TECHNOLOGY ADOPTION AND IMPROVED RICE PRODUCTION AMONG SMALLHOLDER FARMERS: A CASE OF PICAGL PROJECT IN SOUTH KIVU/DEMOCRATIC REPUBLIC OF CONGO

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Abstract

The impact of technology adoption on increased rice production among smallholder farmers was investigated in this study. This paper examines the 2019 Integrated Project on Agricultural Growth in the Great Lakes region (PICAGL) in South Kivu, Democratic Republic of the Congo. One of the most popular cereal crops that helps South Kivu's small-scale farmers, lowers malnutrition and improves their socioeconomic standing is rice. The research employed a mixed-methods sequential explanatory approach. Closed-ended questions based on a Likert scale model were applied to 327 households randomly chosen in the Walungu and Uvira sub-counties. Descriptive and inferential analysis were conducted using the Statistics and Econometric Data (STATA) 17.0 software. The results have demonstrated that by raising rice yield and revenue, two rice technologies the System of Rice Intensification (SRI) and Integrated Soil Fertility Management (ISFM)have improved the socioeconomic life for adopters. The Logistic regression results has shown that age, gender, level of education, non-farm activities, plot size, extension services, farmer participation in training, positively influenced the adoption however, lack of Livestock had a negative influence in the adoption process. Furthermore, the study verified that

South Kivu's rice farmers confront numerous difficulties, including excessive rainfall on their fields, dry spells, insufficient government funding, pests and illnesses, scarcity of fertilizers and seeds, and inadequate rural roads. To address the issues like the availability of hullers, credits aids, and irrigation of all water channels, some management options are needed.

Keywords: Adoption, improved rice production, SRI, ISFM, management strategies.

1. Introduction

Enhancing food security, reducing poverty, and promoting rural development all depend heavily on agriculture. Congolese people rely on agriculture approximately 70%. (FAO, 2020). DRC is far from reducing poverty and malnutrition among its rural population regardless its good climate and soil conditions. Agriculture is very significant in the Congolese economy and contributes 47.7 of the Gross Domestic Product. The Congolese agricultural sector faces numerous, challenges that have isolated its development and plunged the country into food insecurity.

Given its revenue, food supply, and rural employment potential, rice is one of the cereal crops that Congolese farmers grow. Reported by the Food Agricultural Organisation FAO (2020), the production loss of rice in Democratic Republic of Congo passed from 1.6million tons to 0.6million tons, either a loss of 64% in 2018. The country is said to be mainly in cereals deficit of minus 10.7 million tons which is 83% of production. This cereal balance and food have confirmed that there is great food insecurity. The Integrated Project on Agricultural Growth in the Great Lakes region (PICAGL) focused on introducing new farming technologies to farmers in order to assist DRC in meeting its long-term development goals. These technological advancements sought to improve plant protection, poverty alleviation, food production, and income. (IPAGRI 2021).

2. Theoretical Framework and Empirical Review

Several studies on Adoption of new technology and rice production have been conducted worldwide. The growth of agricultural productivity can reduce poverty and food prices by improving farmers' income. Sadoulet, (2016) distinguishes a few different learning theory models, including what can be learned, which suggests that adopting new technology only requires knowledge of it or familiarity with users. Furthermore, based on what the social network observes, farmers share technology information based on their perceptions.

The farmer's decision to adopt new technology is explained by the "Learning for Adoption Theory." This theory, based on constructivist principles, asserts that people actively create their knowledge; reality is determined by learners' own experiences. Meanwhile, the diffusion theory states that an innovation must be learned, used, and spread. According to Roger (2003), an adopter can reject the learned innovation at any time. To prevent adopters from abandoning new techniques, adopting SRI and ISFM as a package is required to make the learned technologies sustainable.

Abubakar et al., (2019) analyzed the elements that motivate farmers to use modern rice-growing techniques in Badeggi's National Cereals Research Institute (NCRI) in Nigeria. A simple random sample method was employed to collect data from 150 participants using a binary logit regression model. The research found that the different ways of delivering extension services were successful.

The study by Dharmendra et al., (2017) identified the barriers to SRI adoption faced by farmers in the India Rewa district. The study found that the most significant constraints faced by farmers were a lack of training (81.66%) and a labor shortage (76.66), lack seeds, and bio fertilizers (70.83%). The study suggested people to raise awareness of the new Rice Intensification System.

According to a description of the vulnerability of small-scale farmers in Madagascar to agricultural risks and climate change, 600 households were chosen at random for the survey (Harvey et al., 2014). The research found that providing Malagasy farmers with technical, financial, and institutional help was the most effective way to increase agricultural output and food security.

3. Research methodology

This study applied a mixed method-sequential exploratory- approach. The data used in this article are from a survey conducted from July 2022 to October 2022. The Likert scale model close-ended questionnaires was used to collect quantitative data and interview guides for qualitative ones. The simple random non-probability sampling technique was used, it means 327 households were selected in Uvira and Walungu applying Yamane's formula (1967). Descriptive and inferential statistics were applied for data analysis using the Statistics and Econometric Data (STATA) 17.0 Software.

4. Objectives of the study

4.1 Main objective

To examine the influence of technology adoption on rice production in South Kivu during PICAGL project implementation 2019 -2021Frame.

4.2. Specific Objectives

1. To explore the determinants for adopting SRI and ISFM by smallholder farmers in South Kivu.

2. To assess the socioeconomic influence of SRI and ISFM adoption on rice production in South-Kivu.

3. To examine the challenges to adopting SRI and ISFM for rice-producing smallholder farmers in South Kivu.

4. To assess the management strategies used to enhance rice production in South Kivu.

5. Findings and Interpretation of Results

5.1 SRI and ISFM Adoption and Rice production

Table 1

Adoption level of SRI and ISFM

Adoption SRI and ISFM	Freq.	Per cent	Cum.
SRI	114	34.86	34.86
ISFM	161	49.24	84.10
FTP	52	15.90	100.00
Total	**327**	**100.00**	

Source: researcher's analysis based on collected data 2022.

Suitable technologies and plant materials play an essential role in productivity growth. Three rice technologies were listed in the operating zones of PICAGL. They included the System of Rice Intensification (SRI), Integrated Soil Fertility Management (ISFM), and Farmer Traditional Practice. According to Ambali et al., (2021), System of Rice Intensification is a technique for weighing the plant, soil, water, and light elements in order to help the plant realize its fullest potential. As for Vanlauwe (2015), using integrated soil fertility management (ISFM), crop productivity can be increased while agronomic effectiveness (A.E.) is maximized. Farmer Traditional Practice (FTP); is the rice-growing technique consists of planting rice randomly without caring about the number of rice seedlings in a pocket. The results in table 1 show that

161(49.24%) respondents have adopted ISFM, 114 (34.86%) adopted the SRI, 52 (15.90%) were reported to stick to the farmer's traditional techniques because of technical and forced labor-intensive reasons.

> Rice crop has been qualified seasonal rice presenting much broken and full of sand grains in South Kivu. However, rice production increased and updated agricultural techniques for improving transformation conditions was effective through PICAGL project. (P. 5)

Local soil and climate influence how each technology is adopted. It implies that ISFM was primarily adopted by farmers in Uvira due to soil fatigue. SRI was present in Walungu.

5.2. Adoption and the socioeconomic life of smallholder rice producers

Table 2

The socio-economic life of the smallholder farmer in the surveyed area

Variable	**ADOPTION**		
Socio-economic effect	**Non-adopters**	**Adopters**	**Total**
No	7(70.00)	3(30.00%)	10(100.00%)
Yes	39(12.30%)	278(87.70%)	317(100.00%)
Total	46(14.07)	281(85.93%)	327(100.00%)

Source: researcher's analysis based on collected data 2022

The Adoption of SRI and ISFM positively impacted smallholder farmer's life and rice production. The study shows how it has increased the farmer's yield and income in 2019. Farmers could use fewer inputs and harvest more outputs. It implies 3 kilograms of seed, could harvest 400 kilograms of paddy, and an average of 280 kilograms of white rice contrary to the farmer's

traditional practice that required much seed. According to IPAGRI (2021), some improvements were observed in rice production. The produced rice paddy passed in 2018 from 100900 tons to 126248 tons either an increased rate of 25% in 2019. Table 2 proves that 278 (87.70%) adopters and 39 (12.30%) non-adopters had acknowledged that SRI or ISFM improved their socio-economic life. Compared to 3(30%) adopters and 7(70%) non-adopters who revealed that adoption did not help them, they blamed their failure on climate change rather than the nature of the new technologies.

5.2 Constraints on Rice production and Adoption of Improved Technologies

In South Kivu, rice smallholder farmers undergo many challenges that hinder rice production and prevent some farmers from adopting due to different reasons. This paper results restricts on the most significant constraints like Excess rainfall water(erosion); 172(52.76%) farmers have agreed to be affected with this problem on rice plots 123(37.73%) strongly agreed,23(7.06%) disagreed, 5(1.53) respondents were uncertain. Water drought (early cessation of rain) was reported to challenge producers of rice 154(47.09%) respondents agreed, 83(25.38%) strongly agreed,69(21.10%)disagreed,10(3.06%)strongly disagreed and 11(3.36%) were uncertain. The effect of damage to rice crops and plant disease is unquestioned. Rice crop is eaten by insects' rice weevils (scientific name Sitophilus oryzae) and is affected by pests and disease blast, bacterial blight, sheath blight, tungro virus, etc.

> There is a physical reduction in yields that causes economic loss. However, to handle pest and disease challenges, we use pesticides named (Roquette, dudu, and Rapid). The lack of market is another challenge we meet in this area, which implies a lack of coordination, government credits aids, warehouse, rice hullers, and lack of market integration. (P.7).

It implies that smallholder farmers undergo so many challenges that all stakeholders involved in agriculture should worry about.

5.3 Management strategies.

Management strategies system is important to the successful rice growth production in South Kivu. To meet the smallholder farmers' objectives, 196(60.49%) of respondents reported that all rice plots need to have good dykes' layout 120(37.04%)strongly agreed,5(1.54%) disagreed, and 3(0.93%) were uncertain. In addition, farmers need to know how to drain and rinse water channels; thus, 176(54.32%)agreed, 134(41.36%)strongly supported this idea,9(2.78%)disagreed and 5(1.54%) were uncertain. Pest and disease management by farmers, the government credits support and Capacity building were respectively reported to be good managementstrategies.Thus,158(48.77%)agreed,108(33.33%)stronglyagreed,55(16.98%)disagreedand2(0.62%)strongly disagreed and 1(0.31%)was uncertain.

5.4 Statistical test analysis of SRI and ISFM technologies

This study used the chi-square and student t-test to compare the means of two sample groups.

5.4.1 Chi-square test of adoption

The assumptions in this study were testing the existence of a relationship that is not necessarily linear.

H0: this implies that variables are independents

H1: this indicates that the variables are linked (positively or negatively).

Based on the empirical Spearman correlation coefficient, the chi-square test is calculated on the matched sample data. The researcher postulates that adopting new rice technologies is relatively related to a strong correlation with gender at a 1% alpha level with a degree of freedom

1. It implies that being male strongly correlated with adopting the new rice techniques. Similarly, farmers' membership in a cooperative strongly correlated with adopting new rice varieties in South Kivu province. The study rejects the null hypothesis of independence while validating the alternative hypothesis.

5.4.2 The student's t-test

a. Adoption and rice production

H0: Rice production for farmers who have switched to the new varieties is equal to that of farmers who have not.

H1: Rice production for farmers who used new technologies differs from rice production for others.

Table 3

Two sample t-tests with equal variance adoption and rice production.

Variable	**Freq.**	**Mean**	**Std. err.**	**Std. dev.**	**[95% conf. interval]**	
Yes	281	4.274021	.0352744	.5913074	4.204585	4.343458
No	46	3.630435	.1218167	.8262014	3.385083	3.875786
Combined	327	4.183486	.0368797	.6669011	4.256039	
Diff	.6435866	.1000577	.446744	.8404291		
diff = mean(Yes) – mean (No)		t = 6.4322				
H0: diff = 0		Degrees of freedom = 325				
Ha: diff < 0		Ha: diff! = 0		Ha: diff > 0		
Pr(T < t) = 0.0000		Pr(|T| > |t|) = 0.0000		Pr(T > t) = 0.0000		

Source researcher's analysis based on collected data 2022

According to the above table results, the student t-value is 6.4322 with a degree of freedom of 325. The researcher can reject the null hypothesis and accept the alternative hypothesis because the p-value is less than 5%. Thus, the adoption of new technologies significantly affects rice production. With a margin of error of 1%, we can thus confirm that the difference in rice production is due to the adoption of new technologies.

5.5. Econometric Results

The study used the logistic regression model to highlight the elements that favorably or unfavorably influenced the adoption of technologies on rice production in the study areas.

5.5.1 Determinants of SRI and ISFM technologies adoption and rice production

The model was statistically significant at the 1%, 5%, and 10% levels, indicating that the model was good at estimating at least the explanatory variables. The coefficient signs guide this econometric binary model interpretation in the below table.

Table 4

Logistic regression of determinants of adoption of rice varieties in Uvira and Walungu.

ADOPTION	**Coeff.**	**St. Err.**	**t-value**	**p-value**	**[95% Conf**	**Interval]**
GENDER	0.369	0.434**	0.85	0.039	-.482	1.219
EDULEV	0.214	0.171***	1.26	0.009	-.12	.549
OFFARM	0.311	0.197**	1.58	0.011	-.697	.076
LIVESTOCK	-0.058	0.175*	-0.33	0.074	-.401	.285
PLOTSIZE	0.332	0.529*	0.63	0.053	-.706	1.369
ACCESSEXT	0.425	0.276	1.54	0.024	-.116	.965
Constant	-11.006	2.779	-3.96	0.000	-16.453	-5.559
Mean dependent var	0.857		SD dependent var		0.350	
Pseudo r-squared	0.246		Number of obs		327	
Chi-square	32.728		Prob> chi2		0.005	
Akaike crit. (AIC)	231.258		Bayesian crit. (BIC)		291.650	

Source researcher's analysis based on collected data 2022

Gender of the head of the household (GENDER): It is one of the determinants of improved rice adoption. The gender of the household's head significantly influenced the adoption of improved rice production technology at a 5%. It implies that families led by men had greater access to technologies than female-headed households. Similarly, Theis et al. (2018), research in Ethiopia,

Ghana, and Tanzania on gender-specific features of tiny-scale irrigation technologies. The study found that empowerment of diverse agricultural technologies had all benefited women. However, there is still gender gap in technology adoption.

Education level (EDULEV), was statistically significant with a variation t-value of 1.26 with and 0.009 p-value probability at 1% of the significance level. According to the study, farmers' willingness to adopt new technology is positively influenced by their education level. In contrast, the results by Murhi et al., (2018) revealed that high formal education negatively influences agricultural productivity in South Kivu.

Off-farm activities (OFFARM), positively affected adoption. It proved that the variation t-value was 1.58, and the probability of adopting SRI or ISFM was 0.011p-value at a 5% significant level. Extra revenue from agriculture is an important strategy for rural households in many developing nations to overcome credit constraints. Similar results were found by P.M. Dontsop (2016), not every technology, however, have demonstrated a positive relationship between off-farm income and adoption. Some labor-intensive studies on technology adoption have found a negative relationship between off-farm income and adoption

Livestock ownership (LIVESTOCK)**,** the lack of livestock had a negative impact on the adoption of improved rice technologies, with a variation t-value of -0.33 and probability of 0.074 at a 10% level of significance because of the farmer's vulnerability in the studied area. In Contrast Kassie (2019), shows that, in Ethiopian agriculture, a significant source of income, food, and draught power for crop cultivation comes from livestock.

Plot Size (PLOT SIZE) the study found that the farm size, bigger or smaller it could be, did not prevent farmers from adopting improved technologies with 0.63 variations and 0.053 probability at a 10% significant level. In contrast, Mignouna et al., (2011 ;) demonstrated that plot

size had a negative impact on new technology's adoption. Small farm size may provide an incentive to adopt technologies, particularly those that are labor-intensive.

Extension services access (ACCESSEXT) has positively influenced the adoption with the t-value 1.54 and 0.024 p-value at a 5% significance level. It implies that farmers who interacted with extension agents frequently were more likely to adopt. Similary, Kanyamuka (2017), the likelihood of adopting both inorganic fertilizers and maise legume intercropping at the 5% alpha level significantly increased.

Conclusion

The study concludes that improved rice technologies System of Rice Intensification and Integrated Soil Fertility Management adoption have a positive impact on the farmers' socio-economic lives. Rice yield can be increased if all households adopt one of the improved rice technologies in South Kivu as a package. According to the findings, significant challenges to rice production in the studied area included a lack of water channel irrigation in Walungu and climate change, which causes water draughts in Uvira. Furthermore, poor marketing systems (it implies non-regulation of market price) are barriers to higher rice production in South Kivu. According to the study's findings regarding the logistic regression, certain variables related to policy have impacted the uptake of ISFM and SRI. Demographic factors like (Gender, Education level of the household's head), Socio-economic factors (off-farm income) have positively impacted the adoption of SRI and ISFM. While lack of livestock, has negatively influenced the adoption of SRI and ISFM. The study concludes that Institutional factors like the presence of Extension services, a farmer's membership in a cooperative, positively influence the adoption of SRI and ISFM. The results of this study signified that the application the improved techniques increases the production

of adopters. The implications of the results are straightforward, even when the adoption of rice-improved technology is relatively poor in South Kivu.

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