The Impact of Adoption of Modern Agriculture on Poverty Reduction in Rwanda: A case of KABOKU Cooperative Members in Nyagatare District

Alphonse NKEZA NYABYENDA[*]**, Dr. Andala O. Hesbon**[**]

[*]School of Social Sciences, Mount Kenya University, Rwanda
[**] Lecturer, School of Education, Mount Kenya University, Rwanda

Abstract- Crop yields in Rwanda remain as low as 40-50 percent of their potential owing to subsistence farming practiced by more than 70% of the population. This study examined the impact of adoption of modern agriculture on poverty reduction among KOBAKU cooperative members in Nyagatare District, Rwanda in a period of 2013-2018. The specific objectives were; to identify determinants of farmer's decision to adopt modern agriculture, to compare farmers' household income and consumption expenditure, and to determine the relationship between the farmer's adoption of modern agriculture and their households' poverty reduction. A sample size of 108 was drawn from 1083 cooperative members and 8 key informants using purposive and stratified sampling techniques. A survey was conducted on 64 male and 44 female, while 8 local authorities were purposively selected based on their relevance to this study as key informants. The Chi-square test of independence was applied to measure the significance of the determinants of farmers' decisions to adopt modern agriculture, while a t-test was used to identify the difference between their household's income and consumption expenditure, and poverty reduction before and after adoption of modern agriculture. The findings showed that the farmers' mean annual income per household increased from around 200,000Rwf before adoption of modern agriculture to around 1,000,000Rwf after adoption, with a significant mean difference of 1.44 (P-value =0.000<0.05) and t=20.2726 (great magnitude). Their weekly expenditure made almost a twofold rise from 8,000Rwf to 15,000Rwf, with a significant mean difference of 0.8 (P-value =0.000<0.05) and t=17.6541 (great magnitude). As a result, their living standards made a fourfold increase from 21.5% before to 82.2% after adoption as a proof of their poverty reduction. Inputs and the market for the output from modern agriculture as well as related services proved to be the major determinants of farmer's adoption of modern agriculture. As recommendations, policy makers and other development partners should consider making contextualized decisions by taking into account the main determinants of farmers' decisions to adopt new technologies for poverty reduction and sustainability of agriculture sector.

Keywords: *Agriculture, Cooperative, Modern Agriculture, Poverty, Poverty reduction*

I. INTRODUCTION

In 2015, about 736 million were living in extreme poverty. About 80 percent are living in rural areas depending on agriculture (FAO, 2019). Agricultural modernization has a pertinent role to play in attaining Sustainable Development Goal1-2 (Alvarez, 2017).

Current figures show that though Africa's full agriculture remains unexploited, over 60% of the population in Sub-Sahara Africa are smallholder farmers and about 23% of its GDP comes from agriculture. The number of people living in extreme poverty is on the rise in Africa with a poverty rate of 30%. According to the World Bank (2018), more than a half of the world extreme poor population in 2015 were sub-Saharan African with 27 out of the 28 world's poorest countries.

In Rwanda, agriculture is the main economic activity on which most of the population depend for a living. However, the sector has been subsistent in nature. Because of different development initiatives, including irrigation and mechanization programs, the sector started to know a rise. In line with the first Economic Development and Poverty Reduction Strategy (EDPRS), the agricultural sector saw growth rising from 2 per cent to 7 per cent (2011-2012). Severe poverty has dropped from 39.5 percent to 26.4 percent over the last five years (MINECOFIN, 2018).

Under the Economic Development for Poverty Reduction, the Strategic Plan for the Agricultural Sector aims to reduce poverty. Ambitious goals was set in marshlands and hillsides irrigation and mechanization to increase productivity (MINAGRI, 2018). The government of Rwanda is determined to transform agriculture from a substance to a market-led sector where the focus is on agricultural intensification and amplified market and business orientation of the smallholder farmers. In this, Cooperatives are seen as key vehicles to achieve food production for both domestic and international market and poverty reduction.

Most of the previous studies failed to consider a qualitative aspect of smallholder farmers in cooperatives, adopters of new agriculture technology, to show in details how farmers' households were positively or negatively affected.

This study intended to examine the impact of adoption of modern agriculture on poverty reduction of in Rwanda; a case of KABOKU Cooperative members in Nyagatare district with the following specific objectives:

- ❖ Identifying the determinants of farmers' decisions to adopt new technologies for poverty reduction;
- ❖ Compare households' income and consumption expenditure; and
- ❖ Determine the relationship between farmer's adoption of modern agriculture and their households' poverty reduction.

II.   LITTERATURE REVIEW

Determinants of farmers' decisions to adopt modern agriculture

Empirical literature converges on the evidence that the factors influencing the adoption of modern agricultural production technologies are grouped into three main categories, namely economic, social and institutional.

The economic factors include farm size, which focuses heavily on empirical adoption as it can influence and be influenced by other factors influencing adoption. It could affect the adoption of modern agriculture (Challa & Urgessa, 2014; Udimal, et al, 2017). The effect may be negative as mentioned by Melesse (2018); or oddly neutral (Asiedu-Darko, 2014). In addition to this, other factors are also mentioned in various empirical literature, namely technology, costs of adoption, income-generating activities carried out by farm households (Rajeev Sharma, 2015; Nani Raut, 2011; Shadi-Talab, 1997; Solomon A., Bekele S and Leslie L., 2012)

As for social factors, according to the studies, including that of Qian Guo et al. (2020); Challa and Tilahum (2015), the farmers' age is expected to affect their decisions of adopting agricultural technologies. They added that the aspect of age is an important social factor and a key latent feature in the farmers' decisions in adopting new technology as this factor is directly related to their experience in agriculture.

In addition to the farmers' age and experience, most of the studies converged on education as a key determinant for farmers' decisions to adopt new technology. Albert I. Ugochukwu (2017); Rajeev Sharma (2015); Nani Raut (2011); Shadi-Talab, 1997, and many others found that the farmers' level of education creates a favorable mental attitude for accepting new practices. They also include a gender dimension as an important criterion to be considered in this regard. Asiedu-Darko (2014) found that, even though in most of the areas adoption of new agricultural technologies seems to be neutral in terms of education, age, and gender, these factors cut across the areas and affect the farmers' decions to adopt technologies in the sector.

Finally, according to Qian Guo et al. (2020); Challa and Tilahum (2015), the farmers' access to information and extension services among the determinants of farmers' decisions to adopt modern

technologies in agriculture. They reiterated that extension agents play a constructive and significant role in influencing all technologies' probability of adoption.

Modern agriculture and adopters' income and consumption expenditure

The farmers' adoption of modern technologies increases the effectiveness, leading to increase in productivity and eventual farmers' income and welfare. Villar (2019) documented that modernizing the agriculture sector holds the key to reduction, if not eliminating, rural poverty, while Jain *et al.* (2009) found that agricultural technologies, through quality of high variety of input-output link, new technologies aimed at increasing outcomes and decreases average cost of production that lead to important benefits in income.

The report by The World Bank (2016) shows that by 2010, one million people in Rwanda had pulled themselves out of severe poverty as agriculture productivity increased more than threefold in ten years, and farmers' incomes have increased by 30%, which has led to a 14% decrease in extreme poverty. In their study on modern inputs. According to LIN (2018) and NEPAD (2013), adoption of modern agriculture accelerates the rise in income of pope people living in drought-prone SSA areas. The farmers' shift to modern agricultural technology could generate a very positive impact to the economy of the agrarian community. According to FAO (2019); Alvarez (2017) and Modern technologies in agriculture improve the livelihoods of farmers. Rajeev (2015), modern agriculture would reduce food costs and improve food security and the overall quality of life for households.

Adoption of modern agriculture and Poverty Reduction

The farmers' shift to modern agricultural technology could generate a very positive impact to the economy of the agrarian community. According to FAO (2019); Alvarez (2017) and Modern technologies in agriculture improve the livelihoods of farmers. Rajeev Sharma (2015), modern agriculture would reduce food costs and improve food security and the overall quality of life for households. They added that modern agriculture provides consumers with enormous economic and social benefits including improved quality of life and living standards such as providing more purchasing power for other consumer goods, schooling, health care, leisure, etc.

Different studies stressed the expected benefit of farmers from the adoption and off-farm income generation activities that the farming households are engaged in as having an impact on poverty reduction. The Rwanda Ministry of Economy and Finance, MINECOFIN (2018), recorded a decline in poverty, while the people's access to clean water rose to 88.5% in 2016, access to improved sanitation facilities at 84%, the literacy rates rose from 48% in 2000 to 66% by 2017, whereas the life expectancy that rose from 49 years in 2000 to 66 by 2017.

III.   MATERIALS AND METHODS

This research used a survey and descriptive research design-correlation coefficients for measure of effect size-r to describe

characteristics of the sample selected and interpret statistical results.

A sample size of 108 members of KOBAKU cooperative and eight key informants was drawn from 1083 using a formula of Mugenda and Mugenda (2003):

n=N*0.1;

Where n: Working sample; N: Target population

The research also purposely selected six (6) local authorities as participants of the key informant interview (the in Charge of Community Development at the Cell level, the in charge of Socio-economic Development at Sector level, the in Charge of Cooperative Development at Sector level, and the in the Cooperative Development Officer at District level).

The study drafted clear and specific questionnaires containing questions on adoption of modern agriculture and poverty reduction. The Chi-square test of independence with as formula was applied to measure the significance of the determinants of farmers' decisions to adopt modern agriculture:

$$X^2c = \Sigma \left(\frac{Oi-Ei}{Ei} \right)^2 \qquad (1)$$

Where the subscript "C" are the degrees of freedom; "O" is the observed value and "E" is the expected value.

A test was used to compare the means of the farmers 'income and consumption expenditures before and after the adoption of modern agriculture as well as the association between the farmers' adoption of modern agriculture and poverty reduction. The t-test formula is as follow:

$$t = \frac{m}{s/\sqrt{n}} \qquad (2)$$

Where "m" and "s" are the mean and the standard deviation of the difference (d), respectably and n is the size of d. The degrees of freedom (df) used in the test are:

$$df = n - 1 \qquad (3)$$

IV. RESULTS AND DISCUSSION

Objective 1:

The researcher identified determinants of farmer's decisions to adopt agriculture technology for poverty reduction. The assessment was done using respondents' age, education, experience, farm size, access to credit and access to mechanization facilities. According to the results as shown in table 1, this study has shown inputs and the market for the output from modern agriculture as well related services as major determinants of farmer's adoption of modern agriculture. Important factors such as the farmers' age, education, experience in agriculture, land size, access to credit, and availability of irrigation facilities are significantly associated to farmers' decisions to adopt modern agriculture technology, as their P-values are less than 0.05.

Regarding the age, the farmers' adoption of new technology is more significant for the farmers whose age bracket is 30 to around 50, mainly for the farmers whose age is 31-43 (at 100%). This indicates that the farmers' adoption of new farming technology has to do with the young age. The factor of age goes with farmers' experience for the fact that the adoption of modern agriculture increases for the farmers whose experience is 4-8 (at 100%) for the farmers whose experience is above 8 years.

Table 1. Determinants of farmers' decision to adopt modern agriculture

Variables	Description	No	Yes	P-value
Age	18-30	5(29.41)	5(5.49)	
	31-43	0(0.000)	13(14.29)	
	44-56	7(41.18)	46(50.55)	0.009
	Above 56	5(29.41)	27(29.67)	
Gender	Male	7(41.18)	57(62.64)	
	Female	10(58.82)	34(37.36)	0.098
Education	None	14(82.35)	22(24.18)	
	Primary	3(17.65)	44(48.35)	
	Secondary	0(0.00)	18(19.78)	0.000
	Tertiary	0(0.00)	7(7.69)	
Family members	1-4	7(41.18)	34(37.36)	
	5-8	7(41.18)	53(58.24)	0.096
	Above 8	3(17.65)	4(4.40)	
Farmers' experience	Below 4 years	11(64.71)	3(3.30)	
	4-8 years	6(35.29)	76(83.52)	0.000
	Above 8 years	0(0.00)	12(13.19)	
Farm size (ha)	Below 0.5	5(29.41)	1(1.10)	
	0.5-1	11(64.71)	37(40.66)	
	1.1-1.6	1(5.88)	38(41.76)	0.000
	1.7-2.2	0(0.00)	7(7.69)	
	Above 2.2	0(0.00)	8(8.79)	
Transportation facilities	No	15(88.24)	63(69.23)	0.108
	Yes	2(11.76)	28(30.77)	
Access to market	No	6(35.29)	17(18.68)	0.125
	Yes	11(64.71)	74(81.32)	
Access to credit	No	6(35.29)	6(6.59)	0.001
	Yes	11(64.71)	85(93.41)	
Mechanization facilities and other inputs	No	7(41.18)	10(10.99)	0.002
Yes		10(58.82)	81(89.01)	

According to Qian Guo (2020); Challa and Tilahum (2015), and others found that the aspect of age is an important social factor and a key latent feature in the farmers' decisions in adopting new technology as it is directly related to their experience in agriculture. Albert I. Ugochukwu (2017) and Rajeev Sharma (2015) found that the farmers' level of education creates a favorable mental attitude for accepting new practice; while The Sustainability (2018); Nahayo Alphonse, et al. (2017), Challa and Tilahum (2014) found a close relationship in farmer's decisions to adopt modern technologies and their credit accessibility and mechanization facilities, including tractors, irrigation machines and related services.

Objective 2:

The tables 2 and 3 show that the respondents' mean annual income per household after adoption of modern agriculture is almost 3.5, i.e. an income of around one million Rwandan Francs; compared to that of before adoption which was around 2, i.e. an income of around 200,000Rwf. A significant mean difference of 1.44 which is equivalent to around 800,000Rwf (table 4.9) in respondents'

income before and after adoption of modern.agriculture. This amount is the result of the farmers' adoption of modern agriculture.

Table 2. Respondents' household annual income before and after adoption

Annual income	Frequency	%	Frequency	%
Amount (Frw)	Before adoption		After adoption	
Less than 200,000	32	29.63	0	0.00
200,000-700,000	49	45.37	15	13.85
800,000-1,300,000	20	18.52	28	25.93
Above 1,300,000	7	6.48	65	60.19

Source: Primary data (2021)

Table 3. Paired t test of annual incomes before and after adoption

Income	Obs	Mean	Std.Err.	Std.Dev	[95%Conf.	Internal]
After	108	3.462963	.0701404	.7289209	3.323918	3.602008
Before	108	2.018519	.0831842	.8644752	1.853616	2.183421
Diff.	108	1.444444	.0712512	.7404638	1.303197	1.585692

t = 20.2726   Pr(T > t) = 0.0000

Source: Primary data (2021)

The statistical significance of the difference between the farmers' current incomes as compared to their situation before their adoption of modern agriculture was proved by the p-value =0.000, which is less than 0.05. The statistical significance is also emphasized by great magnitude of t (20.2726).

As for the modern agriculture households' consumption expenditure, the tables 4 and 5 show that the respondents' current mean weekly consumption expenditure per household is around

Table 4. Households' weekly consumption expenditure

Weekly expenditure	Frequency	%	Frequency	%
Amount (Rwf)	Before adoption		After adoption	
less than 7,000	5	4.63	0	0.00
7,000-14,000	71	65.74	18	16.67
15,000-22,000	29	26.85	68	62.96
23,000-30,000	3	2.78	13	12.04
Above 30,000	0	0.00	9	8.33

Source: Primary data (2021)

Table 5. Paired t-test of weekly expenditures before and after adoption

Incomes	Obs	Mean	Std.Err.	Std.Dev	[95%Conf.	Interval]
After	108	3.12037	.0752492	.7820127	2.971198	3.269543
Before	108	2.277778	.0570919	.5933169	2.1646	2.390956
Diff.	108	.8425926	.0477228	.4960034	.7479775	.9372077

t = 17.6541   Pr(T>t)=0.0000

Source: Primary data (2021)

3.1, which is equivalent to the amount of around 15,000Rwf per week per household; as compared to that of before adoption of modern agriculture adoption whose mean was around 2.3, an equivalent to around 8,000 Rwandan francs per week per household.

The P value =0.000, which is less than 0.05 and t = 17.6541 (great magnitude), prove that the mean difference of 0.8 (almost equivalent to 7,000Rwf per week per household) and a standard deviation of around five are statistically significant.

Interview between the researcher and president of the cooperative, he argues "adoption of modern agriculture provide has proved to be a reliable source of cash for smallholder farmers and promotes more human welfare, particularly to the poor than it was before its adoption". Results of this objective complement various studies around modern agriculture and its impact on poverty reduction, including The World Bank (2019) and Rajeev Sharma (2015) who found that modern agriculture provides a source of cash for smallholder farmers and promotes more human welfare, particularly to the poor.

Objective 3:

The third chapter established the relationship between the adoption of modern agriculture and poverty reduction in Rwanda. A simple regression was used to establish the effect of adoption of modern agriculture (determinants of farmers' decisions to adopt new technology, adoption of modern techniques and practices, and use of modern farm inputs) and poverty reduction (annual income, household consumption expenditure and household welfare and living standard).

The table 6 shows that adopters improved their access to food, basic health services, clothing, saving and ability to pay school fees for their children, respectively from 40%, 6.5%, 41%,15% and 11%; to 100%, while their access to clean water, housing and the creation of off-farm income generating activities rose from 19%, 33%, 6%; to 55%, 87%, 15%, respectively.

Table 6. Modern agriculture households of adopters' poverty reduction

Living standards	Freq.	%	Freq.	%
Livelihood indicators	Status before		Current status	
1.Access to food(at least two meals a day)	43	39.81	108	100.00
2.Access to clean water (below 1 mile distance)	8	19.44	60	55.56
3.Access to basic health service (at least a health insurance)	7	6.48	108	100.00
4.Ability to buy clothes (at least biannually)	44	40.74	108	100.00
5.Access to improved house (Rental or own)	36	33.33	94	87.04
6.Created an income generating activity(off-farm)	7	6.48	16	14.81
7.Having a saving account(currently operational)	16	14.81	108	100.00
8.Ability to pay school fees (at least for children)	12	11	108	100.0

Source: Primary Data (2021)

This means the overall rise of the aforementioned indicators of poverty from 21.5% before the adoption to 82.2% after adoption. A t-test analysis was done to analyze the difference between the change in the farmers' living standard following the farmers' response to the extent at which their living standard has changed as a result of adopting modern agriculture.

Following the rankings (very high, high, medium, low and very low) based on their expression of the extent at which the adoption of modern agriculture has affected their living standards, results from the table 7 indicators that a significance of means variance (2.62963) between the respondents' living standard as proved by the P-value=0.000, which is less than 0.05 and the great magnitude t = 46.3568.

Table 7. Paired t-test of households of adopters' poverty reduction

Incomes	Obs	Mean	Std.Err	Std.Dev	[95% Conf.	Interval]
After	108	4.12963	.0396694	.412256	4.05099	4.208269
Before	108	1.5	.0772718	.8030316	1.346818	1.653182
Diff.	108	2.62963	.0567259	.5895126	2.517177	2.742082

t = 46.3568   Pr(|T| > |t|) = 0.0000

Source: Primary data (2021)

Information from interview guide felt that the district cooperative officer says "modern agriculture practices have improved the overall community's quality of life and living standards, including among others access to basic needs, increased savings, health services,etc.".

The result correlates much with different studies including that of FAO (2019); Alvarez (2017) and Rajeev Sharma (2015) that mention modern agriculture as a practice that would improve the overall community's quality of life and living standards such as providing more purchasing power for other consumer goods, schooling, health care, leisure, etc. And MINECOFIN (2018) that reported a decline in poverty and an increase in access to clean water to 88.5% in 2016 as well as access to improved sanitation facilites increased to 84% in 2017.

V. CONCLUSION

Results to the first objective conclude that determinants of the adoption of modern agriculture are market for the output from modern agriculture, experience in agriculture, land size, access to credit, and availability of irrigation facilities are significantly associated to farmers' decisions to adopt modern technology. Results to the second objective conclude that there is an increased income from the output of modern agriculture, where farmers are able to save and invest the extra money in other business, which raised their living standards and that of their community to around fourfold. Results to the third objective conclude that a unit change in use of modern farm inputs to 0.108 reduces poverty when all other independent variables are reduced to zero. The study recommends to take into consideration the context, particularly determinants of farmers' decisions to adopt new technologies including their age, education, experience, farm size, accessibility of financial services and mechanization facilities and other inputs

before making any agricultural related decisions. Through a Public Private Partnership, there should be ways in which farmers, particularly smallholders, easily access modern inputs. Research and extension services should be consistent so that all interventions are based on current evidences and relevant. Further researchers need to use meta-analysis to expand this research by conducting an empirical research on the factors affecting people's resistance in adopting modern technology.

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AUTHORS

First Author – Alphonse NKEZA NYABYENDA, Postgraduate Student, Mount Kenya University, alphonsenkeza@gmail.com
Second Author – Dr. Andala O. Hesbon, PhD., Lecturer-Mount Kenya University, Rwanda, and email address.