The impact of technology use on agricultural production in Rwanda (2016 season A, B, C)

Jules Maurice UBARIJORO (m.julesubarijoro@gmail.com)
University of Rwanda
Jean Bosco NDIKUBWIMANA
University of Rwanda https://orcid.org/0000-0001-5154-8218
Angelique DUKUNDE
University of Rwanda
Eric Shyaka MUZUNGU
University of Kigali

Research Article

Keywords: technology, agricultural productivity, irrigation, improved seed, fertilizers, agricultural area.

Posted Date: September 14th, 2020

DOI: https://doi.org/10.21203/rs.3.rs-73725/v1

The impact of technology use on agricultural production in Rwanda (2016 season A, B, C)

By:

Jules Maurice UBARIJORO[1], Jean Bosco NDIKUBWIMANA [2], Angelique DUKUNDE[3]and Eric Shyaka MUZUNGU [4]

[1]Applied Statistics Department, School of Economics, College of Business and Economics, University of Rwanda. E**-mail**:m.julesubarijoro@gmail.com , (+250)784327855
[2]Applied Statistics Department, School of Economics, College of Business and Economics, University of Rwanda. **E-mail:** ndikujeanbosco@gmail.com , (+250) 788568333
[3] Economics Department, Faculty of Business Management and Economics, University of Kigali (UoK) and ACE-DS, College of Business and Economics (CBE), University of Rwanda (UR). E-mail: adukunde@uok.ac.rw and angeliquedukunde@gmail.com , (+250) 788803313
[4] Economics Department, Faculty of Business Management and Economics, University of Kigali (UoK); E-mail: emuzungu@uok.ac.rw
Corresponding Author e-mails:m.julesubarijoro@gmail.com, ndikujeanbosco@gmail.com

Abstract

This study deals with the impact of technology use on agricultural productivity in Rwanda with purpose of assessing the impact of technology adoption in agriculture to its productivity in season A, B, and C in 2016 .The researchers used data from Rwanda seasonal agricultural survey (RSAS) to successfully complete the analysis. Chi-square, cross tabulation analysis and multiple linear regression analysis were used to identify the impact of technology use on agricultural production. From bivariate analysis find that there are some existing technologies that are not influencing production just because of low level of their utilization and multiple linear regressions was found that some of the technologies such as use of improved seed, use organic fertilizers, area and use irrigation were showed that are statistically significant on agricultural production with p-values of 0.0455, 0.0313, 0.000, and 0.0457 respectively which means that, these technologies increased agricultural production for few farmers who used technologies in 2016. Researchers conclude that, technologies were inefficiently used by farmers due to the accessibility of these technologies and then recommend the Government policy makers, farmers policy makers, researchers and farmers to consolidate their efforts towards technology adoption in agriculture sector to ensure food security and sustainable agriculture and also further researches that will emphasis on adding certain variables which reduce the farmers' vulnerability to loss the income are highly encouraged.

Keywords: technology, agricultural productivity, irrigation, improved seed, fertilizers, agricultural area.

Introduction

The World Bank's World Development Report 2008 reported that agriculture remains one of the most promising instruments for poverty reduction (world Bank, 2008). Rwanda's economy has been growing steadily for most of the past decade, at rates ranging between 6-7% and often exceeding double digits (11.8% in 2008) (MINAGRI, 2012). In the third quarter of 2014, the economy grew at an impressive 7.8%. This rate makes Rwanda one of the fastest growing economies in the world. This growth is the result of steady and consistent investment in areas such as infrastructure (mostly roads, electricity), agricultural production etc. (MINAGRI, 2015). The history of technological change in developing country agriculture is one where farmers and farming communities have historically been the main innovators, followed by the public sector which released the technology of the Green Revolution as a public good, and subsequently the private sector when changes in intellectual property rights (IPR) legislation allowed to capture returns from research in biology, unleashing a new wave of biotechnological innovations as private goods (Alain de Janvry, David Zilberman, Gregory Graff, & Elisabeth Sadoulet, 2001).

Agricultural production is generally rain-fed, with only 2.1% farmers practicing irrigation, thus, the variety and type of crop grown and when, depends largely on the rainfall pattern. The Government of Rwanda (GoR) has recently rolled out a comprehensive irrigation program to put at least 20,000 hectares of land under irrigated agriculture (NISR, 2013) Rwandan Government is seeking how to intensify agricultural production and raise farmer's income on existing small lands. For this reason, heavy investments are being to render marshlands cultivable, putting in place irrigation systems, facilitate inputs and mechanization to diversify and enhance the level of productivity in small farms (KATHIRESAN, Arumugam, 2012).

Increasing agricultural productivity is all the more urgent LDC issue because the majority of the developing world's poor are found in rural areas, and the sector's average productivity is actually declining in many low-income countries (Norton, 2017), but agricultural productivity varies due to large differences in the level of adoption of selected agricultural technologies and the underlying determinants of adoption of these technologies. A study from Kenya (Salasya, B, Mwangi, W.M., Mwabu, D, & Diallo, A, 2007), showed that the main attributes of WH(wheat hybrid) 502 that influenced its

adoption were high yield, early maturity and non-lodging, whereas the important socio-economic factors were farm size, cattle ownership, education level of the farmer and locality specific characteristics. Unexpected climatic factors may make farmers to hesitate to adopt the new technology. Results by (Cavatassi, Lipper, & Narloch, 2011) on Adoption rates of improved or modern varieties (MV) showed that risk-factors coupled with access to markets and social capital drive farmers' decisions to adopt MVs or not to adopt. On the one hand, it appears that farmers use MVs to mitigate moderate risks. On the other hand, farmers who have been most vulnerable to extreme weather events are less likely to use MVs. This indicates that climatic risks negatively influence farmers' adoption of modern technologies (Cavatassi et al., 2011).

(Solomon Asfaw, Menale Kassie, Franklin Simtowe, & Leslie Lipper, 2010), estimated the casual impact of technology adoption by utilizing endogenous switching regression and propensity score matching methods to assess results robustness, in the research conducted on Ethiopia and Tanzania,, and identified the welfare effect of technology adoption by controlling for the role of selection problem on production and adoption decisions. His analysis revealed that adoption of improved agricultural technologies has a significant positive impact on crop income although the impact on consumption expenditure is mixed. This result confirms the potential direct role of technology adoption on improving rural household welfare, as higher incomes from improved technology translate into lower income poverty.

To enhance the agricultural sector the Rwandan government set a number of programs including the intensification of sustainable production systems in crop cultivation and animal husbandry; building the technical and organizational capacity of farmers; promoting commodity chains and agribusiness, and strengthening the institutional framework of the sector at central and local level. Rwanda has improved the agricultural sector by helping farmers adopt modern farming techniques to increase productivity. The Ministry of Agriculture and Animal Resources (MINAGRI) hopes this will be the viable road to end poverty and improve the standards of living for all Rwandans. Agricultural output in the country meets 90 per cent of the national food needs and generates more than 70% of the country's export revenues, a substantial share of the country's development (Ernest Nyetera, 2016).

Agricultural sector in Rwanda is confronted with many challenges: agricultural production system is dominated by small-scale farming with less than one ha of cultivable land, soil degradation, dependence of agriculture on climate, shortage of fertilizers, lack of improved seed, and so on (GoR, 2009)

However, the population growth, although at a diminishing rate, is increasing posing the land size equation to be more complicated due to declining per capita farm size and land fragmentation into smaller pieces of land parcels. This situation makes difficult the option of increasing agricultural production through increased cultivated space (DFID, 2011). To overcome this great challenge, the agricultural sector should be deeply transformed and modernized. This requires an extension strategy able to facilitate all producers to access technological packages and information they need. According to (GoR, 2009). This will be done through adoption new and modern agricultural technologies to reach the projection of vision 2020 of modernized agricultural sector to employ more 50% of the population.

Most of the reviewed literature did not analyze specifically, the relationships and the contribution of available technologies that are nearly presences in agricultural sector. Majority of the study focused on the factors that influencing adoption of technologies in agriculture sector in different communities. Hence this study is designed to address that gap, by assessing contribution of agricultural area, use of irrigation, use pesticides, improved seeds, soil preparation equipment, use of fertilizers and use anti-erosion methodologies to address and inform farmers the existing technologies which are not being exploited for the improvement of Rwandan agricultural productivity.

The general objective is to assess the impact of technology adoption/use in the agriculture productivity in Rwanda. Specifically, the study assess the adopted technology in agriculture; investigate the level of agricultural production and assess the relationship between technology use and agricultural productivity in Rwanda. The study uses the following hypotheses: The agricultural productions are different across provinces in Rwanda, the adoption of technology affects negatively the agricultural productions and there is a positive relationship between technology and agricultural productions.

Materials and Methods

This study was investigated by using data set from seasonal agricultural survey across the country in 2016. This is because RSAS dataset compiled all indicators used for agricultural productivity such as use of organic and inorganic fertilizers, use of improved seeds, irrigation, pesticides, agricultural equipment, and anti-erosion methodologies. This study used secondary data mainly in agricultural sector, private sector especially in agribusiness which was collected from national institute of statistics of Rwanda. Then conducting this study provide, orient, and discover the agricultural opportunity for youth as one of the solution to the high rate unemployment and their influences on the sustainable agriculture. The descriptive statistics was used for summarizing the characteristics of population in the study. Bivariate analysis also helped us using p-values to test the significances of variables included in the study and ensuring also the reliability of the model. Multiple linear regression models consisting of eight independent variables like used agricultural area, use of irrigation, percentage of plots with organic and inorganic fertilizers, percentages of plots use pesticides, use of anti-erosion, and improved seeds and agriculture equipment for assessing "technology impact on agricultural production".

$$Y = \beta_0 + \beta_1 AA + \beta_2 IR + \beta_3 OF + \beta_4 IF + \beta_5 PE + \beta_6 AE + \beta_7 IS + \beta_8 AEQ + \varepsilon_i$$

Y: agricultural production, β_i **(i=0,1,2,3,4,5,6,7,8)**: estimation parameter, **AA**: agricultural area, **IR**: use of irrigation, **OF**: use of organic fertilizer, **IF**: use of inorganic fertilizers, **PE**: use of pesticides, **AE**: anti-erosion methods, **IS**: improved seeds, **AEQ**: agricultural equipment and ε_i is the error term.

Data obtained from Rwanda seasonal agriculture survey, the researcher use STATA to describe univariate descriptive, bivariate analysis and run the multiple linear regression to identify the relationship between dependent and independent variables, before analysing the researcher went through data and clean the dataset to remove all missing values in the dataset and remain with the variables indeed.

Analysis and Discussions

The analysis was divided to the following specific objectives, which include: assess the

adopted technology in agriculture, investigate the agricultural production and assess relationship of technology on agricultural productivity.

Table 1. Descriptive statistics of all variables included in regression

Variables	Description	Mean	SD	Min	Max
Area	Agricultural area used	61587.13	65914.77	1099	277804
Irrigation	Any type of irrigation used (yes=1 and no=2)	1.910526	.285677	1	2
Equipment	Equipment or oxen used in land preparation (yes=1& no=2)	1.942105	.2337494	1	2
Erosion	Any anti-erosion method used (yes=male &no=2)	1.510526	.5003283	1	2
Improved seed	Use of improved seeds (yes=1 & no=2)	1.626316	.4842062	1	2
Organic Fertilizers	Use of organic fertilizers (yes=1 & no=2)	1.375439	.4846613	1	2
Pesticide	Use of pesticide (yes=1 & no=2)	1.814035	.3894201	1	2
Inorganic fertilizers	Use of inorganic fertilizers (yes=1 & no =2)	1.7	.4586601	1	2

Source: RSAS (NISR, 2016), STATA output

The table1 shows means and standard deviations of the observation variables (covariates) of the agricultural productions. It is inferred that the mean agricultural area used in season A, B, C 2016 is about 61587.13 Ha, shows that the agricultural areas across provinces are high comparing to the non-agricultural spaces which is about 468,327 Ha across province.

The mean use of irrigation is about 1.910526 which indicates that almost of the respondents who are farmers included in the study did not use any irrigation methodology in the season A 2016 where it seems that irrigation adoption in agricultural area is nearly absent across provinces. The mean use of equipment or oxen in land preparation is about 1.916 which is the same as the one of irrigation. Also, results show that the mean use of organic fertilizers, use of erosion methodology and use of improved seed are showing that the respondents are somehow using these technologies comparing to the mean use of inorganic, equipment, irrigation, and pesticides.

Table 2. Distribution of agricultural production across provinces

source |	Partial SS	Df	MS	F	Prob > F
Model	1.6155e+11	4	4.0386e+10	1.56	0.1840
Id1	1.6155e+11	4	4.0386e+10	1.56	0.1840
Residuals	1.4642e+13	565	2.5915e+10		
Total |	1.4804e+13	569	2.6017e+10		

Source: RSAS (NISR, 2016), STATA output (ANOVA analysis)

The ANOVA test analysis in table 2, researchers were looking on distribution of agricultural production across provinces and shows that the agricultural productions are different across provinces, it is indicated by the probability of 0.1840 greater than the F-test, which allow the researchers to reject the null hypothesis and concluding that the agricultural production were different across provinces in 2016 seasonal A, B and C.

Table 3. Distribution of type of technologies used in agriculture (n=570)

	Yes			No			
	Freq	%	Cum%	Freq	%	Cum.%	Tot
Use of improved seed	213	37.37	37.37	357	62.63	100.00	570
Use of organic fertilizers	356	62.46	62.46	214	37.54	100.00	570
Use of inorganic fertilizers	171	30.00	30.00	399	70.00	100.00	570
Use of pesticides (cypermetric, dithane, other pest)	106	18.60	18.60	464	81.40	100.00	570
Use of anti-erosion activities (water drainage, distiches, trees, cover plan...)	279	48.95	48.95	291	51.05	100.00	570
Use any type of irrigation(water Chan or pumps/tubes)	51	8.95	8.95	519	91.05	100.00	570
Use of land preparation equipment (use tractors or oxen)	33	5.79	5.79	537	94.21	100.00	570

Source: RSAS (NISR, 2016), STATA output

Table 3 is describing the existing technologies and the level of its uses by famers. The researchers surveyed 570 farmers across country. And it was shown that only 37.37% of them are using improved seeds, 62.46% used organic fertilizers in 2016 season A, 30% used inorganic fertilizers, only 18.6% use pesticide while cultivating, and irrigation adoption still at low percentage where only 8.95% of the respondents used any irrigation method, The same as in the use of equipment/oxen in land preparation which is about 5.79% of the respondents. The table 3 also showed that anti-erosion methods are being adopted at 48.95%.

Table 4. Multiple Linear Regression Analysis

Production	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]
Area	.5509624	.1006224	5.48	0.000	.3533226 , .7486021
Organic fertilizer used	.5689.478	13842.86	4.31	0.0481	-21500.27, 32879.23
Any irrigation type	.8949.066	24115.57	3.7	0.0291	-38418.05, 56316.18
Improved seed	.11686.84	14372.87	8.1	0.0416	-16543.94, 39917.62
Constants	.74358.23	49820.01	4.96	0.0136	-23496.81 172213.3

Source: RSAS (NISR, 2016), STATA output

The results in table 4 revealed that after controlling for other covariates, agricultural production is statistically significant associated with agricultural area, use of improved seed, use of irrigation, and use of organic fertilizers. Those variables indicating that they are robust predictors of agricultural production. Researchers find that agricultural area is statistically significant factor of agricultural production. The agricultural area [or 0.5509624, 95% ci= (.3533226, .74486021)] has indicated that in additional of one Ha of existing agricultural area, the production also increase about .5509624. Used improved seed [or .1168684, 95% CI (-16543.94 39917.62)] has indicated that when farmers use improved seed the production also increase about .1168684. Used of irrigation [.8949066, 95% CI (-38418.05 56316.18)] has increased the agricultural production about .8949066 when one more farmer use the irrigation. Use of organic fertilizers [or .56889478, 95% CI (-21500.27 32879.23)] has increases the agricultural production about .56889478 when one farmer use these kind of fertilizers.

Conclusions & Policy Recommendations

Agricultural technology development is an essential strategy for increasing agricultural productivity, achieving food self-sufficiency and alleviating poverty and food insecurity among smallholder farmers in Rwanda as the country is now overpopulated with small agricultural areas across country.

The findings reviewed that the technologies people use played a significant role in determining how fast agricultural productivity are growing even if they are not efficiently used by farmers which leads them to continue live and farming waiting for rainfall which are low and erratic, continue farming on the soil which are tending to infertile and in additional to that, the infrastructure such as irrigation, input, and extension services tend to be poorly developed.

Policy recommendations for researchers

It is recommended that further research and rural development efforts should focus on the development of infrastructure and institutions in these areas.

To encourage adoption of new technologies, agricultural researchers must look beyond simply boosting productivity. They should emphasize certain variables which reduce the farmers' vulnerability to loss of income.

Modern researchers also should therefore seek to investigate the reasons why farmers do the same thing they use to do, and attempt to improve on them. This will be more effective strategy then the prevailing approaches which seek to displace traditional technologies.

Recommendations for Policy Makers

The agricultural technology development could be very high and far reaching countrywide through facilities targeted towards the smallholder farmer all work together to access these technologies.

Further studies and development efforts needs to be paid to technologies that require few assets because the technology that build on assets that farmers already have are more likely to be adopted.

Introducing technologies that require less labor is also likely to lead to their adoption.

References

Alain de Janvry, David Zilberman, Gregory Graff, & Elisabeth Sadoulet. (2001). *Technological Change in Agriculture and Poverty Reduction*. University of California at Berkeley.

Cavatassi, R., Lipper, L., & Narloch, U. (2011). *Modern variety adoption and risk management in drought prone areas: Insights from the sorghum farmers of eastern Ethiopia* (Vol. 42). https://doi.org/10.1111/j.1574-0862.2010.00514.x

DFID. (2011). *rural and agricultural financial services strategy.minisrty of agriculture and animal resources and DFID rwanda revised version*.

Ernest Nyetera. (2016, June). Rwanda shifting the agriculture narrative. *REGIONAL MEDIA CENTER Ltd*, *3*(2).

GoR. (2009). *National agricultural extension strategy*. Ministry of Agriculture and Animal Resources:GoR.

KATHIRESAN, Arumugam. (2012). *Farm land use consolidation in Rwanda:assessment fromthe perspectives of agriculture sector*.

MINAGRI. (2012). *Farm land use consolidation in rwanda: Assessment from the perspectives of agriculture sector*. Kigali.

MINAGRI. (2015). *Rwanda 2014 national human development report*.

NISR. (2013). *seasonal agricultural survey report*.

Norton, R. (2017). *The Competitiveness of Tropical Agriculture, A Guide to Competitive Potential with Case Studies (Academic Press, forthcoming in January 2017)*.

Salasya, B, Mwangi, W.M., Mwabu, D, & Diallo, A. (2007). Factors influencing adoption of stress-tolerant maize hybrid (WH 502) in western Kenya, *2*(10), 544–551.

Solomon Asfaw, Menale Kassie, Franklin Simtowe, & Leslie Lipper. (2010). Poverty Reduction Effects of Agricultural Technology: A Micro-evidence from Tanzania. Nairobi: International Crops Research Institute for the Semi-Arid Tropics.

world Bank. (2008). *Agriculture for development* (world development report). Washington, DC.