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A Model for the Adoption of Innovative Technology in Marondera District Ward 22 Rural Agricultural Sector

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TITLE: A MODEL FOR THE ADOPTION OF INNOVATIVE TECHNOLOGY IN MARONDERA DISTRICT WARD 22 RURAL AGRICULTURAL SECTOR.

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Abstract

Limited Agricultural technology access is a key factor that has greatly limited agricultural advancement in Africa. The study was conducted to model the adoption of innovative technology in Zimbabwean, small scale rural agriculture sector in Marondera District, Mashonaland East Province. Quantitative data were collected from 200 farmers in Ward 22 resettlement using structured questionnaires. To complement primary data, annual reports from Marondera Agritex Offices were considered. Stratified random sampling was employed to balance participation of all small-scale farmers categories that are in crop production, farmers in livestock production and horticultural production in providing information. Data were analyzed using descriptive statistics and linear regression in SPSS v25. Regression model was marginally non-significant ($F=1.546$, $p=0.056$). Results showed that there is a positive and statistically significant effect on farmer performance GIS/GPS ($p=0.045$), irrigation (0.033) and greenhouse ($p=0.029$), Early warning system, integrated farming and conservation agriculture are not significantly related to farmer performance as indicated ($p>0.05$). The study was theoretically anchored in the Technology Acceptance Model (TAM), which explains how perceived usefulness and perceived ease of use influence uptake. Therefore, since adoption of innovative technology was found to have a bright

future to farmers; it is important for the government and its Ministry land, Agriculture, as well as non-governmental agricultural agencies to take into consideration peculiar needs of group of farmers and their farming areas when planning programs on adoption of technologies. To conclude, it was found that providing all innovative technologies, rural small scale farmers performance that is production and income can be improved in agriculture.

Key words: Adoption, innovative technologies, small-scale farm, food security, government policy

Introduction

Agriculture plays a critical role in economic development, food security, poverty reduction, and rural livelihoods, particularly in Zimbabwe where most agricultural producers are smallholder farmers (Olarinde and Oladunni, 2013; Coff et al., 2015; Yamba et al. 2017). However, farmers face challenges such as climate change, pests, diseases, soil degradation, limited access to reliable information, and declining agricultural resources. These challenges create a need for innovation and the adoption of modern agricultural technologies.

Technological innovations such as sensors, drones, artificial intelligence (AI), remote sensing, and agricultural decision-support systems can improve farm productivity and efficiency. These technologies can help farmers to make better decisions, detect pests and diseases early, improve resource management, increase revenues, and reduce environmental impacts (Wang, Xu, Wang, Li & Li, 2021).

Overall, the background establishes that technological innovation has the potential to improve agricultural productivity and farmer performance, but challenges in access and adoption make it important to examine how new farming technologies influence the performance of farmers.

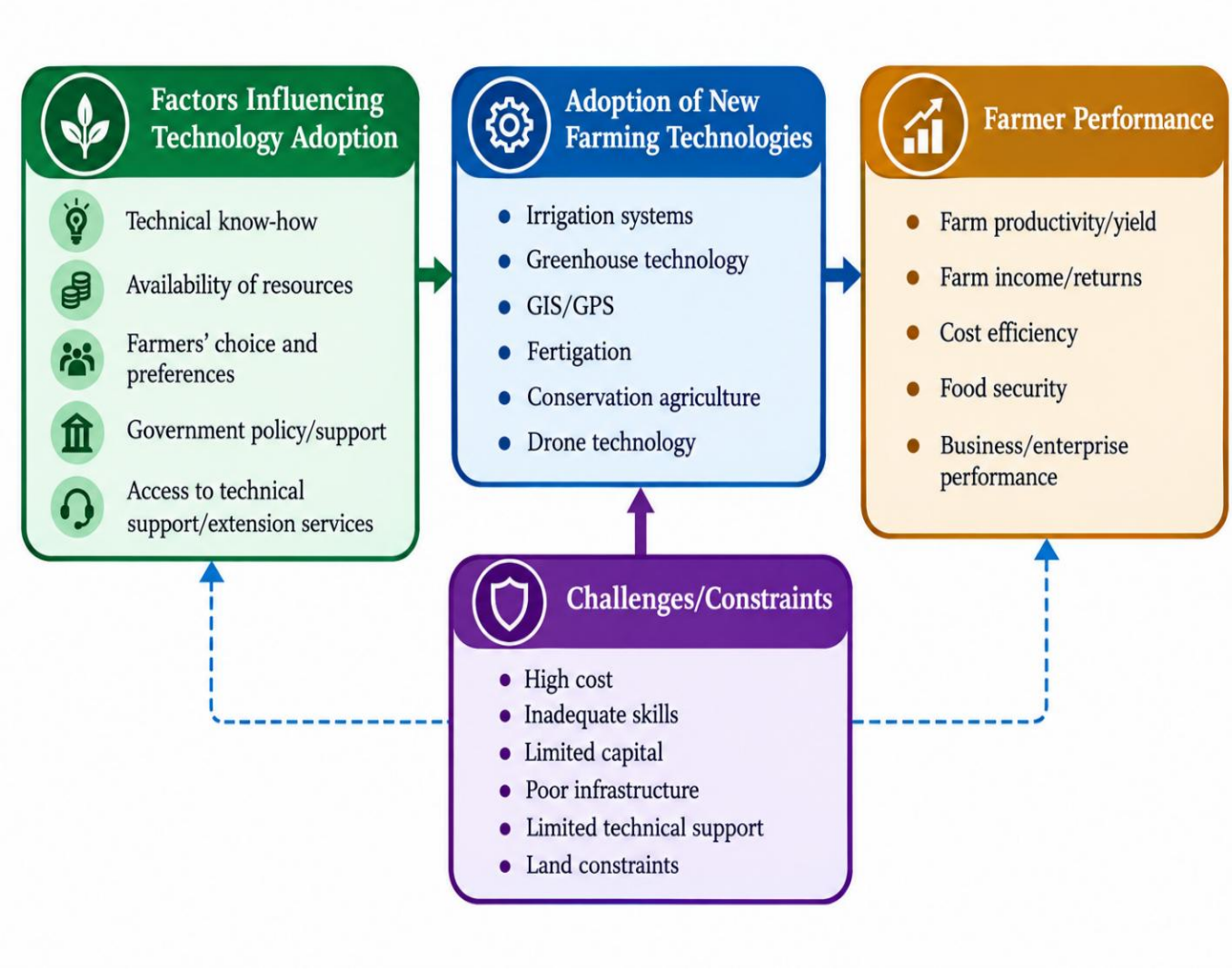
Globally, the growing population and increasing demand for food, together with climate-related challenges and declining farmland, are putting pressure on agricultural production, World Bank (2019). Consequently, agricultural innovation and technology adoption are increasingly important for improving productivity and enhancing food security (Musungwini,2016, 2018). However, smallholder farmers often face barriers to accessing modern technologies, information, financing, and other agricultural services.

Locally, small-scale farming is a major source of income for rural households Zimbabwe, but farmers continue to face climate change, drought, and declining productivity while many still rely on traditional farming methods (Kuwornu et al., 2017). Increasingly, farmers are adopting technologies such as modern irrigation, fertilizers, pesticides, mechanization, improved crops, post-harvest storage, and GIS to improve productivity, income, and food security (Takawira, D. 2018).

However, According to Fianko (2015), agricultural technologies can also have negative environmental and health effects, particularly through excessive use of fertilizers and pesticides. To promote better farming practices, the Zimbabwean government has introduced policies such as the Agricultural Policy Framework (2012-2032) and National Development Strategy 1 (NDS1), supported by agricultural extension services (FAO 2020; Ministry of Agriculture 2019).

Problem statement is that small-scale farming is a major source of income for rural households in Zimbabwe, and farmers are increasingly adopting innovative agricultural technologies to improve productivity and income (Asante et al., 2014; Donkor et al., 2014). However, The World Bank (2019) reported that the adoption and effective use of these technologies remain constrained by limited technical knowledge, inadequate financial resources, high transaction costs, land tenure uncertainties, and poor infrastructure. Reduced investment in agricultural education and training has also weakened farmers' access to the knowledge needed to use modern technologies effectively. These constraints may limit the ability of farmers to obtain the full benefits of technological innovation.

Figure 1. Conceptual framework: the adoption of innovative technology and farmer performance among smallholder farmers.



Source: own source

The conceptual framework in *fig 1* illustrates that farmers' adoption of new agricultural technologies is influenced by their technical knowledge, availability of resources, preferences, government support, and access to extension services. Technologies such as irrigation, greenhouse farming, GIS/GPS, fertigation, conservation agriculture, and drones are expected to improve farmer performance through higher productivity, increased income, cost efficiency, improved food security and better business performance. However, constraints may hinder technology adoption and reduce its potential benefits. The arrows show the direction of these relationships, while challenges can constrain technology's adoption and its benefits.

Materials and Methods

The study was conducted in Ward 22 of Marondera District, Mashonaland East Province, Zimbabwe. Marondera District comprises 23 wards, and Ward 22 was purposively selected because smallholder farmers are actively engaged in different crop fields and exhibit variation in resource endowments and levels of technology adoption. The study's target audience consisted of 1215 farmers and other agricultural stakeholders in Mashonaland East Province's Marondera district with special focus on ward 22. The study focused on farmers engaged in horticulture, animal production, and crop production, among other farming operations. The Agritex department, which typically collaborates with farmers, provided the information for the Marondera ward 22 farmers list. To determine which groups of smallholder farmers were present in ward 22 region, a stratified sample technique was utilized. Three kinds of farmers, those involved in crop, animal, and horticultural production—were identified by use of the stratified sampling system.

Statistically the ward 22 area was estimated to have a total number of small-scale farmers up to 1215 (Marondera Agritex 2024). Yamane (1967:886) formula was used to determine the sample size to represent the Marondera ward 22 area for quantitative data, where a sample size of 200 farmers was determined to represent the area.

Quantitative data was collected using structured questionnaires administered to farmers face to face. To complement primary data, the researcher considered annual reports from Marondera Agritex office. Data base for farmers in Marondera district was also collected from the Agritex which was then used to select the sample for primary data collection.

Data analysis was conducted at two levels. Descriptive statistics were used to summarize the current level of innovative technology adoption by small scale farmers, factors that influence the adoption and use of farming technology and challenges faced by small scale farmers in adoption and use of innovative technology. These statistics were used to provide a clear picture of the current situation of technology adoption among smallholder farmers.

Hypothesis testing

H_{01}. There is significant new farming technology adoption by small scale farmers.

H_{02}. New farming technology adoption significantly influences farm performance.

For hypothesis 1, one-sample t-test was used to determine whether the mean level of new farming technology adoption among smallholder farmers was statistically significant when compared with the hypothesized test value. To examine whether new farming technology adoption influence farm performance regression analysis was applied, with farm performance as the dependent variable. Independent variables included greenhouse farming, conservation agriculture, early warning system, geographical information system, fertigation, integrated farming and irrigation.

$$Yi=\beta0+\beta1X1i+\beta2X2i+\beta3X3i+\beta4X4i+\beta5X5i+\beta6X6i+\beta7X7i+\epsilon i\ldots \quad 1$$

Where:

Yi = Fam performance (dependent variable)

β0 = Intercept

X^1i = Early warning

X^2i = Conservation agriculture

X^3i = Greenhouse technology

X^4i = Irrigation

X^5i = Fertigation

X^6i = integrated farming

X^7i = GIS/GPS

ϵi = Error term

Results and Discussion

Descriptive statistics

Variables	N	Minimum	Maximum	Mean	Std. Deviation
Early warning	168	1	4	2.05	1.436
Fertigation	168	1	4	2.12	1.060
GIS/GPS	168	2	4	3.20	.982
Irrigation	168	1	4	2.30	1.161
CA	168	1	4	1.99	1.078
Permaculture	168	4	4	4.00	.000
Greenhouse	168	2	4	3.71	.704
Inte Farming	168	1	4	2.18	1.470
Valid N (listwise)	168				

Source: survey 2024

The descriptive statistics *(table1)* indicate varying levels of innovative technology adoption among smallholder farmers. GIS/GPS had a higher mean of 3.20 and relatively low variability (SD=0.982), permaculture recorded a mean of 4.00 with a standard deviation of 0.000, indicating a complete consistency, with all farmers reporting the same level of adoption. While early warning systems showed relatively high variability (m=2.05), suggesting differences in usage patterns that may be influenced by farm characteristics and individual preference, fertigation showed moderate variability (SD=1.060; M=2.12) and irrigation showed moderate variation (m=2.30; SD1.161) demonstrate greater differences in usage. These findings highlight the need for targeted farmer support, education and training to strengthen the adoption and effective use of innovative technologies.

Hypothesis testing

One sample T test was conducted against a test value of four to assess the level of innovative farming technology adoption among smallholder farmers. The results show that early warning, GIS, irrigation, permaculture, greenhouse technology, integrated farming, and conservation agriculture were statistically significant ($p<0.05$). Fertigation was not statistically significant ($p=0.559$). Overall, the findings indicate that farmers' adoption levels differed significantly from the test value for most technologies, while fertigation did not show a significant difference. The results therefore provide evidence of variation in the adoption of innovative farming technologies among smallholder farmers

	Test Value = 4					
	T	Df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
CEarlywarning	-18.167	167	.000	-1.357	-1.50	-1.21
CFertigation	-.586	167	.559	-.060	-.26	.14
CUseofGIS	-14.754	167	.000	-1.792	-2.03	-1.55
CIrrigation	-11.303	167	.000	-1.512	-1.78	-1.25
CPermaculture	-69.695	167	.000	-2.619	-2.69	-2.54
CGreenhouse	-10.625	167	.000	-1.482	-1.76	-1.21
CIntegratedf	10.789	167	.000	.411	.34	.49
CCA	-2.027	167	.044	-.226	-.45	-.01

Source: survey 2024

Regression Analysis

Regression results in table 3 confirmed the descriptive trends. Positive predictors of farm performance included GIS (β = 0.013), irrigation (β = 0.005), greenhouse (β = 0.067). These variables may enhance farmers' ability to manage resources, improve production conditions, and increase productivity. Conversely, early warming, fertigation, CA, and integrated farming were negative predictors, indicate that adoption of a technology does not automatically translate into improved performance.

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	2.454	.162		15.193	.000
	Early warning	.003	.015	.016	.196	.845
	Fertigation	-.035	.020	-.138	-1.794	.135
	GISGPS	.013	.022	.047	.607	.045
	Irrigation	.005	.019	.022	.276	.033
	CA	-.008	.020	-.032	-.414	.679
	Greenhouse	.067	.031	.174	2.206	.029
	Integrated F	-.014	.015	-.077	-.955	.341

a. Dependent Variable: FARMER_PERFORMANCE

Discussion of results

The data indicates that there is a positive correlation between farmer performance and GIS/GPS, with a p-value of 0.045 for GIS/GPS. This indicates that a unit's increased use of GIS/GPS will result in a 0.045 increase in farmer performance while maintaining other variables constant. With increased education, one can understand better how to use and manage the production of crop enterprises. Nin et al. (2003) claims that the use of modern farming techniques and agricultural technologies has enhanced yield in emerging nations and resulted in the expansion of farmlands available for crop cultivation. This suggests that an increase in GIS corresponds to an improvement in farmer performance.

A coefficient of 0.033 for irrigation had a positive influence on farmer performance. This means that holding other things constant an increase in use of irrigation by a unit will lead to an increase

in farmer performance by 0.033 units. This means that irrigation is critical in farming as it allows farmers to be productive all year around unlike those who solely depend on rainfed. Improved irrigation systems, the use of pesticides, and novel seed varieties that significantly boost crop yield are examples of appropriate agricultural technology that could be beneficial for Zimbabwe (Kumar 2020). This translates to 3.3% which means that increase in use of irrigation leads to an increase in input investment.

A coefficient of 0.029 for greenhouses had a positive influence on farmer performance. This means that holding other factors constant an increase in use of greenhouses by a unit will lead to an increase in farmer performance by 0.029. This changes to 2.9%, indicating that more investments in new technologies result in higher agricultural output.

Early warning, fertigation, CA and integrated farming are not significantly related to farmer performance as indicated ($p>0.05$).

In conclusion, the results show that use of GIS/GPS has the most significant impact on farmer performance as indicated by its coefficient of 0.045 which has the greater magnitude. This supports Zimbabwe's economic growth and development by enhancing and improving the livelihoods of farming people (Albrecht and Bauckhag 2012; Akudugu et al., 2012).

CONCLUSION

According to0the report, adopters'0lives have been0somewhat improved by0the technologies they have adopted.0This must do with0raising the productivity and0income of farmers as0well as encouraging more0young people to pursue farming.0Additionally, it was shown that a variety of institutional,0political, and socioeconomic0variables support the farmers'0decision to adopt. The bulk of0farmers' adoption0of the technology0has been0impacted by institutional0factors such0as availability0of extension services and0advice, assistance0from farmer cooperatives,0proximity to input markets,0workshops, and community0training programs. The capital and0productive resources that0farmers have access to, their educational0attainment, the amount of acreage0they own, the age and0gender of the heads of their0farming households0these are the socioeconomic0elements.

But other0factors have made it0difficult for these0farmers to0adopt the technology,0such as0their limited capital0and resource base,0difficulty0obtaining credit,0the high cost0of inputs0needed to implement0the technology, their fear0of the long-term effect0on soil fertility and0quality, and their0past experiences0losing money and accruing0debt. As a result,0the study came0to the conclusion0that it is necessary to0create a welcoming0environment where0farmers may obtain knowledge0at a reasonable0cost and for0free.

While this research has provided valuable insights into the determinants of farmer performance when adopting innovative technologies in Ward 22 Marondera district. Future studies could: Additional0research might do a0comparative analysis of the0various intersectional0aspects that influence farmers'0adoption decisions across0the nation's farming communities. This0would make it possible0to conduct a0thorough investigation into the0various dynamics, overlapping,0and connected0elements that affect0how different farmers0decide to use new0technologies.

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DECLARATION

Funding Declaration

There was no funding.

Ethics Approval

Ethical approval for this study was granted by Senate Research and Postgraduate Degrees Committee at Marondera University of Agricultural Sciences and Technology.

Accordance

This study was conducted in accordance with the applicable institutional research ethics requirements and relevant ethical guidelines governing research involving human participants. Participation was voluntary, informed verbal consent was obtained from participants before data collection, and measures were taken to protect participants' confidentiality.

Consent to participate

Informed verbal consent was obtained from all participants before data collection. The purpose of the study was explained to participants, and participation was voluntary.

Consent to publish

As authors, we allow you to publish this article.

Clinical trial

This study was not a clinical trial.

Data Availability Statement (DAS)

The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

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