,169.83	0	700,000
Improved seeds (FRW)	11204	2,247.89	19,699.16	0	1,000,000
Poverty*	11801	2.50	.73	1	3

Note: * indicates that poverty is measuring the welfare categories (1=severely poor, 2=moderately poor, and 3=non poor). FRW stands for Rwandan francs. Food cons. means food consumption, and Mar_status stands for marital status.

For analyzing data, the Chi Square statistic was computed to test for the association between two categorical variables (Diener-West, 2008) using the formula 1.

(1) $\chi^2 = \sum \frac{(O-E)^2}{E}$,

Where χ^2 is the Chi Square statistic, O stands for the observed frequency, and E the expected frequency.

To test for the association between continuous variables, the Pearson Product-Moment Correlation coefficient "r_{xy}" was computed (Asuero et al., 2006; Hall, 2015). This is known as the ratio of the normalized covariance of two continuous variables "C_{xy}" to the square root of their variances "$\sqrt{C_{xx}C_{yy}}$", and well described by the formula 2. The pairwise correlations between food consumption, crop production, land size, farm income, family size and the age of the household head were computed.

(2) $$r_{xy} = \frac{\sum_i (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_i \{[(x_i - x)^2][(y_i - y)^2]\}}} = \frac{C_{xy}}{\sqrt{C_{xx}C_{yy}}} = \frac{C_{xy}}{\sigma_x \sigma_y}$$

The third method used to analyze data is the t test. The t statistic was used to compare food consumption between producers and non-producers of selected crops (maize, potato, bean, soybean, wheat, coffee and rice). The t statistic was computed using the formula 3.

(3) $$t = \frac{M_1 - M_2}{\frac{S_1}{\sqrt{n_1}} + \frac{S_2}{\sqrt{n_2}}}$$

Where $(M_1 - M_2)$ is the difference between the means of the two groups (the growers, and the non-growers of selected crops), S_1 and n_1 are the standard deviation and the size of one group, S_2 and n_2 are the standard deviation and the size of another group, respectively.

Finally, an econometric approach was used to identify the factors affecting crop production and food consumption among crop growers. Following Gujarati (2009) and Wooldridge (2013), the model to be estimated for this case study is described by the formula (4).

$$(4)\ Y_i = \beta_0 + \beta_2 \sum_{k=1}^{n} X_{ki} + e_i$$

where Y is a dependent variable (food consumption, or crop production), Xs are independent variables, e_i is a disturbance term, βs are parameters to be estimated. For identifying the determinants of crop production, two models were specified and estimated. One is the linear model that included both farm inputs and socioeconomic characteristics of farmers (following the application by Mpawenimana, 2005 as an example), while the other is a Cobb-Douglas production function that included exclusively the farm inputs (see Debertin, 2012 for details). As for the food consumption function, a linear model was chosen (see Gujarati, 2009). Seeing that crop production was among the determinants of food consumption, a Two-Stage Least Squares (2SLS) estimator was used to estimate the coefficients of this function and to account for endogeneity and simultaneity bias (Wooldridge, 2013).

Results and Discussion

This study attempted to compare the average food consumption between producers and non-producers of main crops grown in Rwanda, namely maize, potato, bean, soybean, wheat, coffee and rice. The results from the t test show that crops whose producers consume more food than the non-producers are the maize, potato, bean, soybean and rice, while the producers of wheat and coffee afford less food than the non-producers (see Table 3).

This could be due to the fact that the production system of coffee and wheat requires the farmers to incur huge amount of expenses, which appeals the household members to deprive themselves from some food items for sometimes. The table 4 summarizes the relationships between different crops and welfare categories. The results show the percentages of the crop producers who are severely poor, moderately poor and non-poor, respectively. For the maize for example, 11.01% of producers are severely poor, 20.64% are moderately poor, while 68.35% are not poor. The first three crops with high percentage of non-poor are rice, maize and soybean, with 72.43%, 68.35% and 67.49%, respectively. The Chi-square test (formula 1) indicates that the welfare of Table 3. Comparison of food consumption between producers and non-producers of different crops.

Crop grown	**Comparison of food consumption between producers and non-producers**						
	Maize	**Potato**	**Bean**	**Soybean**	**Wheat**	**Coffee**	**Rice**
Non-growers	617 297	695 665	640 848	725 631	740 894	745 280	735 999
Growers	799 781	782 997	750 755	785 122	770 575	716 409	877 743
Combined	742 317	742 317	742 317	742 317	742 317	742 317	742 317
Difference	-128 485	-87 331	-109 907	-59 491	-29 682	28 871	-141 744
t statistic	-13.65	-9.27	-6.21	-5.67	-1.34	1.86	-6.21
Prob > t	0.00	0.00	0.00	0.00	0.18	0.06	0.00

households is significantly associated with maize production (chi2=164.40; p-value=0.00), bean production (chi2=103.72; p-value=0.00), and potato (chi2=83.35; p-value=0.00), as well as soybean and rice. However, wheat (chi2=4.28; p-value=0.12) and coffee (chi2=0.57; p-value=0.75) are not significantly associated with household's welfare.

Table 4. Relationships between different crops and welfare categories.

Welfare categories	**Maize growers**	**Potato growers**	**Bean growers**	**Soybean growers**	**Wheat growers**	**Coffee growers**	**Rice growers**
Severely poor (%)	11.01	11.74	13.13	11.30	14.49	13.38	7.79
Moderately poor (%)	20.64	21.18	22.22	21.21	25.62	22.87	19.77
Non poor (%)	68.35	67.08	64.65	67.49	59.89	63.75	72.43
Total (%)	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
Total (Numbers)	**6 522**	**6 304**	**10 895**	**3 310**	**566**	**1 211**	**526**
Pearson chi2	164.40	83.35	103.72	37.53	4.28	0.57	23.50
Prob > chi2	0.00	0.00	0.00	0.00	0.12	0.75	0.00

This enhances the idea that farmers should choose to grow the crops that contribute to the improvement of household welfare (Pender et al., 2004; Maniriho & Bizoza, 2013; Nyambose & Jumbe, 2013). This shows the positive effects of the crops selected for the implementation of the Crop Intensification Program (CIP) to the transformation of livelihoods in Rwanda, even though the issue of low productivity of these crops remains crucial (Table 1).

Concerning the econometric analysis (Table 5), the 2SLS estimates from Model 1 indicated that food consumption was positively influenced by the age and the marital status of the household head, as well as the household size, , while it was negatively affected by the sex of the household head. For the crop production, the log-log model (R2=0.39) was superior to the linear model (R2=0.36). The results revealed that the crop output increased with the increase in inputs (labour, chemical fertilizers, organic fertilizers, pesticides, and traditional seeds) in line with the existing literature in economics (Dwivedi, 2006; Schotter, 2009; Besanko et al., 2011; Debertin, 2012). The effect of improved seeds on crop production was unexpectedly negative. This could be due to the seeds and/or the farming practices that may not be adapted to the soils, or to climate variability. The results also show that the crop system uses intensively the organic fertilizers (given their elasticity of 0.38) followed by labour (elasticity=0.21). This implied that the use of chemical fertilizers should be enhanced if the increasing crop productivity is to be achieved. The table 5 shows the pairwise correlations of the key variables of the study, and table 6 summarizes the linear regression estimates of food consumption and crop production.

Table 5. Pairwise correlations of the continuous variables.

Variables	(1)	(2)	(3)	(4)	(5)	(6)
(1) Age	1.00					
(2) Food cons.	0.01	1.00				
	(0.53)					
(3) Family size	-0.03	0.47	1.00			
	(0.00)	(0.00)				
(4) Agri_income	0.02	0.14	0.07	1.00		
	(0.06)	(0.00)	(0.00)			
(5) Land size	0.04	0.13	0.07	0.08	1.00	
	(0.00)	(0.00)	(0.00)	(0.00)		
(6) Production	0.01	0.24	0.13	0.09	0.09	1.00
	(0.58)	(0.00)	(0.00)	(0.00)	(0.00)	

Note: The figures in the parentheses are the significance levels (p-values).

Table 6. Linear regression estimates of food consumption and crop production.

Model 1 Food consumption (2SLS)		Model 2 Crop production (OLS)		Model 3 Crop production (Ln) (OLS)	
Variables	Coefficients	Variables	Coefficients	Variables	Coefficients
Age	1199.81***	Labour	0.004***	Labour (Ln)	0.35**
Sex	-79400.00***	Land size	0.09**	Land size (Ln)	0.07
Mar_status	19199.52	Chem. fert.	0.01***	Chem. fert. (Ln)	0.14*
hhsize	90803.69***	Org. fertil.	0.001	Org. fertil. (Ln)	0.15
Crop prod [a]	274.51***	Pesticides	0.02***	Pesticides (Ln)	-0.06
--	--	Tradit. seeds	0.01***	Tradit. seeds (Ln)	0.21***
--	--	Improv. seeds	0.004***	Improv. seeds (Ln)	0.20
--	--	Age	2.35***	--	--
--	--	Sex	-6.16	--	--
--	--	Mar. status	-23.27	--	--
--	--	Hh size	34.11***	--	--
--	--	Farm income	-0.001***	--	--
--	--	Crops dummies	Yes [b]	--	--
--	--	Locat. factors	Yes [c]	Return to scale	1.06 [e]
Constant	165000.00***	Constant	-104.41***	Constant	1.66***
Obs.	11801	Obs.	11204	Obs.	148
R-squared	0.028	F-stat	23.86	F-stat	20.697
Chi2	2993.35	Prob > F	0.00	Prob > F	0.00
Prob > chi2	0.00	R-squared	0.35 [d]	R-squared	0.509 [d]

Note: *** p<0.01, ** p<0.05, * p<0.1. [a] Crop production was instrumented with land size, farm income, chemical and organic fertilizers, traditional and improved seeds, as well as pesticides. [b] Crop dummies (yes=1; selected crops: maize, bean, soybean, rice, wheat, potato, and coffee). [c] This study controlled the location by including province, district and clusts (villages) in the regression. [d] The R-square was significant as the study used cross-section data (see Wooldridge, 2002 for details). [e] The return to scale of 1.06 implied that the crop farming scored increasing returns to scale (see Debertin 2012 for details). Ln stands for natural logarithm, hhsize for household size, mar_status for marital status, chem. fert. for chemical fertilizers, org. fertil. for organic fertilizers, crop prod for crop production, tradit. for traditional, improve. for improved, and locat. lor locational (factors).

Besides, the return to scale of crop production was 1.06, which implied that the farming system scored increasing returns to scale. This means that the crop output increased more quickly than the inputs increase (Dwivedi, 2006; Schotter, 2009; Besanko et al., 2011; Debertin, 2012). The regression estimates were complemented with the pairwise correlations of continuous variables given in Table 6. These results showed that food consumption was positively and significantly correlated with farm income, land size, crop production and family size. As for the crop production, the results indicated that it was positively and significantly correlated with land size, farm income, family size and food consumption.

Conclusion and Recommendations

This study attempted to assess the way farmers' welfare is affected by crop production and food consumption in Rwanda. In collaboration with diverse development partners, the Government of Rwanda committed to boost crop yield so as to increase farm income and improve farmers' welfare. We used the 5th round of the Integrated household life conditions survey data collected from October 2016 to October 2017. The Chi-Square test, the Pearson's correlation coefficient, the t test, and the OLS methods were used for data analysis.

The results from linear regression analysis showed that the increase in agricultural inputs lead to a significant increase in crop output with increasing return to scale. The t test showed that the crop farmers who grew maize, potato, bean, soybean and rice had higher consumption than the producers of other crops (see Table 2). Besides, the chi-square test outcome indicated that the production of maize, potato, bean, soybean and rice were significantly associated with the welfare categories (see Table 3). The results of both t and chi-square tests implied that the production of maize, potato, bean, soybean and rice made the farmers better off than other crops. As for the correlation test (see Table 6), the results showed that food consumption was positively and significantly correlated with family size, farm income, and land size, but not significantly correlated with crop production. This complemented the positive effects of these variables on food consumption as revealed by 2SLS estimates of the Model 1.

From the OLS estimates of the Model 3, we concluded that the crop output was driven by the amount of labour, fertilizers, pesticides and seeds used. The most influential inputs were organic fertilizers, labour and pesticides and the agriculture scored increasing returns to scale. The results from econometric estimations and other statistical tests led to state that crop production was among the primary drivers of famers' welfare besides the farm income, the land size and the family size.

With reference to these findings, we recommend that the strategies to increase the crop yield and farm income and thus sustain food consumption and improve farmers' welfare should be enhanced.

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