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Unlocking the potential: challenges and factors influencing the use of ICTs by smallholder maize farmers in Zimbabwe

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ABSTRACT

The study aims to investigate the challenges faced by smallholder maize farmers and identify the pivotal factors influencing the adoption of ICTs in agriculture. A blend of descriptive and probit regression analytical techniques is applied by analyzing cross-sectional survey data from a selected multistage random sample of 155 maize farmers in Marondera Rural District, Zimbabwe. The study findings revealed that the foremost obstacles hampering ICT adoption include electricity shortages attributable to load-shedding and persistent communication network challenges. Additionally, it was observed that the utilization of mobile phones for agricultural purposes remains moderately low, while the use of computers in agriculture is strikingly minimal. The probit regression model results revealed that age, gender, access to credit, and extension contact are significant determinants for computer use in agriculture. Furthermore, critical influencers of mobile phone adoption for agricultural activities that were identified include farming experience, engagement in non-farm activities, credit access, remittances, and extension visits. The study recommends fostering an enabling environment to encourage farmers to embrace ICTs for agricultural purposes. To support this endeavor, the study advocates an improved agricultural training and extension system, with particular attention to less experienced and elderly farmers who may exhibit resistance to technological advancements.

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1. Introduction

1.1. Background

Agricultural development is crucial for emerging countries to foster economic growth and support their growing populations (Pawlak & Kołodziejczak, 2020; Sassi, 2023). Agriculture reduces health-related costs by providing crops that prevent undernutrition, obesity, and diet-related diseases (Adenle et al., 2019). However, in many developing countries, including Zimbabwe, smallholder farmers, who contribute approximately 80% of the agricultural output, continue to grapple with numerous challenges (Kamara et al., 2019). These challenges encompass limited access to credit and markets, volatile market prices, pest and disease pressures, and changing environmental conditions (Hlatshwayo et al., 2021; Paudel et al., 2023). Therefore, the smallholder farmers' capacity to adapt, cope with, and navigate the increasingly dynamic and complex markets is hindered (Abate et al., 2023).

Research suggests that many of these challenges can be overcome if smallholder farmers adopt technologies that provide access to up-to-date information, facilitating prompt and well-informed decision-making in their agricultural operations (Abate et al., 2023; Campo et al., 2017; Nwafor et al., 2020). Considering the dynamic and complex markets, characterized by an increasing demand for adaptable

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decision-making, adopting Information and Communication Technologies (ICTs) has become imperative (Ali & Kumar, 2011; Ayim et al., 2022). ICTs encompass a spectrum of technologies, tools, and systems for collecting, processing, storing, transmitting, and disseminating information electronically (Mdoda & Mdiya, 2022). This adoption has particularly become crucial for accessing and disseminating agricultural information in developing countries (Kante et al., 2019; Mayoyo et al., 2023).

Existing studies have extensively debated the benefits of ICT use in agriculture. For instance, evidence suggests that the use of ICTs equips farmers with reliable market information, enabling them to refine their marketing strategies, thereby maximizing profitability and improving their standard of living (Adegbidi et al., 2012; Magesa et al., 2020; Mayoyo et al., 2023). By furnishing farmers with comprehensive market information, ICTs promote active market participation (Chancellor, 2023; Makaula, 2021; Mishra et al., 2020). Additionally, ICTs facilitate the exchange of essential information for enhancing agricultural production, ensuring broader access to various products, services, and initiatives (Musungwini et al., 2023). This empowerment enables farmers to make informed decisions and optimize resource utilization in agricultural production (Abebe & Cherinet, 2019; Otene et al., 2018; Spielman et al., 2021). Ultimately, this drives agricultural transformation (Ajani, 2014; Obeng et al., 2019), fosters growth in the agricultural sector, and contributes to economic sustainability and self-reliance.

Similar to other developing countries, agriculture in Zimbabwe is evolving into a high-tech industry as farmers increasingly adopt ICT technologies to monitor their crops and livestock and enhance their production methods. This transformation is reinforced by government policy to develop e-agriculture (Masuka et al., 2016), facilitating collaborative knowledge exchange between farmers and agricultural extension service providers (Musungwini et al., 2023). Despite the government efforts and rich literature on the pivotal role ICTs play in accessing agricultural information and the related benefits, only a few studies have investigated the use of ICTs among smallholder farmers in Zimbabwe, and these studies observed the low usage of ICTs for agricultural purposes (Ifeoma & Mthitwa, 2015; Musungwini et al., 2023). Consequently, an understanding of ICT usage among smallholder farmers in rural Zimbabwe remains limited, including the challenges they encounter and the primary factors driving its adoption. A more comprehensive grasp of the barriers to ICT utilization and the critical factors influencing its use can provide valuable insights into how to effectively reach and support smallholder farmers in the context of the ICT revolution (Fawole & Olajide, 2012).

1.2. Conceptual framework

The conceptual framework (Figure 1) guiding the study analysis draws from literature on the challenges and factors affecting the use of ICTs in agriculture. This literature suggests that these factors can be grouped into social, economic and institutional factors (Ali & Kumar, 2011; Mdoda & Mdiya, 2022; Yaseen et al., 2016). The institutional factors in the conceptual framework reflect some of the challenges being faced by smallholder farmers concerning the use of ICT, which is the first objective of the study. The utilization of computers and mobile phones for agricultural purposes can be faced with several challenges, including illiteracy, electricity and network issues, insufficient means of transportation for internet access, a lack of repair facilities, affordability constraints regarding ICT devices, and a deficit in knowledge and available time (Ahsan et al., 2022; Misaki et al., 2018; Mutambara & Munodawafa, 2014; Okello et al., 2012; Tata & McNamara, 2016). Regarding the second objective of the study on the factors influencing ICT use, studies in other countries suggest that socioeconomic and demographic factors encompass age, marital status, household size, level of education, land size, farming experience, engagement in non-farm activities, credit acquisition, and ICT experience (Ali, 2012; Awuor & Rambim, 2022; Derso et al., 2014; Khan et al., 2022; Rajkhowa & Qaim, 2022; Wawire et al., 2017).

1.3. Objectives

As an empirical window to understand the challenges and factors influencing ICT usage, this study examined the case of smallholder farmers in rural Zimbabwe, with a specific focus on smallholder maize farmers in Marondera District, Zimbabwe. Hence, the study's overarching objectives are two-fold: (i) to examine the challenges faced by smallholder maize farmers when using ICTs in agriculture, and (ii) to

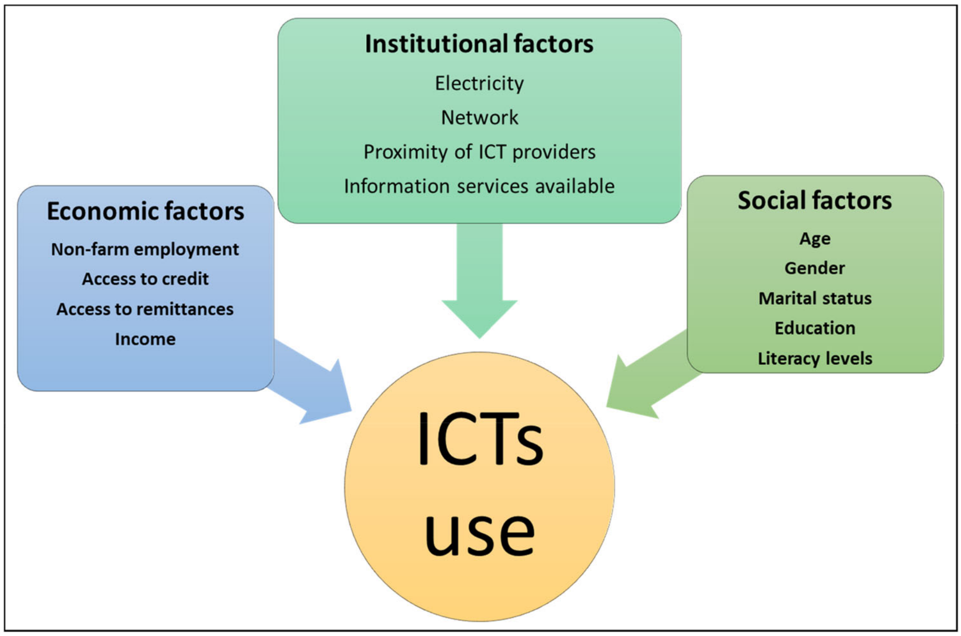

Figure 1. Conceptual Framework on the use of mobiles and computers in agriculture.
(*Source:* Authors' conceptualization).

investigate the factors determining smallholder farmers' use of ICTs, including mobile phones and computers, for farming purposes.

2. Materials and methods

2.1. Study area

The study was conducted in Marondera Rural District, located in the Mashonaland East Province of Zimbabwe. It is bounded by Murewa district to the north, Makoni district in the province of Manicaland to the east, Wedza and Chikomba Districts to the south, as well as Manyame and Goromonzi Districts to the west (Marondera RDC, 2023). Marondera Rural District is one of the nine districts in the Mashonaland East Province, covering a total area of 3,414 square kilometers and accommodating a population of 136,173 (ZIMSTAT, 2022). This district falls within agricultural, natural region 2, with an average annual rainfall of 500 mm to 1000 mm and relatively constant temperatures year-round (Mafuse et al., 2021). In addition, the district is reported to have the most fertile lands, making it well-suited for agriculture (Mafuse et al., 2021). Farmers in this district primarily engage in two major agricultural activities, maize and beef production, although it grapples with recurring dry spells, necessitating irrigation systems (Musoma, 2016).

Administratively, the district is divided into 23 wards (Marondera RDC, 2023), which can be classified into three distinct regions: urban, peri-urban, and rural communities constituting resettlement areas. The resettlement areas are home to small-scale (A1) and large-scale (A2) commercial farmers. Notably, this district holds the highest number of A1 farmers in the province (Mafuse et al., 2021). Previous studies have underscored the significance of farming in these resettlement areas as the primary source of employment and income for many households.

This study focused on A1 farmers, with small farm sizes averaging approximately 6 hectares of arable land (Musoma, 2016). Figure 2 depicts the study's geographical location.

2.2. Research design

A blend of descriptive and causal research designs was used in this study. The study employed a descriptive research design to explain the current circumstances including the challenges on the use of ICT by smallholder maize farmers in the Marondera District. A causal research design is then employed

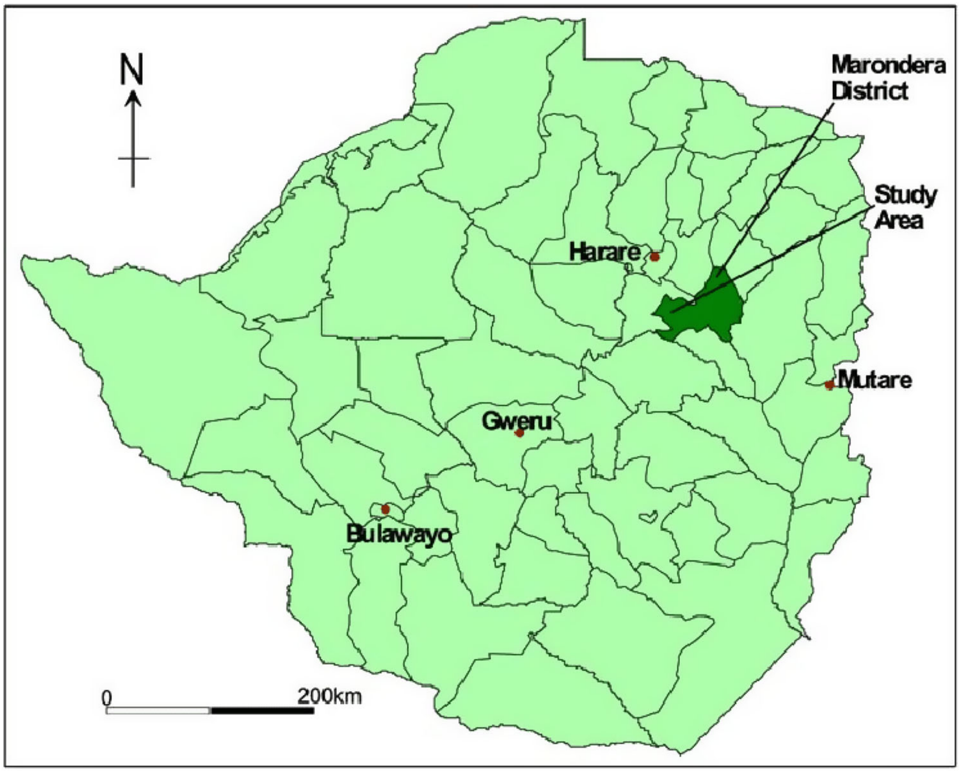

Figure 2. Map for Marondera, Zimbabwe. (Source: Dzwairo et al., 2006).

to assess the factors influencing the decision by smallholder maize farmers to use ICT in computers and mobile phones in their farming operations. The quantitative approach used in this study helps to understand the farmers' characteristics, their farming activities and the challenges they are facing in the use of ICT for agricultural purposes.

2.3. Sampling

The study's target population comprised smallholder farmers who grew maize during the 2022–2023 cultivation season. The study employed a multistage random sampling method, targeting all smallholder farmers in the study area. The sampling strategy commenced with a purposive selection of the Marondera Rural District based on its proximity, followed by the selection of wards with the highest concentration of maize farmers as maize production is the primary agricultural activity. A comprehensive list of all farmers was obtained from extension officers in the district. Given the uneven distribution of maize farmers across wards, the study conducted a proportionate-to-size selection of maize farming villages within the chosen wards to ensure a representative sample of smallholder maize farmers, encompassing both those who use and those who do not use ICTs, including mobile phones and computers, for agricultural purposes. Questionnaires containing inaccuracies were disregarded, therefore, a sample of 155 smallholder maize producers was employed for the study.

2.4. Data collection

The primary data used in this study was collected using questionnaires that were administered by trained individuals. The designed questionnaire captured information on maize production, ICT usage by farmers as well as the demographic and socio-economic characteristics of the households. Before collecting data, a mobilization exercise was conducted to inform local authorities and community leaders in the study area about the survey. This proactive approach proved instrumental in maximizing cooperation among the respondents (Lemay & Durand, 2002). The data collection team comprised four enumerators and one supervisor, all well-qualified and with prior experience collecting farm-level data in the same region. Additionally, they underwent a one-day training session to familiarise themselves with the survey's objectives and methodology and comprehensively understand each survey question. The survey was conducted in November 2022, with all selected participants agreeing to participate.

A quality check mechanism was established to ensure the collection of high-quality data. A WhatsApp group was also created to facilitate real-time communication among all enumerators, supervisors, and the research team. This platform was instrumental for seeking clarification on questions, sharing challenges, and discussing experiences. At the end of each workday, each enumerator submited a daily report to their supervisor for review and feedback.

2.5. Data analysis

Data analysis in this study predominantly employed descriptive statistics and a probit regression model, with the results presented in tabular format. The data obtained from the questionnaire surveys was first coded using Microsoft Excel, before being analyzed using Stata software. First, the study used Pearson's chi-square test for independence to understand the relationships between categorical variables. Utilizing a 5-point Likert Scale, the challenges faced by smallholder farmers in their use of ICT were systematically ranked to identify the most prevalent issues among this group of farmers. The challenges were ranked from strongly disagree to strongly agree. When using the Likert Scale, the responses for strongly disagree were assigned a value of −2, whilst disagree, neutral, agree and strongly agree responses were assigned values of −1, 0, +1 and +2, respectively. The frequencies for each challenge were then multiplied by the respective value assigned for each response and then added to get the ranking score for each challenge. The challenge with the highest score was ranked first whilst the challenge with the lowest score was ranked the last.

Subsequently, the study employed the probit regression model to gain deeper insights into the relationship between ICT use in agriculture and various socio-economic factors. These factors encompassed age, gender, marital status, educational attainment, farming experience, household size, access to credit, and several other pertinent variables. This comprehensive approach unraveled the multifaceted dynamics surrounding the utilization of ICT among smallholder farmers.

2.5.1. Analytical model

This study employed a probit regression model to elucidate the determinants of ICT usage in agriculture. As recommended by Wooldridge (2012), the probit model was chosen for its adherence to a standard normal distribution, which effectively addresses various specification issues. The dependent variable in this analysis is binary, representing either the utilization of ICT (coded as 1) or non-utilization (coded as 0) (Gujarati, 2004). Specifically, the study centered on mobile phones and computers, the primary ICT tools employed by farmers for accessing agricultural information (Muhammad et al., 2019; Mdoda & Mdiya, 2022). According to Wooldridge (2012), the probit model can be derived from a latent variable model that satisfies the assumptions of a classical linear model. The latent variable (y^*) is determined using the following equation 1:

$$y^* = \beta_0 + x'\beta + \varepsilon \tag{1}$$

Where: $y = 1[y^* > 0]$, β = coefficients and ε = random errors, assumed to be normally distributed, with a μ of 0 and a σ^2 of 1.

In this study, y is specified as 1 for ICT users and 0 for non-users, while x represents the vector of independent variables. The response probability of y was derived using Equation (2):

$$P(y = 1|x) = \Phi(\beta_0 + \beta_1 x_1 + \ldots + \beta_k x_k) = G(\beta_0 + x'\beta) \tag{2}$$

where $P(y = 1|x)$ represents the conditional probability of ICT usage, Φ is the cumulative distribution function of a standard normal distribution, which ensures that the probability lies between 0 and 1 (Habyarimana, 2015; Wooldridge, 2012). The parameters to be estimated are denoted as $\beta_0, \beta_1, \ldots, \beta_k$. The variables $x_1, x_2 \ldots, x_k$ represent a set of predictor variables, which are socio-economic factors like age, gender, remittance, credit, marital status, level of education, farm size, and farming experience.

Equation (3) depicts the specified probit regression model to understand the relationship between ICT usage in agriculture and various socio-economic factors.

$$P(ICT\ \ User = 1|x) = \Phi(\beta_0 + \beta_1 age + \beta_2 gender + \beta_3 maritalstatus + \beta_4 householdsize + \beta_5 farmingexperience + \beta_6 farmsize + \beta_7 remittance + \beta_8 creditaccess + \beta_9 educationlevel) \quad (3)$$

Since the primary interest of the study lies in estimating how each variable (x) influences the probability of using ICT for agricultural purposes, the magnitudes of individual coefficients (β) obtained from the probit model results may not provide a clear understanding (Wooldridge, 2012). Therefore, this study incorporated average marginal effects for dummy and continuous variables. Marginal effects enable one to quantify the impact of a one-unit change in an explanatory variable on the likelihood of achieving a favorable outcome (Nyakatonje and Jambo, 2023; Habyarimana, 2015; Wooldridge, 2012).

Following the estimation of the probit model in Equation (3), the study derived the average marginal effects (AME) of the various explanatory variables on the probability of using ICT for agricultural purposes as outlined in Equation (4):

$$\partial P(y_i = 1|x_i)/\partial x_i = \partial E(y|x_i)/\partial x_i = \Phi(\beta_0 + x_i\beta)\beta \quad (4)$$

2.5.2. Description of variables used in the model

Table 1 describes the explanatory variables considered in this study and their respective expected regression outcomes.

3. Results & discussion

3.1. The socio-economic characteristics of the respondents related to ICT use

The study categorized the respondents into those who used ICT for agriculture and those who did not. Table 2 shows that only 73 farmers used mobile phones for agricultural purposes, while 82 respondents did not use mobile phones for agricultural purposes. The level of mobile use in agricultural activities in the study area is low, as highlighted by the 47.1% in Table 2. The results also indicate that, out of the 155 respondents, only 34 farmers utilized a computer for agricultural tasks, with the majority not employing computers for any agricultural-related activities. This underscores the deficiency in computer usage for agricultural purposes (21.94%) in the Marondera Rural District. This low ICT use can be

Table 1. Definitions and descriptions of variables.

Variable	Description	Measurement	Expected results
Age	The age of the farmer.	Years	Positive/ negative
Maritalstatus	Marital status of the farmer.	0 = single, 1 = married, 2 = divorced, 3 = widow	Positive/negative
Household size	Household size	Number of people living together in one dwelling	Positive
Farming experience	Number of years in farming	Years	Positive
Gender	Male or female.	1 = male, 0 = female	Positive/negative
Education level	Number of years in formal education.	Years in formal education.	Positive
Farm size	Total hectares of land owned by a farmer.	Hectares	positive
Non-farm activities	Having non-farm activity.	1 = yes, 0 = no	positive
Access to credit	Having received credit	1 = yes, 0 = no	positive
Extension visit	Having frequent extension visits	1 = yes, 0 = no	positive
Remittances	Having received remittance	1 = yes, 0 = no	positive

Table 2. Mobile and computer use for agriculture.

Mobile use for agriculture	Freq	Percentage
n = 155		
Yes	73	47.10
No	82	52.90
Computer use for agriculture		
Yes	34	21.94
No	121	78.06

attributed to the prolonged communication network problems and electricity challenges caused by load shedding. These results are similar to the findings of previous studies which associated the low ICT adoption in agriculture with several challenges such as lack of awareness and confidence, unreliable internet, lack of technological skills and lack of access to internet gadgets (Lawal-Adebowale, 2015; Muktar et al., 2022).

Table 3 compares mobile ownership to mobile use for agricultural purposes. The study results indicate that, out of the 137 farmers who owned mobile phones, only 73 used mobile phones for any activities related to their farming work. This implies that a large number of farmers who own mobile phones do not use them for agricultural purposes, but rather for social reasons. Mousavi et al. (2018) pointed out that there is low use of ICT for agricultural purposes mainly because the majority of people do not use ICT gadgets such as mobile phones for agricultural benefit but rather for social chatting and messaging.

Table 4 also compares the level of computer use for agriculture against the ownership of computers by the respondents. Of the 66 farmers who indicated they own computers, 34 individuals used them for agricultural-related activities. As indicated by Lawal-Adebowale (2015), even though farmers may have ICT gadgets such as mobile phones and computers, the majority of them lack the knowledge and skills needed during the use and maintenance of technology equipment situation.

Table 5 reveals a significant association between the use of mobile phones in agriculture and several demographic factors, including gender, marital status, access to remittances, and access to credit, as indicated by their respective *p*-values. The results indicate that most male farmers did not utilize mobile phones for agricultural purposes, whereas many female farmers incorporated mobile phones into their agricultural activities. This may be because male farmers mostly have non-farming activities which leaves them without enough time to attend trainings being brought to farmers on how to use ICTs for agricultural purposes. Lwoga and Chigona (2020) mention that smallholder farmers lack proper training and knowledge concerning the use of ICTs like computers for agricultural purposes. Farmers who were

Table 3. Comparison between mobile ownership and mobile use for agricultural purposes.

	Mobile use for agriculture		
Mobile ownership	Yes	No	Total
Yes	73	64	137
No	0	18	18
Total	73	82	155
Pearson chi2(1) = 18.1298; Pr = 0.000			

Table 4. Comparison between computer ownership and computer use for agricultural purposes.

	Computer use for agriculture		
Computer ownership	Yes	No	Total
Yes	34	32	66
No	0	89	89
Total	34	121	155
Pearson chi2(1) = 58.7315; Pr = 0.000			

Table 5. Chi-square tests of association regarding mobile use in agriculture.

Variables		Frequency for mobile users in agriculture	Frequency for non-mobile users in agriculture	Chi2 value	*p*-value
Gender	Male	34	54	5.8486	.016
	Female	39	28		
Marital status	Unmarried	11	9	6.0439	.094
	Married	42	61		
	Divorced	9	11		
	Widowed	3	9		
Received Remittances	Yes	41	31	5.2334	.022
	No	32	51		
Received credit	Yes	25	42	4.5334	.033
	No	48	40		

married were found to use their mobile phones for farming the most, followed by those who were single; while widowed people used their phones the least. Additionally, many farmers who used mobile phones for agricultural purposes received remittances, whereas most farmers with access to credit did not employ their mobile phones for agricultural activities. Farmers may be able to obtain loans, but their lack of awareness and confidence may also keep them from allocating funds for the use of ICTs in agriculture (Lwoga et al., 2011).

Table 6 highlights a significant association between the use of computers in agriculture and various factors, including gender, involvement in non-farm work, and access to credit. Similar to the results on mobile use in agriculture, the study findings also show that more female farmers incorporated computers into their farming activities than male farmers. Among those engaged in non-farm activities, most did not utilize computers for agricultural purposes, unlike those who did not engage in non-agricultural work. Additionally, Table 6 illustrates that most farmers with access to credit used computers in their farming activities, whereas the majority of those without access to credit did not employ computers in agriculture. Lack of finance to purchase ICT technologies is one of the main challenges being faced by smallholder farmers, therefore, credit access is essential if we are to improve the use of computers by farmers (Girma, 2022).

3.2. Challenges associated with the use of ICTs among smallholder maize farmers

The study's primary objective was to investigate the challenges encountered by smallholder farmers in the Marondera Rural District concerning their use of ICTs in agriculture. To assess these challenges, a 5-point Likert Scale was employed to rank them based on their prevalence among the farmers who utilized ICTs. Table 7 presents an overview of the challenges smallholder farmers face when using ICTs for agricultural purposes, along with their respective rankings.

The most significant challenge most respondents face is the electricity shortage, ranked number one (Table 7), with the highest score of 274. Zimbabwe experiences frequent load-shedding, so farmers resort to traditional methods in their production processes (Mutambara & Munodawafa, 2014). This situation leads to lower production levels and incomes, which may not be sufficient to afford mobile phones or computers. However, some farmers have explored alternative solutions to address the electricity issue by charging their mobile devices using affordable solar systems. A study by Otene et al. (2018) concluded that unreliable electricity supply and poor network coverage were significant challenges influencing the use of mobile phones by farmers.

Furthermore, the results indicate that mobile network issues follow the challenge of power shortages. This is primarily because bad weather conditions can adversely affect mobile phones and computers,

Table 6. Chi-square tests of associations regarding the use of computers in agriculture.

Variables		Frequency for computer users in agriculture	Frequency for non-computer users in agriculture	Chi2 value	*p*-value
Gender	Male	15	73	2.8429	.092
	Female	19	48		
Having Non-Farm Activity	Yes	12	63	2.9896	.084
	No	22	58		
Received Credit	Yes	19	48	2.8429	.092
	No	15	73		

Table 7. Challenges associated with the use of ICTs in agriculture.

Challenge	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Score	Rank
Electricity shortage	119	36	0	0	0	274	1
Network challenge	109	19	8	19	0	218	2
Scarce transport to access the internet	32	63	42	18	0	109	3
Insufficient repairing facilities	36	62	11	46	0	88	4
Do not afford ICT gadgets	44	30	20	61	0	57	5
Inadequate knowledge	30	43	35	47	0	56	6
Lack of time	21	38	32	64	0	16	7
Literacy rate	16	23	40	76	0	−21	8

consequently impeding the utilization of technology by smallholder farmers in agriculture. In such instances, farmers may be unable to access critical agricultural information, reducing their chances of achieving their goals and objectives. Similar findings were reported by Ali (2012) as well as Tata and McNamara (2016), highlighting the impact of network challenges on the use of technology by smallholder farmers. Moreover, smallholder farmers in Marondera encounter difficulties related to transportation for accessing internet facilities, ranked at number 3, and a lack of repair facilities ranks at 4. The shortage of knowledge ranks at 6, while the inability to afford ICT devices is ranked at 5. Several studies identified the lack of knowledge or skills and the lack of finance as obstacles to the use of ICT technologies by smallholder farmers (Idoje et al., 2021; Mishra et al., 2020; Saidu et al., 2017). Interestingly, the lack of time is ranked at 7, indicating that farmers generally have sufficient time for agricultural activities. This is because agriculture is the primary source of income for the majority of smallholder farmers and most of the farmers do not engage in non-farm activities.

Furthermore, the results also indicate that literacy rates did not significantly affect most respondents' usage of ICTs. This suggests a moderate level of education among the respondents, as reflected by an average of 12 years of formal education. In this context, many individuals in Marondera Rural District have attained at least an O-level education, enabling them to read and comprehend information effectively. This finding aligns with the observations of Madanda (2010) and Tiwari (2022), who noted that individuals with higher levels of education are more likely to use technology as they possess the necessary understanding of computer and mobile phone functions.

3.3. Factors influencing the use of ICTs for agricultural purposes

The second objective of the study was to investigate the factors influencing the utilization of ICTs by smallholder farmers in the Marondera Rural District. This section discusses the results of the probit model regression analysis. The results of average marginal effects, which elucidate the critical determinants of mobile phone and computer usage in agriculture, are presented in Tables 8 and 9, respectively. Table 8 indicates that five variables, namely access to credit, extension visit, remittances received, marital status (being widowed), and farming experience, exhibit a significant relationship with using mobile phones for agricultural purposes.

On the other hand, age, gender, access to credit, and extension contact are significant determinants for computer use in agriculture as indicated in Table 9. The study found no significant relationship between mobile phone usage for agricultural purposes and variables such as age, gender, household size, farm size, and engagement in non-farm activities. Moreover, the study also identified an insignificant relationship between computer usage for agricultural purposes and several variables, including marital status, education level, and involvement in non-farm activities.

Table 8. Average marginal effects showing factors affecting mobile use in agriculture.

Variable	dy/dx	Std. Err	z	P > z	95% Confidence Interval	
Age	−0.0014	.0042498	−0.32	0.749	−.0096873	.0069715
Gender						
Male	−0.1256	.0846332	−1.48	0.138	−.2914584	.0402975
Marital status						
Married	0.0452	.1191137	0.38	0.704	−.1882489	.2786683
Divorced	0.1068	.1464042	0.73	0.466	−.1801274	.3937666
Widow	0.4548	.1553009	2.93	0.003***	.1503847	.7591531
Household size	−0.0073	.0192211	−0.38	0.703	−.0449926	.0303527
Farming Experience	−0.0119	.006632	−1.80	0.072*	−.0249398	.0010572
Farm size	0.0127	.035164	0.36	0.718	−.0562036	.0816365
Non-farm activity						
Yes	−0.0237	.0824088	−0.29	0.774	−.1852182	.1378186
Remittance						
Yes	0.2428	.0781253	3.11	0.002***	.0896914	.3959368
Access to credit						
Yes	−0.1546	.0803807	−1.92	0.054*	−.3121948	.0028919
Extension Visit						
Yes	0.2429	.0926518	2.62	0.009***	.061385	.4245734
Number of obs = 155, LR chi2(12) = 29.06, Prob > chi2 = 0.0039, Pseudo R2 = 0.1356						

***1% LOS, ** 5% LOS and * 10% LOS.
Note. dy/dx for factor levels is the discrete change from the base level.

Table 9. Average marginal effects showing the factors affecting computer use in agriculture.

Variable	dy/dx	Std. Err	z	P > z	95% Confidence Interval	
Age	−0.0069	.0028953	−2.38	0.017**	−.0125783	−.0012287
Gender						
Male	−0.1894	.0761186	−2.49	0.013**	−.3386523	−.0402729
Marital status						
Married	0.1007	.0817424	1.23	0.218	−.0595118	.2609127
Divorced	0.0907	.1183511	0.77	0.443	−.1412032	.3227247
Widow	−0.0283	.1396849	−0.20	0.839	−.3021674	.2453872
Education Level						
Primary	−0.2548	.2011318	−1.27	0.205	−.6490696	.1393524
Secondary	−0.2204	.1924958	−1.15	0.252	−.59772	.1568495
Tertiary	0.0011	.2118894	0.01	0.996	−.4141075	.4164836
Non-farm activity						
Yes	−0.0296	.0697953	−0.43	0.671	−.1664693	.1071231
Access to credit						
Yes	0.1178	.0702885	1.68	0.094*	−.0199102	.2556155
Extension Visit						
Yes	0.1368	.0761379	1.80	0.072*	−.0123776	.2860774
Number of obs = 155, LR chi2(11) = 20.96, Prob > chi2 = 0.0031, Pseudo R2 = 0.1525						

***1% LOS, ** 5% LOS and * 10% LOS.
Note. dy/dx for factor levels is the discrete change from the base level.

The probit model results reveal a positive and significant relationship between being a widow and using a mobile phone for agricultural purposes at a 1% significance level. The associated marginal effect of being widowed is 0.4547689, as indicated in Table 8. This signifies that, compared to unmarried farmers, being widowed increases the probability of using a mobile phone for agricultural purposes by 45.5%, holding all other factors constant. Farmers who have lost their spouses often bear additional responsibilities towards their families, influencing their decision-making. They may be more inclined to invest in agricultural technologies to augment their income and provide for their families.

In contrast, several studies have reported that married farmers use ICT more than their single, divorced, or widowed counterparts (Adepoju, 2017; Muhammad et al., 2019; Okwusi et al., 2010). In these studies, married farmers were considered rational decision-makers who recognized the importance of investing in ICT for agricultural purposes. Research conducted by Tambo et al. (2019) and Mdoda and Mdiya (2022) also concluded that married farmers are more inclined to invest in ICTs such as mobile phones and computers for their agricultural activities to access crucial agricultural information compared to farmers without spouses. However, Henri-Ukoha et al. (2014) found an insignificant relationship between marital status and the use of ICT in agriculture.

According to the study results, farming experience is statistically significant at a 10% level and negatively influences the use of mobile phones in agriculture. Table 8 shows the marginal effect associated with farming experience being −0.0119413, which implies that a one-year increase in farming experience results in a 1.19% decrease in the probability of using mobile phones for agricultural purposes, holding all other factors constant. In contrast to new farmers who can use ICT to access information on agricultural production, markets, and techniques, experienced farmers are often old farmers who are resistant to change, especially adopting innovative technology because they are unfamiliar with it and have not used it. The results align with the findings of Pivoto et al. (2019) and Choudhary et al., who found the farming experience to have a negative impact on the use of ICTs in agriculture. On the other hand, studies by Ayanwale and Adekunle (2010) and Okello et al. (2012) found conflicting results where experience had a positive relationship with the use of ICT in agricultural activities. This is because, compared to less experienced farmers, farmers with experience are more receptive to new concepts and advances. In a study by Aldosari et al. (2019), farming experience had no significant impact on farmers' ICT use in Northern Pakistan.

The results indicate a positive relationship between access to remittances and mobile phone use for agriculture at a significant level of 1%. As shown in Table 8, the marginal effect for the remittance variable is 0.2428141. This suggests that, compared to farmers without access to remittances, having access to remittances is associated with a 24.3% increase in the use of mobile phones for agricultural purposes while holding other factors constant. This positive relationship can be explained by the fact that farmers who receive remittances often have the financial means to afford ICT devices such as mobile phones and the necessary data bundles required to access crucial agricultural information, which, in turn, can enhance their production. This finding aligns with the results obtained by Asif et al. (2017), who observed a similar trend where farmers receiving remittances tended to use ICT more than those without remittances. However, it's worth noting that other studies have reported conflicting results, where remittances were found to have a negative relationship with the adoption of ICT technologies (Zegeye, 2021). In such cases, farmers who do not receive remittances rely heavily on agriculture income and may invest in ICT technologies to maximize their production.

This study found a negative and statistically significant relationship between the use of mobile phones in agriculture and access to credit at a significance level of 10%. The marginal effect, as presented in Table 8 for the access to credit variable, is −0.1546515. This suggests that compared to farmers who did not have access to credit, having access to credit is associated with a 15.5% decrease in the use of mobile phones for agricultural purposes. This result contradicts the expected outcome, as access to credit typically enables farmers to invest in technologies that enhance their agricultural production. However, many farmers in this study lacked prior experience with ICT, which may have influenced their decision to allocate the acquired funds to other areas of production instead. In contrast to the results of this study, Mdoda and Mdiya (2022) observed that access to credit increased the likelihood of using ICT tools among livestock farmers in South Africa. A study by Derso et al. (2014) also found a positive relationship between credit access and ICT use in agriculture. According to Muhammad et al. (2019), access to credit typically enhances a farmer's ability to acquire ICT tools for agricultural purposes.

This study identified a positive and statistically significant relationship between contact with extension workers and the use of mobile phones for agricultural purposes at a 1% significance level. The marginal effect of extension contact on the use of mobile phones in agriculture is 0.2429792, as presented in Table 8. These results indicate that, compared to farmers who do not have extension visits, having contact with extension workers is associated with a 24.2% increase in the likelihood of using a mobile phone for agricultural purposes, assuming all other factors remain constant. Farmers who participate in extension programs acquire valuable knowledge and skills related to using ICTs for agricultural purposes as they receive training on ICT usage and access to other information services through these programs. These findings are consistent with previous studies conducted by Derso et al. (2014) and Das (2014), which found a positive relationship between using ICTs in agriculture and extension visits. However, a study by Mamun-ur-Rashid (2020) reported conflicting results, where extension visits negatively influenced the use of ICT for agricultural information in Bangladesh. This was attributed to farmers in the region maintaining solid relationships with extension officers, leading them to contact field extension workers directly for information rather than relying on ICT tools such as mobile phones.

Table 9 reveals a negative relationship between the use of computers in agriculture and the farmer's age, with statistical significance at a 5% level. The marginal effect of age on the use of computers for agricultural purposes is −0.0069035. This implies that for every one-year increase in the farmer's age, there is a corresponding decrease of 0.69% in computer usage for agricultural activities, assuming all other factors remain constant. The observed negative relationship can be attributed to the fact that older farmers are often more resistant to technological change and may be less inclined to adopt new agricultural advancements and ideas than younger farmers. This finding is consistent with the results of previous studies conducted by Ali (2012), Derso et al. (2014), Wawire et al. (2017), and Khan et al. (2022), all of which reported a similar inverse relationship between ICT usage in agriculture and the age of the household head.

In contrast, Awuor and Rambim (2022) reached a different conclusion, suggesting that an increase in the farmer's age increases the likelihood of adopting ICT as younger generations migrate to urban areas for better job opportunities, leaving the older population to manage rural agriculture. The study also identified a negative and significant relationship between gender (being male) and the use of ICT for agricultural purposes, with statistical significance at a 5% level. Table 9 displays the marginal effect of the gender variable, which is −0.1894626. This indicates that, compared to female farmers, male farmers are associated with an 18.9% decrease in the likelihood of using a computer for agricultural purposes, assuming all other factors remain constant. Male household heads in the study area often engage in income-generating activities unrelated to farming, which may limit their capacity to invest entirely in agricultural technologies such as ICTs. These results contrast with the findings of studies by Wawire et al. (2017), Freeman and Mubichi (2017), and Mdoda and Mdiya (2022), which suggested that male farmers were more likely than female farmers to use ICT. The discrepancy may be attributed to traditional gender roles that place a heavy burden of household responsibilities on women, leaving them with limited time for agricultural-related activities.

The study found a positive relationship between the use of computers in agriculture and access to credit and extension services, with statistical significance at a 10% level. Table 9 displays the marginal effects associated with the variables of access to credit and extension visits, which are 0.1178527 and 0.1368499, respectively. Having access to credit and extension services is associated with an increase in the likelihood of using computers in agriculture by 11.7% and 13.6%, respectively, compared to those without access, assuming all other factors remain constant. Farmers with access to loans can use the funds to purchase ICT equipment, such as computers, to access crucial agricultural information. Additionally, farmers who receive extension services gain essential knowledge and training that empowers them to invest in ICT technologies. Ali (2012) noted that supported agricultural extension services in most developing countries are vital in disseminating information on modern agricultural methods and technologies, including mobile phones and computers. Similar findings were reported by studies conducted by Derso et al. (2014) and Wawire et al. (2017), where access to credit and extension visits was positively associated with the probability of using ICT technologies in agriculture.

4. Conclusion

This study investigated the challenges smallholder farmers in the Marondera Rural District face in using ICTs, including mobile phones and computers, and assessed the key factors influencing the farmers' decisions to use ICTs in agriculture. The study concludes that the use of mobile phones for agricultural purposes is low in Marondera Rural District, while computers for agricultural purposes are incredibly low. Despite many farmers having access to both mobile phones and computers, only a minority employ them for agricultural purposes. Electricity power shortages and network challenges were identified as the major obstacles farmers face in utilizing ICT for agriculture. The study underscores that several factors, including marital status, farming experience, access to credit, and extension visits, significantly influence the use of mobile phones for agricultural purposes. In contrast, the adoption of computer use in agriculture depends on age, gender, access to credit, and engagement in extension visits.

5. Recommendations

It is recommended that farmers utilize Information and Communication Technology (ICT) for optimal resource utilization and production. The study recommends farmers to make use of extension programs for training and also explore alternative power sources like solar energy to address the persistent electricity challenges in the agricultural sector. The government should collaborate with non-governmental organizations to support smallholder farmers and enhance agricultural training facilities. These efforts should cater to the diverse needs of all farmers, including those who may be less experienced or elderly and hesitant to embrace new concepts and innovations Policy reforms should be instituted to empower women in agriculture by providing better training opportunities and resources.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Author contribution statement

Stella Nyakudya is a graduate student in the Department of Agricultural Economics and Development at Manicaland State University of Applied Sciences. Stella contributed during the conception and design of the article including writing the first draft paper, questionnaire design and data collection and analysis as well as providing approval for the article to be published.

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Data availability statement

The data and materials supporting the results and analysis presented in this paper is readily available upon reasonable request.

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