

FACTORS INFLUENCING THE INTENSITY OF ADOPTING RICE FARM INNOVATIONS AMONG SMALLHOLDER RICE FARMERS IN THE WEST KANO IRRIGATION SCHEME, KENYA

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Abstract

The aim of this study was to identify the determinants influencing the intensity of adoption of farm innovations among smallholder rice farmers in the West-Kano Irrigation Scheme amid the rising demand for rice in Kenya, which significantly outpaces local production. Despite the introduction of various innovations, adoption rates and influencing factors remain scarcely explored. Data were collected from 116 smallholder rice farmers using a standardised questionnaire. The Standard Poisson Model was employed for data analysis due to its suitability in handling count data, specifically the number of innovations adopted by farmers. This model helped identify key factors influencing innovation uptake. Findings reveal that several factors significantly impact adoption of farm innovations, including number of household income contributors, the proportion of land used for farming, decision-maker's farming experience, land ownership, and access to transportation and infrastructure. Notably, 98 per cent of farmers used improved seeds, 38 per cent adopted the line transplant method, and 97 per cent implemented pest management practices. Additionally, 47 per cent used the urea deep placement method and all participants engaged in some form of mechanised farming. The study concludes that understanding these factors can optimise policies aimed at enhancing rice productivity and commercialisation. Recommendations include employing the use of demonstration farms, collaborating with key rice value-chain actors, and building capacity. The significance of this study lies in its potential to inform policy formulation and strategic interventions that support the adoption of agricultural innovations, ultimately contributing to the sustainability and growth of the rice sector in Kenya.

Key terms: Adoption, farm innovations, irrigation scheme, rice, smallholder

1.0 INTRODUCTION

Rice (*Oryza sativa*) is a crucial staple crop, ranking third in global agricultural production with 761.5 million metric tonnes produced in 2018. It is a vital food source for over half the global population, particularly in Asia, where it provides up to half of the daily caloric intake for around 520 million individuals living below the poverty line (Chandio et al., 2022). In addition to Asia, rice consumption is rising in the Caribbean, Latin America, and Africa, highlighting its global significance (Apata et al., 2018).

Globally, the demand for rice is expected to surge by 70 per cent over the next 30 years due to population growth, urbanisation, and increasing incomes (Fahad et al., 2019). China and India dominate rice production, contributing 214 and 173 million tonnes respectively (Shaheen et al., 2022). In Africa, where smallholder farmers produce 80 per cent of the continent's food, rice is emerging as a key crop to ensure food security and reduce poverty (Behnassi et al., 2021). Despite their critical role, smallholders face challenges such as poverty, food insecurity, and limited access to resources (Cilliers et al., 2018).

Kenya demonstrates these challenges, with rice consumption growing at 12 per cent annually. However, domestic production of 181,000 tonnes falls short of the national demand of 846,000 tonnes and is projected to rise to 1.29 million tonnes by 2030 (National Rice Development Strategy 2, 2019–2030). In response, various initiatives, including collaborations with the Kenya Agricultural and Livestock Research Organisation (KALRO) and the International Rice Research Institute (IRRI), aim to boost rice production and address resource limitations (Hornum & Bolwig, 2021).

This study focuses on the West Kano Irrigation Scheme, a key region in Kenya for rice cultivation in Kenya. Despite ongoing efforts, there are gaps in understanding the factors influencing the intensity of adoption of agricultural innovations among smallholder farmers. Addressing these gaps is essential for enhancing productivity, food security and farmer livelihoods.

2.0 LITERATURE REVIEW

Mbatha et al. (2020) affirmed that rice is grown in more than 114 nations around the world, with an annual production of roughly 503.8 million tons on over 150 million acres of land. This equates to roughly 11 per cent of all cultivated land on the planet (FAO, 2017). According to Ali et al. (2019), the top producer of paddy rice in 2019 was China, followed by India, with 31.8 per cent and 22.4 per cent, respectively. More than half of the world's paddy production comes from these two countries. Rice requires enough water for growth (Shelley et al., 2016), and so the crop is produced in locations with enough water.

Rice is a stable food product for around half of the world's population, and Asia produces and consumes 90 per cent of it. As a result, it is a primary driving force behind global food security and the development of developing countries (Bandumula, 2017). Rice is the principal source of income for about one billion households across the Asian, African and American continents (Ali et al., 2017), and it has been at the vanguard of the fight against global hunger and poverty reduction among rising communities for decades. These developing countries gain foreign cash by exporting rice, and a strategy for increasing rice production and quality to ensure appropriate quantities for local consumption while leaving surpluses for export markets is needed (Hughes, 2016).

The adoption of agricultural innovations is influenced by multiple factors, including farmer characteristics, farm assets, and institutional support. Studies have shown that education, access to credit, extension services and availability of irrigation water significantly impact the adoption of modern rice technologies (Mariano et al., 2012; Ghimire et al., 2015). On the other hand, gender dynamics also play a role, as evidenced by lower adoption rates of the New Rice for Africa (NERICA) variety among male farmers in Uganda compared to female farmers (Kijima & Sserunkuuma, 2013).

In the Democratic Republic of the Congo (DRC), membership in farmers' associations and off-farm income positively influenced the use of mineral fertilisers (Lambrecht et al., 2014). In Ghana, factors such as labour availability, farm size, and household size affected the adoption of row-planting methods and mineral fertilisers (Donkor et al., 2018). Achandi et al. (2018) highlighted gender disparities in technology adoption, noting that women's limited participation in training sessions impedes the upscaling of rice technologies.

In Kenya, there are significant challenges in the rice production stages that are affecting the domestic rice subsector, which include: limited water for irrigation; declining productivity of land; the rising cost of inputs, machinery and mortgages; low-quality seeds and seedlings; inefficient agricultural practices (Muhunyu, 2012; Atera et al., 2018). Comprehensive management of the rice crop will address the issue of problem reduction, particularly the poor control of the nutrients and health of the soil and the problem of high production costs with low economic returns (Tsujiimoto et al., 2019). Over recent years, small-scaleholder farmers have depleted beneficial nutrients in large quantities from the soil without the use of enough amounts of farmyard manure or inorganic fertilisers in an attempt to replenish the soil.

The low productivity of the agricultural sector in developing countries has been largely attributed to a lack of innovation and a low uptake of improved technologies, which saves on labour and capital while increasing output and output per unit of labour (Mardianto et al., 2014). The primary goal of innovations is to increase food production while simultaneously improving the quality of the growing process of farm produce and the growth conditions.

According to Mutiso et al. (2018), rice production in Kenya is largely done under irrigation and with low uptake of innovations. Despite the fact that the country has been experiencing an increase in the area under rice production and yield, the production is still low compared to other countries in the region. Low uptake of innovations such as improved seed varieties, modern agronomic practices and mechanisation has limited the production of rice in Kenya. Other challenges such as low soil fertility, inadequacy of pest and disease management, lack of access to affordable and appropriate inputs, limited access to markets and poor access to credit have also hindered the production of rice in the country.

3.0 METHODOLOGY

This study was conducted in the West Kano Irrigation Scheme, located in Kisumu County, Kenya. The scheme, established in the 1970s, covers a gross area of 2,830 acres and supports over 2,200 smallholder rice farmers. The irrigation system relies on water pumped from and drained back into Lake Victoria, serving approximately 30,000 people dependent on rice farming.

A multistage sampling approach was adopted for this study. The West Kano Irrigation Scheme was purposively selected due to its prominence in rice cultivation and its inclusion in the Kilimo Trust R4iCSA Project. Rice farming households were systematically sampled from a list provided by the National Irrigation Authority (NIA). This approach ensured a representative sample of smallholder rice farmers within the scheme.

The starting point was randomly selected. The sampling interval was calculated by dividing the population size, which is 362 smallholder rice farmers, by the required sample size, which is 116 smallholder rice farmers, to get three as the sampling interval. From the starting point on the list of households of smallholder rice farmers, every third household of smallholder rice farmers was selected as the household head or the household decision-maker to represent the household by participating in the study.

The study aimed to model the determinants of the intensity of farm innovations adopted by smallholder rice farmers using a Poisson regression model. This model is appropriate for count data, where the intensity of farm innovations represents the dependent variable. The Poisson model assumes that the conditional mean of the dependent variable equals its variance, with the model specified as follows:

$$f(Y = y_i) = \Pr(Y = y_i) = \frac{e^{-\lambda_i} \lambda_i^{y_i}}{y_i!} = \dots \dots \dots y_i = 0, 1, 2, \dots, n \dots \dots \dots 1$$

Where the parameter μ_i is the conditional mean intensity of events for each explanatory variable. The parameter μ_i is given by:

$$\mu_i = \text{EXP}(x_i' \beta) \dots \dots \dots 2$$

Where, β is a $(k + 1) \times 1$ parameter vector with the β_0 parameter being the coefficient for the intercept and $\beta_1, \beta_2, \beta_3, \dots, \beta_k$ are coefficients associated with k regressors.

The following is how the assumption that mean equals variance was expressed:

$$V(y_i/x_i) = E(y_i/x_i) = \mu_i \dots \dots \dots 3$$

Where y_i is the intensity of farm innovations adopted by smallholder rice farmers (non-negative integer), x_i is the vector of the intensity of farm innovations adopted by smallholder rice farmers, and μ_i is the conditional mean of the intensity of farm innovations.

The variables included in the model, informed by prior studies (Zakaria et al., 2020), encompass education level, gender, household income contributors, farming experience, land size, land ownership, extension services intensity, group membership and access to transport facilities. The study hypothesised that these factors significantly influence the intensity of farm innovation adoption among smallholder rice farmers in the West Kano Irrigation Scheme, as shown in Table 1.

Table 1: Variables Included In Standard Poisson Model and Expected Signs

Variable	Definition of variable and their measurement	Expected sign
Dependent Variable	Intensity of farm innovations adopted by smallholder rice farmers (continuous)	
Independent Variables		

Education	Education level of decision-maker years	±
Gender	Gender of decision maker (1 male, 0 otherwise)	±
Members	Members contribute to the household income.	±
Experience	Farming experience of decision maker in years	±
Land size	Proportion of land under farming (acres)	±
landownership	Ownership of land (1 owned, 0 otherwise)	±
Extension	Intensity of extension visits in the last 12 months (Continuous)	±
Group membership	Membership to agriculture-related group (1=yes, 0= otherwise)	±
transport access	Access to transport facilities/infrastructure (1=yes, 0= otherwise)	±

¹ Decision maker is the individual who makes major household decisions, including farming

4.0 RESULTS AND FINDINGS

Descriptive Statistics of Categorical Variables

The categorical variables in the study were examined, including the decision maker's gender, access to transportation facilities/infrastructure, membership in agriculture-related groups, land ownership and farm innovations used by smallholder rice farmers. Descriptive statistics in the form of frequencies and percentages were employed to analyse the data provided in tables. Table 1 indicates the results for the gender of the household, access to transport facilities/infrastructure, membership to an agriculture-related group and ownership of land.

Table 1: Descriptive Statistics of categorical variables

Variables	Category	Frequency	Percentage %
Gender of decision-maker	Female	27	23.3%
	Male	89	76.7%
Access to transport facilities/infrastructure	No	16	13.8%
	yes	100	86.2%
Membership in agriculture related group	No	94	81.0%
	yes	22	19.0%
Ownership of land (1 owned, 0 otherwise)	No	70	60.3%
	Yes	46	39.7%

The results in Table 1 indicate that the majority (76.7%) of the respondents were male, compared to 23.3 per cent female. This implies that most households are headed by males, who are the decision-makers concerning rice production. In terms of access to transport facilities and infrastructure, 86.2 per cent of the respondents confirmed that they access transport facilities, while 13.8 per cent cited an inability to access transport facilities. This could be attributed to dry-weather roads, which are efficiently utilised during the dry season and impassable during the wet season.

In terms of group membership, 81 per cent of the respondents indicated they were not members of an agriculture-related group, while 19 per cent confirmed that they were members of an agriculture-related group.

Table 1 results revealed that 39.7 per cent of the respondents owned land in the West Kano Irrigation Scheme, while the majority (60.3%) did not own it. The results suggest most of the smallholder rice farmers in the West Kano Irrigation Scheme rent or lease land for rice production. Table 2 indicates the results of farm innovations adopted by smallholder rice farmers in the West Kano Irrigation Scheme.

Table 2: Farm Innovations Adopted By Smallholder Rice Farmers (N= 116)

Farm innovations	Category	Frequency	Percentage %
Intermittent Irrigation	Yes	116	100.0
Pesticides	No	3	2.6
	Yes	113	97.4
Improved rice varieties	No	2	1.7
	Yes	114	98.3
Fertilisation-Urea deep placement	No	2	1.7
	Yes	114	98.3
Row-planting	No	72	62.1
	Yes	44	37.9
Crop rotation	No	81	69.8
	Yes	35	30.2
Mechanisation	Yes	116	100.0

The results in Table 2 revealed that 100 per cent of the respondents practised intermittent irrigation farm innovations. The results suggest that smallholder rice farmers in the West Kano Irrigation Scheme synonymously adopted irrigation and mechanisation as the main farm innovations to enhance rice production. The adoption of this irrigation technique could be attributed to the reliability of enough water from Lake Victoria.

The findings on the adoption of enhanced rice varieties among smallholder rice farmers are significant, with a large majority, particularly 98.3 per cent, recognising its use as a strategy to increase rice production. This strong endorsement highlights the critical role performed by efforts such as the National Rice Development Strategy (NRDS-I&II) Phases One and Two, which have clearly helped the distribution and acceptance of improved rice varieties among these farmers. Furthermore, statistics on fertilisation practices, as shown in Table 2, show a similar pattern of adoption.

In terms of row-planting agricultural innovation, the results in Table 2 showed that the majority (62.1%) of smallholder rice farmers in the West Kano Irrigation Scheme did not practice it. In comparison, 37.9 per cent of smallholder rice farmers used row-planting farm innovation to increase rice production. Also, on crop rotation farm innovation, the results in Table 2 showed that the majority of smallholder rice farmers in the West Kano Irrigation Scheme (69.8%) did not practice crop rotation, while 30.2 per cent admitted to using crop rotation farm innovation to increase rice production.

Descriptive Statistics of Continuous Variables

The following continuous variables from the standard Poisson regression model were examined in the study: The intensity of farm innovations adopted by smallholder rice farmers, the intensity of household

income contributors, decision-maker education level (intensity of years in school), proportion of farmland under cultivation (acres), and intensity of extension visits in the previous year. Table 3 shows the results of the descriptive statistics of continuous variables included in the standard Poisson regression model.

Table 3: Descriptive Statistics of Continuous Variables (n=116)

Variable	Mean	Std. dev.	Min	Max
Intensity of farm innovations adopted by smallholder rice farmers (continuous)	4.638	0.908	2	6
Intensity of members who contribute to household income	3.491	1.591	1	9
Education level of decision maker (intensity of years in schooling)	11.250	2.856	5	16
Proportion of land under farming (acres)	2.724	5.401	1	50
Intensity of extension visits in the last 12 months	3.534	1.380	3	10

Table 3 shows that the average intensity of farm innovations adopted by smallholder rice farmers was about 5, with a minimum of 2 farm innovations and a maximum of 6 farm innovations, with a standard deviation of about 1. According to the findings, smallholder rice farmers used at least two farm innovations to increase rice yield. The results revealed that the intensity of household members who contribute to household income was around 3, with a minimum of one person and a maximum of 11 individuals per household, represented by a standard deviation of approximately 1.6. According to the findings in Table 3, approximately four members in the home contribute to household income.

On the education level of the decision maker (intensity of years in schooling), the average intensity of years in schooling was approximately 11, with a minimum intensity of 5 and a maximum intensity of 16 years in schooling, specified by a standard deviation of approximately 2.9. The results suggest a large disparity in the intensity of years in schooling since the minimum intensity of years in schooling was 5 and the highest intensity of years in schooling was 16 years.

In terms of the proportion of land under farming (acres), the average land under rice farming was approximately 2.7 acres, with a minimum intensity of one acre and a maximum of fifty acres under rice farming, specified by a standard deviation of approximately 5.4. The results suggest a major dispersion from the mean intensity of acres under rice production since the minimum acreage under rice production was one, and the maximum acreage was 50 under rice production. This could be attributed to the high cost of land leasing for rice production in the West Kano Irrigation Scheme, exacerbated by the inability of the majority of smallholder farmers to raise a sufficient amount of money for land leasing.

In terms of the intensity of extension visits in the last 12 months, the average intensity of extension visits per year was approximately 4, with a minimum intensity of 3 visits and a maximum of 10 visits, indicated by a standard deviation of approximately 1.4. The results suggest a large dispersion from the mean intensity of extension visits per year since the minimum intensity of visits per year was 3 and a maximum of 10 extension visits. This could be attributed to the small number of employed extension officers employed in the Nyando sub-county. The intensity of extension visits in the last 12 months showed a positive but insignificant relationship with the intensity of innovations adopted. This suggests that while

extension services are generally beneficial, the frequency of these visits did not significantly enhance the adoption of farm innovations among smallholder rice farmers. This is in line with findings by Nakano et al. (2018), who also noted that extension services have a positive, although sometimes statistically insignificant, impact on the adoption of agricultural innovations.

Diagnostic Test
Multicollinearity Test

Multicollinearity, which is a state of very high inter-correlations or inter-associations among the proposed independent variables, was tested using the variance inflation factor (VIF) and the results are presented in Table 4.

Table 4: Variance Inflation Factor Test Results for Continuous Explanatory Variables

Variable	VIF	1/VIF
The education level of decision-maker	1.12	0.896412
Gender of decision-maker	1.11	0.904970
Ownership of land	1.09	0.914594
Proportion of land under farming (acres)	1.08	0.928049
Access to transport facilities/infrastructure	1.07	0.936318
Intensity of members who contribute to household income	1.06	0.943538
Farming experience of decision-maker	1.05	0.950777
Membership in agriculture related group	1.05	0.951314
Intensity of extension visits in the last 12 months	1.03	0.966333
Mean VIF	1.07	

The results in Table 4 revealed that the VIF for each explanatory variable was approximately 1, indicating that there was no multicollinearity among the explanatory variables tested since VIF values were less than 10.

Heteroscedasticity Test

The White test was used to detect heteroscedasticity for all hypothesised explanatory variables, and the results are presented in Table 5. Unlike the Breusch-Pagan test, which would only detect linear forms of heteroscedasticity, the white test was preferably applied as it incorporates both the magnitude as well as the direction of the change for non-linear forms of heteroscedasticity (Uyanto, 2019). White's general test is a special case of the Breusch-Pagan test, where the assumption of normally distributed errors has been relaxed.

Table 5: Test for Heteroscedasticity

Source	chi ²	df	p
Heteroscedasticity	37.98	50	0.8937
Skewness	9.98	9	0.3522
Kurtosis	2.63	1	0.1051
Total	50.59	60	0.8016
chi ² (185) = 76.58			
Prob > chi ² = 1.0000			

Table 5 shows that the study found no statistically significant evidence of heteroscedasticity, as indicated by the non-significant chi-squared value of 76.58, highlighting the dataset's robustness in terms of consistent variance.

Determinants of the Intensity of Innovations Adopted By Rice Farmers

The factors contributing to the adoption of innovations by smallholder rice farmers in the West Kano Irrigation Scheme were analysed using a Standard Poisson model regression model. Table 6 indicates the Standard Poisson model results on factors influencing the adoption of innovations by rice farmers.

Table 6: Factors Contributing to the Intensity of Adoption of Rice Farm Innovations by Smallholder Rice Farmers

Variables	Coefficient	std. err.	z	Marginal Effects	std. err.	z
Gender of decision-maker	-0.0115	0.0240	-0.48	-0.0533	0.1110	-0.48
Intensity of members who contribute to household income	0.0020***	0.0006	3.19	0.0093***	0.0029	3.23
The education level of the decision-maker	0.0035	0.0038	0.92	0.0163	0.0177	0.92
Proportion of land under farming (acres)	0.0026*	0.0015	1.71	0.0120*	0.0070	1.72
Intensity of extension visits in the last 12 months	0.0067	0.0071	0.94	0.0310	0.0329	0.94
Farming experience of decision-maker	0.0227***	0.0088	2.59	0.1052***	0.0403	2.61
Membership in agriculture related group	-0.0279	0.0332	-0.84	-0.1295	0.1534	-0.84
Ownership of land	0.3168***	0.0235	13.46	1.4682***	0.1111	13.22
Access to transport facilities/infrastructure	-0.0720**	0.0330	-2.18	-0.3338**	0.1529	-2.18
cons	1.3453***	0.0722	18.64			
Intensity of obs = 116						
Wald chi ² (9) = 669.86***						
Pseudo R ² = 0.0324						
Log pseudolikelihood = -193.36312						

Legend: * p<.1; ** p<.05; *** p<.01

The results in Table 6 indicate that many factors contribute to the adoption of innovations by smallholder rice farmers. They are as follows: Gender of the decision maker, the intensity of members who contribute to household income, education level of the decision maker (intensity of years in schooling), the proportion of land under farming (acres), the intensity of extension visits in the last 12 months, the farming

experience of the decision maker, membership in an agriculture-related group, land ownership and access to transportation facilities/infrastructure.

The gender of the decision maker had a negative, insignificant influence on the intensity of farm innovations adopted by smallholder rice farmers. This implies that the gender of the decision maker does not significantly contribute to the intensity of farm innovations adopted by smallholder rice farmers in the West Kano Irrigation Scheme. This observation is consistent with the study done by Ghimire et al. (2015) on factors affecting the adoption of improved rice varieties among rural farm households in Central Nepal, where the finding of their study established an insignificant gender differential in the adoption of improved rice variety farm technology among rural farm households in Central Nepal. Consequently, the findings of the study were contrary to the findings of the study done by Donkor et al. (2018) on the adoption of farm innovations among rice producers in Northern Ghana, where the findings of their study established that the gender of the household head was a significant contributor to the adoption of farm innovations among rice producers in Northern Ghana.

The intensity of members who contribute to household income was positively and significantly associated with the intensity of innovations adopted by smallholder rice farmers in the West Kano Irrigation Scheme at a significant level of 1 per cent. This implies that a household with more members contributing to household income was more likely to adopt more farm innovations since the income contributed by household members could be used to finance the activities related to the adoption of farm innovations, like purchasing chemical fertilisers and land cultivation using tractors, among others. This observation is similar to the findings of Wordofa et al. (2021) on the adoption of improved agricultural technology and its impact on household income in eastern Ethiopia, where the findings of their study established a significant association between household income and the adoption of improved agricultural technology.

The intensity of innovations adopted by smallholder rice farmers in the West Kano Irrigation Scheme was positively and insignificantly related to the decision maker's years of schooling. This implies that the intensity of years of schooling of the decision maker did not have a significant influence on the intensity of farm innovations adopted by smallholder rice farmers. This observation is similar to that of Donkor et al. (2018), who noted that the education of household heads did not exhibit statistical significance, even at 10 per cent, in the adoption of farm innovations among rice producers in Northern Ghana.

The proportion of land under rice farming (acres) was positive and significantly associated with the intensity of innovations adopted by smallholder rice farmers in the West Kano Irrigation Scheme at a significant level of 10 per cent. This implies that smallholder farmers who allocate a large proportion of land for rice production are likely to adopt more farm innovations than those who allocate a small proportion of land for rice production. These findings conform with the findings of the study done by Anang (2018) on farm technology adoption by smallholder farmers in Ghana, where the findings of the study established a positive, significant association between the proportion of land under farming and the adoption of farm technologies.

The intensity of extension visits in the last 12 months was positively and insignificantly associated with the intensity of innovations adopted by smallholder rice farmers in the West Kano Irrigation Scheme. This implies that the intensity of extension visits in the last 12 months did not have a significant influence on

the intensity of farm innovations adopted by smallholder rice farmers. This observation is similar to the findings of the study done by Moser and Barrett (2006) on the complex dynamics of smallholder technology adoption, where the findings of their study established that past extension presence has no significant effect on technology adoption.

The decision-maker's farming experience had a positive and significant influence on the adoption intensity of farm innovations at a 1 per cent significance level. Experienced farmers are likely to have better knowledge of the benefits and management practices of farm innovations, making them more inclined to adopt such technologies. This finding is supported by previous research, such as that by Simtowe et al. (2016), which highlighted the importance of farming experience in technology adoption decisions and contrary to a study by Bello et al. (2021) on the adoption of innovations by groundnut farmers in West Africa showing that farm experience significantly reduces the likelihood of smallholder farmers' adoption.

The membership of an agriculture-related group of decision-makers had a negative insignificant influence on the intensity of farm innovations adopted by smallholder rice farmers. This implies that membership in an agriculture-related group of decision-makers does not significantly contribute to the intensity of farm innovations adopted by smallholder rice farmers in the West Kano Irrigation Scheme. This observation is consistent with the study of Olagunju et al. (2021), who noted that group membership, like cooperative membership, does not influence the technical efficiency of maize production in Nigeria.

At a 1 per cent significance level, ownership of land by a decision maker had a positive and significant influence on the intensity of innovations adopted by smallholder rice farmers in the West Kano Irrigation Scheme. The results suggested that the more people decide who owns land, the more likely they are to adopt more farm innovations in comparison to non-landowners. These findings are similar to those of Ehiakpor et al. (2021), who noted that farmers' land ownership was significantly associated with the adoption of interrelated sustainable agricultural practices among smallholder farmers in Ghana.

At a 1 per cent significance level, access to transport facilities/infrastructure by decision makers had a positive and significant influence on the intensity of innovations adopted by smallholder rice farmers in the West Kano Irrigation Scheme. The results suggested that those farmers who had access to transport facilities and infrastructure were likely to adopt more farm innovations than those farmers who did not have access to transport facilities and infrastructure. These findings are similar to those of Falo et al. (2020), who noted that access to transport facilities/infrastructure was significantly associated with the adoption of farm innovations.

5.0 CONCLUSION AND RECOMMENDATION

Conclusion: In conclusion, this study emphasises the critical role of several key determinants in shaping the adoption of farm innovations among smallholder rice farmers, including the number of household income contributors, the extent of land under cultivation, the experience of decision-makers in farming, land ownership, and access to transportation infrastructure.

These elements, taken together, demonstrate the multidimensional nature of innovation uptake in this agricultural environment. Given these findings, policymakers and agricultural stakeholders must prioritise the enhancement of agricultural extension services in order to allow the wider adoption of rice farm innovations, ultimately increasing rice yield and commercialisation. Furthermore, specialised training programmes like workshops, field demonstrations of technologies, and farm business schools(FBS) should

be developed to educate smallholder farmers on the technical complexities and benefits of these breakthroughs. Finally, future research can investigate further the precise effects of farm innovations on rice yield and commercialisation to better inform evidence-based agricultural strategy.

Recommendations: Capacity building through targeted training sessions on crop management principles and agricultural innovations is essential for driving the adoption of farm innovations. Farmers who undergo these training programs are better equipped to make informed decisions, leading to higher adoption rates compared to those with limited exposure to such innovations. Collaboration among key stakeholders, including Kilimo Trust, Egerton University, the Ministry of Agriculture Livestock & Fisheries, the National Irrigation Board and other relevant entities in the rice sub-sector, is crucial. These stakeholders can create a robust social network by participating in multi-stakeholder initiatives aimed at developing and promoting innovations like high-yield rice varieties and strengthening the entire rice value chain. This collaborative approach will help bridge the knowledge gap between experts and farmers, facilitating the transfer of valuable information and skills. Promoting the utilisation of rice by-products is another vital recommendation. This includes the use of rice husks to produce biochar, which contributes to resource conservation and environmental protection. Additionally, vermicomposting rice straws using worms can produce organic foliar fertilisers and natural pesticides, offering sustainable alternatives for farmers. The establishment of demonstration plots is recommended as a practical learning tool. These plots, created with the involvement of relevant stakeholders, can serve as platforms for promoting agricultural innovations and allowing farmers to witness first-hand the benefits and applications of new technologies. Government support and the involvement of relevant institutions are necessary for co-financing agricultural innovations. This partnership will ensure the sustainability and continuity of these innovations among rice farmers, even beyond the lifespan of specific projects. Lastly, engaging both local and national media is crucial for promoting agricultural innovations. Media involvement will enhance the dissemination of innovative ideas, increasing awareness and encouraging broader adoption among farmers and other stakeholders in the agricultural sector.

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