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Digital Advisory Systems in Zimbabwean Agriculture: Opportunities and Constraints

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Abstract

The adoption of digital advisory systems is transforming smallholder agriculture in Zimbabwe, a country where agriculture remains the primary livelihood for most of the population. Despite significant investments in digital technologies, agricultural productivity continues to underperform. This study explores the barriers preventing the scaling of digital advisory services among smallholder farmers and identifies strategies to optimize their adoption. Using a mixed-methods approach, data were collected from 854 smallholder farmers, 40 extension staff, and 8 development workers across six districts in Zimbabwe. The study reveals a high mobile penetration rate of 91%, higher than the 85% reported in the literature. However, challenges such as limited digital literacy, poor network connectivity, and financial constraints hinder the effective use of mobile advisory services. The findings also highlight a strong reliance on basic communication tools like SMS (42.83%) and WhatsApp (25.14%) for receiving agricultural information, while more advanced tools like mobile apps have lower adoption. Key recommendations include investing in nationwide digital literacy programs, incentivizing mobile network operators to improve rural connectivity, and developing human-centered, scalable digital solutions tailored to farmers' needs. Furthermore, integrating AI-driven advisory systems with popular platforms like WhatsApp could significantly enhance the delivery of site-specific, actionable farming advice. This research provides insights into how digital advisory systems can be leveraged to improve agricultural productivity in Zimbabwe and other similar contexts.

Keywords

Digital, Agriculture, Advisory Services, Rural Development, Barriers to Adoption, Digital Literacy, Scale

1. Introduction

Sub-Saharan Africa's agricultural systems face urgent challenges related to food security and sustainable productivity growth, driven by rapid population expansion. It is projected that by 2050, the region's population growth could outpace the food supply without targeted interventions [1]. Zimbabwe, where agriculture is the primary livelihood for most of the population, exemplifies these challenges [2]. The country's agricultural sector is highly vulnerable to climate shocks, and a growing food production deficit underscores the need for innovative solutions [3]. Within this context, digital advisory services have emerged as an essential tool for enhancing smallholder farmers' access to information and improving agronomic outcomes [4]. Despite considerable investments in digital technologies and agricultural input programs, Zimbabwe's agricultural productivity has not met expectations [5]. This paper investigates the barriers preventing the scaling of digital extension services among Zimbabwe's smallholder farmers and explores strategies for optimizing these services for agronomic outcomes at scale.

Agricultural extension remains a critical component for enhancing agricultural productivity, particularly in smallholder farming systems, which dominate Sub-Saharan Africa (SSA). As Anderson [6] states, "agricultural extension plays a pivotal role in connecting farmers to new technologies and practices that can improve productivity and livelihoods." Zimbabwe's agricultural extension system has undergone significant evolution since its inception in 1927, adapting to the country's shifting economic, environmental, and social landscapes. Despite these changes, challenges such as resource constraints, fragmentation, and outdated curricula continue to limit the effectiveness of extension services [7]. The Department of Agricultural Technical and Extension Services (AGRITEX), which operates under the Ministry of Lands, Agriculture, Fisheries, Water, and Rural Resettlement, has long served as the primary public extension service provider in Zimbabwe [8]. However, the public extension system has struggled with limited funding, outdated methodologies, and inefficiencies, especially as the sector becomes more reliant on the private sector and non-governmental organizations (NGOs) to provide complementary extension services [9]. According to Christoplos [10], "in many SSA countries, including Zimbabwe, public extension systems are often plagued by underfunding, which limits their ability to provide consistent, high-quality services to smallholder farmers."

Several models of agricultural extension have been implemented in Zimbabwe, with varying degrees of success. The Master Farmer Program, established in the mid-20th century, initially sought to create a cadre of knowledgeable farmers who could serve as peer educators within their communities. While this program helped disseminate agronomic knowledge, it was criticized for primarily benefiting wealthier farmers and excluding poorer, marginalized groups [11]. "The Master Farmer Program has had limited impact on the most vulnerable farmers, as it primarily targeted those with access to resources," writes Ndoro *et al.* [11], emphasizing the need for more inclusive extension models. Another significant extension

model implemented in Zimbabwe is the Training and Visit (T&V) Model, promoted by the World Bank. The T&V model was designed to enhance the technical quality and standardization of extension services, offering a formal structure for regular farm visits and systematic training of extension workers [12]. However, despite its structured approach, the T&V model faced significant challenges. According to Feder *et al.* [13], "the T&V model's top-down approach failed to consider the local contexts and specific needs of smallholder farmers, limiting its effectiveness in addressing on-the-ground challenges." As a result, the model was discontinued, but its legacy still influences some aspects of Zimbabwe's current extension services [14].

In more recent years, demonstration plots have gained traction as a practical tool for promoting technology adoption. These plots allow farmers to witness firsthand the benefits of improved practices, encouraging them to replicate those practices on their own farms [15]. 14 argue that "demonstration plots are a powerful tool for technology dissemination, as they provide farmers with tangible proof of the benefits of modern farming techniques." However, funding limitations, especially when demonstration plots are supported by private companies or NGOs, have hindered the scalability of this approach [16]. A critical issue in Zimbabwe's extension system—and more broadly in Sub-Saharan Africa—is the pluralistic nature of service provision, which has resulted in fragmented and uncoordinated efforts among public, private, and non-governmental actors. "In SSA, extension service delivery often lacks coordination between various actors, leading to inefficiencies and duplication of efforts," note Birner *et al.* [15] This lack of coordination hampers the effectiveness of extension services, particularly in addressing the specific needs of smallholder farmers, who often require tailored support that goes beyond input supply [7].

In response to these challenges, digital advisory services have emerged as a promising innovation for improving the reach and efficiency of extension services in Zimbabwe and across Sub-Saharan Africa. Digital tools offer scalability and the ability to disseminate real-time information, which is particularly useful in addressing the dynamic challenges faced by smallholder farmers. As [4] argues, "digital advisory services can revolutionize the way agricultural knowledge is delivered, particularly in remote and underserved areas where traditional extension models fall short." However, despite their potential, the adoption of digital tools in Zimbabwe's extension services has been slow due to infrastructure limitations and low levels of digital literacy among smallholder farmers [17]. Moreover, ICT infrastructure remains a significant barrier in many parts of Sub-Saharan Africa. As Ayim *et al.* [18] explain, "the adoption of ICTs in smallholder agriculture in SSA has been constrained by poor network infrastructure, high costs of devices, and inefficiencies within agricultural institutions." This is compounded by limited access to mobile devices and the high cost of data, which further restricts the ability of smallholder farmers to fully leverage digital advisory services. Zimbabwe is no exception to these challenges, with many farmers unable to access even the

most basic SMS-based advisory services due to poor network coverage or high airtime costs.

Despite these barriers, digital solutions hold great potential for transforming Zimbabwe's agricultural extension system. The success of mobile-based advisory platforms in countries like Kenya and Uganda illustrates the capacity of digital tools to enhance farmer knowledge and productivity when infrastructure and digital literacy challenges are addressed [18]. Therefore, improving access to mobile devices, investing in network infrastructure, and promoting digital literacy should be top priorities for enhancing the adoption and scalability of digital advisory services in Zimbabwe and the broader region.

2. Materials and Methods

This study employed a mixed-methods approach, integrating both quantitative and qualitative data collection techniques. Six districts in Zimbabwe—Gokwe South, Shurugwi, Kwekwe, Bubi, Matobo, and Chimanimani—were selected for their agricultural relevance and varying levels of digital advisory service adoption.

Research Problem

While digital technologies have been incorporated into Zimbabwe's extension services, several barriers to scaling these solutions remain underexplored. This study seeks to identify the constraints hindering the adoption of digital advisory services among smallholder farmers in Zimbabwe and to explore how these services can be optimized to improve agronomic outcomes at scale.

Sampling and Data Collection

The sample included 854 smallholder farmers, 40 extension staff, and 8 development workers. A multi-stage sampling technique was employed, with a purposive selection of districts and stratified random sampling of farmers based on variables such as age, land size, and farming practices.

Data Collection Methods Included:

1) Farmer Questionnaires: Structured questionnaires were administered to collect socio-economic data, farm size, digital advisory service usage, and perceived impacts.

2) Focus Group Discussions (FGDs): Eight FGDs were conducted with extension staff and development workers to explore institutional barriers and opportunities for scaling digital advisory services.

3) In-Depth Interviews: Eight in-depth interviews were conducted with development workers to gain deeper insights into logistical and operational challenges.

The Research Questions Guiding the Data Collection Were:

1) What resources do smallholder farmers have, and how do these resources influence their use of digital advisory services?

2) What is the perceived value of digital advisory services among smallholder farmers?

3) What barriers constrain the adoption of digital advisory services in smallholder farming systems?

4) What recommendations can optimize the use of digital advisory tools among smallholder farmers?

Data Analysis

Quantitative data were analyzed using descriptive statistics and inferential statistical techniques. A Chi-square (χ^2) test was conducted to assess the relationship between farmer age and land size using the following formula:

$$\chi 2 = \sum \frac{(0i - Ei)2}{Ei}$$

where: $0i$ represents the observed frequency and Ei represents the expected frequency under the null hypothesis.

The null hypothesis (H_0) posited no significant relationship between farmer age and land size, while the alternative hypothesis (H_1) indicated a significant association. The test was conducted at a 5% significance level ($\alpha = 0.05$), and Cramér's V was calculated to measure the strength of association:

$$V = \sqrt{\frac{\chi 2}{n \cdot (k-1)}}$$

where:

- n is the sample size;
- k is the smaller number of rows or columns in the contingency table.

Qualitative data from the FGDs and interviews were transcribed and analyzed using thematic analysis to identify patterns related to the challenges and opportunities for digital advisory services.

3. Results and Discussions

3.1. Objective One: Resource-Based View of the Smallholder Farmer

3.1.1. Demographics Related to Farmer Ages and Land Size

A Chi^2 test was performed between *Farmer Age* and *Land size*. At least one of the expected cell frequencies was less than 5. Therefore, the assumptions for the Chi^2 test were not met. There was a statistically significant relationship between *Farmer Age* and *Land size*, $\chi^2(24) = 78.51$, $p = <0.001$, Cramér's V = 0.15.

The calculated p-value of <0.001 was lower than the defined significance level of 5%. The Chi^2 test was, therefore, significant, and the null hypothesis was rejected.

Table 1 shows the observed values, whereas Table 2 shows the expected values.

Table 1. Observed frequencies.

		Land Size					Total
		2 ha	4 ha	5+ ha	1 ha	3 ha	
Farmer Age	46 - 55 yrs	44	29	73	43	58	247
	56 - 64 yrs	32	34	65	23	21	175

Continued

	36 - 45 yrs	63	26	46	41	47	223
	26 - 35 yrs	13	12	17	25	4	71
	65+ yrs	17	13	54	19	13	116
	18 - 25 yrs	4	0	5	6	3	18
	<18 yrs	0	0	0	1	0	1
	Total	173	114	260	158	146	851

Table 2. Expected frequencies for perfectly independent variables.

		Land Size					Total
		2 ha	4 ha	5+ ha	1 ha	3 ha	
Farmer Age	46 - 55 yrs	50.21	33.09	75.46	45.86	42.38	247
	56 - 64 yrs	35.58	23.44	53.47	32.49	30.02	175
	36 - 45 yrs	45.33	29.87	68.13	41.4	38.26	223
	26 - 35 yrs	14.43	9.51	21.69	13.18	12.18	71
	65+ yrs	23.58	15.54	35.44	21.54	19.9	116
	18 - 25 yrs	3.66	2.41	5.5	3.34	3.09	18
	<18 yrs	0.2	0.13	0.31	0.19	0.17	1
	Total	173	114	260	158	146	851

Chi-Square Test			
	Chi^2	df	p
Farmer Age-Land Size	78.51	24	<0.001

Pearsons Contingency Coefficients	
	C
Farmer Age-Land Size	0.32

Key Insights from the Results

Age and Land Ownership

The results indicate a statistically significant but moderate relationship between a farmer's age and the size of the land they own, with older farmers (46+ years) tending to own larger land parcels, particularly those exceeding 5 hectares. This trend suggests that land consolidation or accumulation is more prevalent among older farmers, possibly due to inheritance patterns, capital availability, or market access. Conversely, younger farmers (18 - 35 years) generally own smaller land plots, with fewer individuals owning larger farms. This trend may reflect the financial constraints and limited market access often experienced by younger farmers.

One of the study's aims was to assess whether younger farmers might demonstrate

a higher propensity to adopt digital tools for agricultural advisory services based on the assumption that older farmers are less likely to engage with digital platforms. The findings align with existing literature; however, they also challenge the prevailing notion that the rural farming population in Sub-Saharan Africa predominantly consists of older individuals. Confirming the findings of Yeboah and Jayne [19], who questioned the assumption that the average rural farmer is above 60 years old, this study revealed that 56% of smallholder farmers in Zimbabwe are between the ages of 36 and 55.

This younger farming demographic presents a growing opportunity for the adoption of digital advisory services at scale. The focus group discussions (FGDs) revealed that, unlike in past decades, when middle-aged individuals often migrated to urban areas in search of employment, the increasing scarcity of jobs in urban centers has made rural agriculture a more attractive and viable livelihood option compared to low-paying blue-collar employment. This shift may also influence younger farmers' openness to adopting innovative digital solutions for agricultural management.

While age is an important factor in understanding land ownership patterns, there are deviations from what would be expected under independent distribution. This suggests that socio-economic and cultural factors—such as family structure, land inheritance practices, and access to financial resources—may also play a significant role in land distribution among farmers. Ultimately, while older farmers tend to own larger tracts of land, the moderate strength of this relationship, as indicated by Cramér's V and Pearson's Contingency Coefficient, suggests that additional factors contribute to these patterns.

3.1.2. Demographics on Sources of Income for Farmers

Understanding the sources of income for smallholder farmers is critical for assessing their willingness and ability to invest in digital advisory services. Additionally, this analysis helps contextualize the extent to which advisory services influence farmers' incomes by informing their production practices and market engagement. **Figure 1** shows the primary sources of income for the farmers.

The majority of farmers (71.66%) rely on on-farm income, underscoring the central role of agriculture in sustaining rural livelihoods. This reliance highlights that for the vast majority of smallholder farmers, agriculture remains the primary economic activity. Given this dependence, fluctuations in agricultural productivity due to environmental, market, or policy factors can have profound implications for household income stability.

Secondary Income Sources

A smaller but notable proportion of farmers derive additional income from off-farm, non-agricultural activities (11.71%). These activities may include small-scale enterprises, skilled labor, or other entrepreneurial ventures. The diversification into non-agricultural income sources suggests that some rural households seek to mitigate the risks associated with agricultural income volatility by engaging in off-farm work.

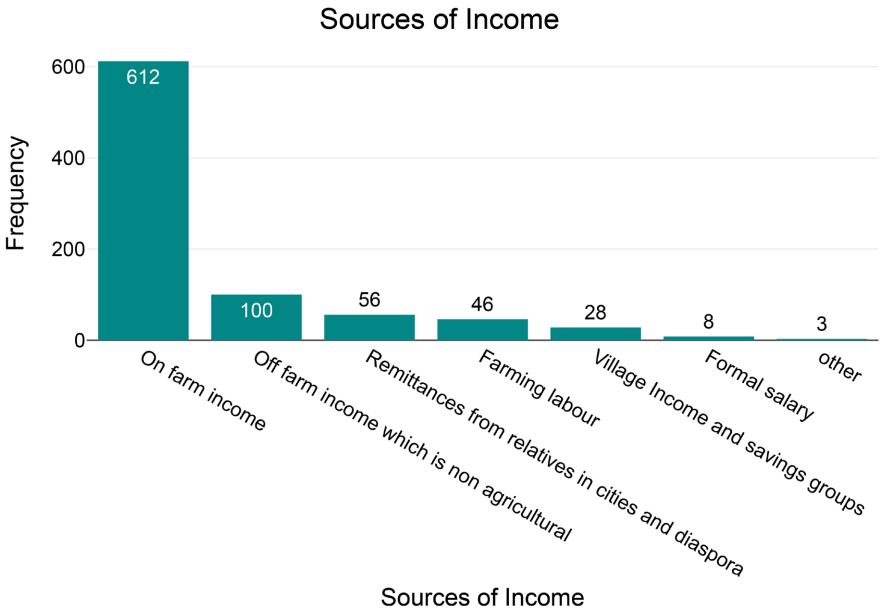

Figure 1. Primary income source.

Remittances provide financial support for 6.56% of farmers, reflecting the role of family networks in supplementing household income. Remittances, whether from urban relatives or family members abroad, serve as an essential financial safety net for many rural households, helping to smooth income fluctuations and enabling expenditures on farming inputs, education, or health services.

Other Income Sources

1) Farming Labor: Approximately 5.39% of farmers earn income by working on other farms, indicating that for some households, agricultural labor provides a vital secondary income stream. This suggests that labor-sharing arrangements or paid farm labor can supplement household income during times of low productivity or market downturns.

2) Village Income and Savings Groups: 3.28% of farmers participate in community-based financial support systems, such as village income and savings groups. These groups often provide access to low-cost loans, which may be used to establish small non-agricultural businesses or to invest in farm inputs. Such communal financial mechanisms are critical for fostering economic resilience and creating alternative income streams within rural communities.

3) Formal Salary: A very small percentage (0.94%) of farmers earn a formal salary, reflecting the limited availability of formal employment opportunities in rural areas. The majority of farmers in this category are either civil servants or have a family member employed in nearby towns, underscoring the predominance of informal and agricultural work in rural economies.

4) Other Sources: A negligible proportion (0.35%) of farmers reported other unspecified income sources, indicating that the majority of rural households are reliant on agriculture and informal work for their livelihoods.

5) Invalid Responses: The proportion of invalid responses was 0.12%, which is

statistically insignificant and unlikely to impact the overall analysis.

Analysis and Implications

This data clearly illustrates that rural farmers in Zimbabwe are predominantly reliant on agricultural income but also engage in income diversification strategies through non-agricultural work, remittances, and community financial groups. However, formal employment plays a minimal role in their income structure, reinforcing the need for targeted interventions that enhance agricultural productivity and financial resilience in rural communities.

The seasonal nature of agricultural income, which varies with environmental conditions such as droughts, floods, and market fluctuations, results in lower disposable income for smallholder farmers. This creates challenges for the adoption of digital advisory services, as farmers may be reluctant to invest significant financial resources in services traditionally perceived as free or publicly funded. Furthermore, the high-risk nature of agricultural investment means that good income in one season does not guarantee the same outcome in the next, compounding farmers' hesitancy to commit to long-term expenditures on advisory services. This insight has significant implications for product design and service delivery models. Digital advisory tools should be designed with an understanding of farmers' financial constraints and their sensitivity to seasonal income volatility. Offering low-cost, flexible advisory services that align with farmers' ability to pay could enhance the scalability of digital solutions. Moreover, the need for subsidized services or performance-based pricing models, which align advisory costs with productivity gains, should be explored to promote widespread adoption.

3.2. Objective 2: Perceived Value of Digital Advisories

3.2.1. Sources of Information for Agricultural Decisions

Below in Table 3 are key insights into how farmers leverage insights leveraging technology.

Table 3. Farmer information insights.

	Frequency	%	% of Cases
SMS	678	42.83%	79.48%
Whatsapp	398	25.14%	46.66%
Radio	282	17.81%	33.06%
Videos	60	3.79%	7.03%
Other sources	52	3.28%	6.1%
Tv shows	37	2.34%	4.34%
Internet	26	1.64%	3.05%
Apps	25	1.58%	2.93%
Podcasts	25	1.58%	2.93%
Total	1583	100%	

Most Used Sources of Agricultural Information

1) Most Frequently Used Sources:

- SMS: SMS emerged as the most commonly used source of agricultural information, accounting for 42.83% of the total responses and cited by 79.48% of respondents. This suggests that SMS remains a critical tool in rural agricultural communication, likely due to its accessibility on basic mobile phones, which are still widely prevalent in rural areas where smartphone penetration remains limited.
- WhatsApp: The second most popular source, WhatsApp, made up 25.14% of responses and was used by 46.66% of respondents. The platform's popularity is likely driven by its ability to facilitate more interactive and multimedia-rich communication, which allows for sharing images, videos, and voice notes—crucial for providing detailed advisory services.
- Radio: Radio was the third most utilized source, representing 17.81% of responses and cited by 33.06% of farmers. Radio continues to play a significant role in rural information dissemination, particularly in areas with limited mobile network coverage or for farmers who prefer more traditional media.

2) Lesser Used Sources:

- Videos: Videos accounted for 3.79% of responses, with 7.03% of farmers citing them as a source of information. Despite their educational potential, videos have lower reach, likely due to bandwidth limitations in rural areas and the cost associated with data usage.
- Other Sources: 3.28% of farmers reported using other, less defined sources of information, accounting for 6.1% of the cases. This suggests that there are still alternative, informal channels through which some farmers receive advisory content.
- TV Shows: Only 2.34% of responses indicated TV shows as a source of information, used by 4.34% of farmers. The limited use of television as an advisory tool may be due to the infrequency of agriculture-focused programming or the limited availability of electricity in some rural areas.
- Internet: 1.64% of responses indicated the internet as a source of information, used by 3.05% of respondents. This reflects the ongoing digital divide in rural farming communities, where internet access remains limited.
- Apps and Podcasts: Both apps and podcasts accounted for 1.58% of responses, used by 2.93% of farmers. The relatively low adoption of these tools can be attributed to low digital literacy and limited access to smartphones and stable internet connections.

Analysis of Information Sources

The data indicate that traditional, easily accessible communication channels—such as SMS and radio—continue to dominate agricultural decision-making in rural areas. These platforms are preferred due to their accessibility and cost-effectiveness. In contrast, modern digital tools, such as apps and podcasts, have seen lower adoption rates, likely due to the high cost of data, device affordability issues,

and low levels of digital literacy among farmers.

Qualitative insights gathered from farmers suggest a preference for alert-based messaging, where specific, actionable information is delivered in real-time. Farmers indicated a strong preference for weather alerts, shared through WhatsApp by extension officers, and extreme weather warnings issued by the Civil Protection Unit (CPU). These kinds of notifications were viewed as more valuable than general agronomy advice, which many farmers considered too broad to be immediately applicable to their local conditions.

Farmers reported a higher appreciation for services such as Ecofarmer and NGO projects like EXTRA, which offer localized advisory content tailored to specific value chains. This targeted approach was seen as more relevant than generalized advisories provided by local programs that may not address the crops or livestock of particular interest to farmers. For example, Ecofarmer's messages allowed farmers to select specific value chains for targeted advisory services, which enhanced the perceived relevance of the content.

In contrast, digital apps such as Kurima Mari showed limited penetration, with uptake largely restricted to districts where they had been actively promoted, particularly in Midlands districts. This finding underscores the fact that static content apps are unlikely to scale virally on their own. Farmers who did adopt these applications had participated in digital literacy clinics, which enabled them to explore the broader functionality of their smartphones beyond basic calls and texting. This suggests that digital literacy remains a barrier to broader app adoption, even among farmers who possess smartphones.

Despite being monologue-driven, radio programs continue to command significant listenership, particularly those hosted by agricultural companies like SeedCo and ZFC. Farmers noted the usefulness of radio programming in addressing basic product knowledge and agronomic challenges, particularly in the area of crop protection.

3.2.2. Mobile Extension Distribution

The dataset also reflects how farmers access mobile extension services through various channels, including SMS, WhatsApp, or a combination of both. This analysis is crucial for understanding farmer behavior, identifying the challenges they face, and recognizing the untapped opportunities for enhancing mobile extension services.

- SMS Dominates: 44.2% of farmers reported using SMS only to access mobile extension services, reflecting its importance due to the widespread ownership of basic mobile phones in rural areas. The lower penetration of smartphones in these regions likely drives the continued reliance on SMS.
- SMS and WhatsApp Combination: 35.4% of farmers use a combination of SMS and WhatsApp to receive agricultural information, indicating that while some farmers are adopting smartphone technologies, they continue to use SMS for critical updates. This combination suggests a growing, though still limited, adoption of more dynamic digital platforms.

- WhatsApp-Only Usage: 11.14% of farmers reported using WhatsApp exclusively for agricultural advisory services. This smaller group likely represents more technologically advanced farmers with access to both smartphones and stable internet connections, allowing them to benefit from the multimedia capabilities of WhatsApp.
- No Access to Mobile Extension: 9.26% of respondents indicated they lacked access to any mobile extension services, primarily due to either device unavailability or poor network coverage. This highlights the significant digital divide that persists in rural farming communities, underscoring the need for targeted interventions to ensure broader access to digital tools.

Implications for Digital Extension Services

The findings suggest that while traditional communication channels (SMS and radio) remain dominant, there is growing interest in more dynamic platforms like WhatsApp. However, the adoption of apps and internet-based services is still constrained by barriers such as cost, device affordability, and digital literacy.

To maximize the impact of digital advisory systems, efforts should focus on expanding access to smartphones, promoting digital literacy, and improving network infrastructure in rural areas. Moreover, ensuring that digital content is tailored to the specific needs and value chains of farmers will be essential for driving adoption at scale. This may involve creating targeted, value-chain-specific advisory messages that allow farmers to select content relevant to their particular crops or livestock rather than providing generalized agronomic information.

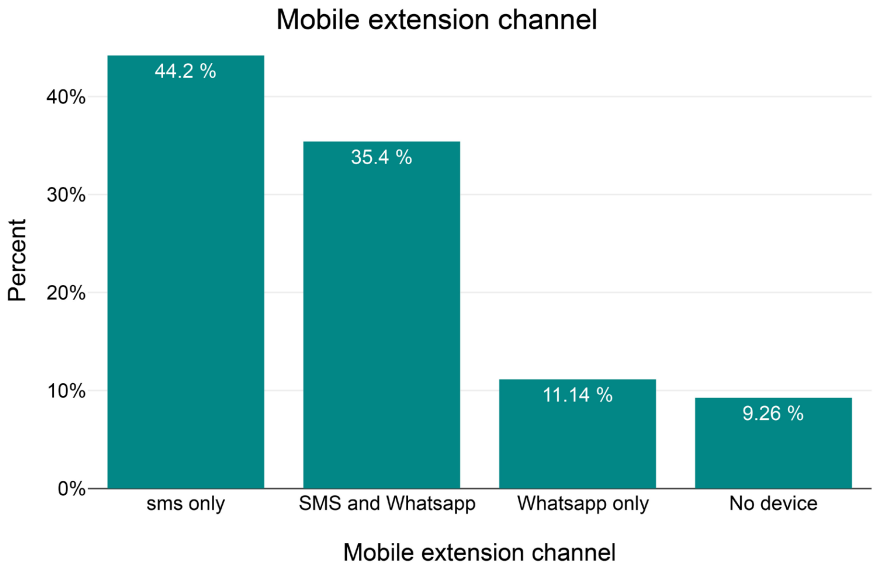

Figure 2. Mobile extension channel usage.

Key Observations

1) SMS Dominates as the Primary Channel:

As shown by **Figure 2**, approximately 44.2% of farmers rely solely on SMS to receive mobile extension services. This dominance reflects the accessibility of SMS

on basic mobile phones, which remain widely used in rural areas where smartphone penetration is relatively low. SMS continues to be a vital tool for reaching farmers, particularly in communities with limited technological infrastructure.

2) SMS and WhatsApp Combination:

A significant portion of farmers (35.4%) use both SMS and WhatsApp to access agricultural information. This group includes farmers with access to smartphones, allowing them to benefit from the multimedia capabilities of WhatsApp while continuing to rely on SMS for basic messaging. The combination of both platforms indicates the growing adoption of WhatsApp, which enables more detailed information sharing, including images, videos, and voice notes, making it a valuable tool for extension services.

3) WhatsApp-Only Usage:

11.14% of farmers use WhatsApp exclusively for extension services. This smaller subset likely represents more technologically advanced farmers who have access to smartphones and stable internet connections, enabling them to rely solely on the internet-based platform. WhatsApp offers richer communication capabilities compared to SMS but requires internet access and smartphones, which are less common in rural areas.

4) No Access to Mobile Extension:

9.26% of farmers report having no device for accessing mobile extension services. This group faces significant barriers, including lack of access to mobile phones and poor network coverage, limiting their ability to benefit from mobile-based agricultural extension services. The digital divide in rural communities remains a substantial obstacle to inclusive agricultural development.

Analysis and Implications

1) Challenges in Digital Inclusion:

The 9.26% of farmers without access to mobile extension services highlight a significant challenge for agricultural development. These farmers, who lack access to mobile phones or face poor network coverage, are at risk of being excluded from the benefits of digital transformation in agricultural advisory services.

Bridging this digital divide will require targeted interventions, such as providing affordable mobile devices, improving rural telecommunications infrastructure, and offering digital literacy training. Such efforts are essential to ensure that all farmers, including those in the most remote areas, can benefit from mobile-based advisory services.

2) Need for a Comprehensive Digital Extension Framework:

While WhatsApp is recognized by extension managers at the district, provincial, and national levels as an effective channel for farmer engagement, there is currently no operational framework to guide how digital extension should be delivered, monitored, and integrated into broader extension programs. This lack of coordination is particularly evident in public extension services, where inconsistent messaging diminishes the potential of WhatsApp as a platform for agricultural advisory.

Farmers reported that WhatsApp is widely used for sharing information on national conservation programs, such as Pfumbvudza/Intwasa, yet there is little consistency in similar messaging across other agricultural domains. Private extension services also suffer from fragmentation, with no formal guidelines for quality assurance or targeting. A notable exception is seen with SeedCo and Windmill Fertilizers, which have established farmer groups in specific regions, providing targeted, trusted advisory content.

3) Trust and Quality Assurance Gaps:

Farmers expressed concerns about the quality assurance of information received through private sector-driven extension services. While these platforms offer valuable advice, farmers have no systematic way to verify the accuracy of the information provided beyond the trust associated with input companies. The absence of farmer off-takers in these extension systems was also noted, indicating a potential gap in providing holistic agricultural support that includes market access.

4) Behavioral Changes and Weather-Related Messaging:

Farmers indicated that the most behaviorally impactful information received via both SMS and WhatsApp were weather updates and advisory messages linked to government input programs. Practices such as basin digging and mulch gathering, which are prerequisites for receiving government inputs, were frequently cited as examples of targeted messaging that had immediate relevance and practical application. This suggests that actionable and context-specific content is more likely to drive farmer engagement with digital platforms.

A substantial proportion of farmers continue to lack access to mobile devices, which highlights the ongoing need to address the digital divide in rural communities. Expanding access to both basic mobile technologies and more advanced platforms will be critical for enhancing the reach and effectiveness of agricultural extension services.

3.2.3. Farmers' Investment in Mobile Technology

For digital advisory strategies to work well, it was crucial to assess the investment levels of SSPs in their mobile devices, as this indicates how well current market products meet their needs. The data is shown in Table 4 as follows:

Table 4. Farmer investment in data.

Farmer budgets on mobile usage	Frequency	%	Valid %
0 - $5	540	63.31%	64.21%
6 - $10	193	22.63%	22.95%
11 - $15	41	4.81%	4.88%
16 - $20	26	3.05%	3.09%
$26+	22	2.58%	2.62%
21 - $25	19	2.23%	2.26%

Continued

Total	841	98.59%	100%
Invalid	12	1.41%	
Total	853	100%	

Key Observations

1) Dominance of Lower Spending:

The majority of farmers (64.21%) reported spending between $0 - $5 per month on mobile usage for agricultural activities, indicating a limited budget allocation for mobile services. This suggests that many farmers are either financially constrained or do not yet perceive mobile services as essential for their farming operations. The minimal investment in mobile services could act as a barrier to accessing valuable agricultural information, such as weather forecasts, market prices, and best farming practices, thus limiting the potential of digital tools to support farm management and productivity.

2) Mid-Range Spending:

A smaller group (22.95%) of farmers falls within the $6 - $10 spending range. Although this indicates a slightly higher level of investment in mobile technology, the data reveal that over 87% of farmers spend less than $10 per month on mobile usage. This further emphasizes that smallholder farmers have modest budgets for technology. Notably, farmers involved in horticultural production and frequent livestock sales tend to be overrepresented in this mid-range category, likely due to their higher need for timely information related to market prices and logistics.

3) Higher Budget Commitment:

A small fraction of farmers (4.88%) spend $11 - $15 per month, 3.09% spend $16 - $20, and only 2.62% allocate more than $26 per month to mobile usage. These farmers, who demonstrate a higher financial commitment to mobile services, likely represent market-oriented farmers engaged with external markets and more complex value chains. Their increased spending suggests a higher reliance on advanced mobile services, such as price tracking, logistics coordination, and advanced agronomic data.

4) Possible Implications for Agricultural Development:

The fact that nearly two-thirds of farmers allocate minimal budgets to mobile services, as shown in Figure 3 below, suggests that cost remains a significant barrier to the widespread adoption of digital farming tools. The development of digital advisory tools in Zimbabwe must, therefore, prioritize low-cost, simple technologies that are accessible and affordable for the majority of smallholder farmers. The continued dominance of SMS-based services, which are affordable and compatible with basic mobile phones, reflects the economic constraints many farmers face.

Moreover, while WhatsApp is gaining popularity, farmers expressed concerns about the data costs associated with receiving videos and multimedia content. Instead, they preferred text-based messages or voice notes, which consume less data.

This pattern suggests that even as smartphone adoption grows, the limited spending power of farmers constrains their ability to engage with more data-intensive mobile applications.

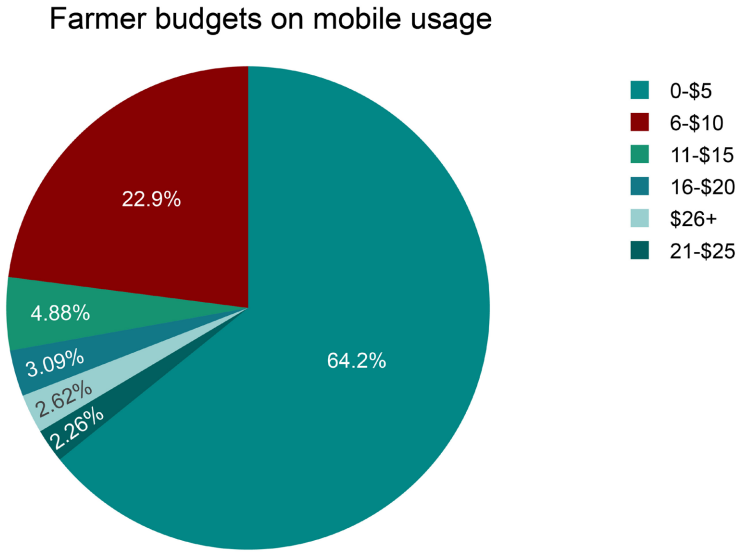

Figure 3. Pie chart of farmer investments in mobile.

To foster digital engagement in the agricultural sector, there is a need for tailored, low-cost mobile solutions that fit within the budgets of smallholder farmers. Programs that provide subsidized services, government support, or NGO-driven initiatives could play a crucial role in overcoming these financial barriers and increasing access to mobile-based agricultural advisory services. Additionally, digital tools should be designed to deliver targeted, actionable content that minimizes data consumption while maximizing utility for the farmer.

Finally, interventions aimed at boosting digital literacy, particularly for smallholder farmers in rural areas, will be essential for ensuring that farmers can fully leverage the potential of digital technologies in agriculture. These efforts should be coupled with affordable data plans, improved network infrastructure, and outreach efforts that enhance farmers' confidence in using mobile platforms to improve their farming practices.

3.2.4. Relationship between Budgets and Motivation for Farming

A Chi^2 test was performed between *Motivation for farming* and *Farmer budgets on mobile usage*. Table 5 and Table 6 show the observed and expected frequencies. At least one of the expected cell frequencies was less than 5. Therefore, the assumptions for the Chi^2 test were not met. There was a statistically significant relationship between *Motivation for farming* and *Farmer budgets on mobile usage*, χ^2 (15) = 60.89, p = <0.001, Cramér's V = 0.16.

The calculated p-value of <0.001 was lower than the defined significance level of 5%. The Chi^2 test was therefore significant and the null hypothesis was rejected.

Table 5. Observed frequencies.

		Farmer budgets on mobile usage						Total
		0 - $5	6 - $10	$26+	16 - $20	11 - $15	21 - $25	
Motivation for farming	Balanced market engagement and subsistence	190	82	14	16	13	16	331
	Subsistence and partial market engagement	186	72	6	7	14	1	286
	Purely subsistence	153	32	0	1	11	0	197
	Market engagement solely	11	7	2	2	3	2	27
	Total	540	193	22	26	41	19	841

Table 6. Expected frequencies for perfectly independent variables.

		Farmer budgets on mobile usage						Total
		0 - $5	6 - $10	$26+	16 - $20	11 - $15	21 - $25	
Motivation for farming	Balanced market engagement and subsistence	212.53	75.96	8.66	10.23	16.14	7.48	331
	Subsistence and partial market engagement	183.64	65.63	7.48	8.84	13.94	6.46	286
	Purely subsistence	126.49	45.21	5.15	6.09	9.6	4.45	197
	Market engagement solely	17.34	6.2	0.71	0.83	1.32	0.61	27
	Total	540	193	22	26	41	19	841

Observed Frequencies analysis:

- The largest group of farmers, those with balanced market engagement and subsistence farming motivation, tends to spend between $0 - $5 (190 farmers).
- Farmers who are purely subsistence-oriented show very low expenditures on mobile usage, with 153 spending in the $0 - $5 category and very few in other categories.
- A very small number of farmers (27 total) are motivated solely by market engagement, with most of them spending $0 - $5 on mobile usage.

Expected Frequencies analysis (for independent variables):

- For balanced market engagement and subsistence, more farmers were expected to spend in higher categories of $11 - $15 and $21 - $25 than what was observed.
- Similarly, for purely subsistence farmers, more individuals were expected to spend in higher mobile usage budget categories than what was actually observed.

- The expected counts for farmers solely motivated by market engagement were higher than observed in some budget categories, indicating a deviation from independence.

Chi-Square Test			
	Chi^2	df	p
Motivation for farming-Farmer budgets on mobile usage	60.89	15	<0.001
Pearson Contingency Coefficients			
		C	
Motivation for farming-Farmer budgets on mobile usage		0.3	

Pearson Contingency Coefficient (C = 0.3):

- The Pearson contingency coefficient provides a measure of association between the variables, with C = 0.3 indicating a moderate association. This coefficient further supports that while the relationship between *Motivation for Farming* and *Mobile Usage Budgets* is significant, it is not particularly strong. Other factors may also play a role in determining farmer mobile usage budgets.

Analysis of Farmer Motivation and Mobile Usage

The analysis reveals that farmer motivation—whether subsistence-oriented or market-oriented—significantly influences farmers' expenditure on mobile technology. Subsistence farmers tend to allocate far less to mobile technology than their market-engaged counterparts, reflecting the differing demands and priorities of these two groups. While this relationship between farmer motivation and mobile usage is statistically significant, the strength of the association is only moderate, indicating that while motivation plays a role in how farmers budget for mobile usage, other factors are also at play.

These additional factors may include access to technology, income levels, and specific farming needs, which together shape a farmer's willingness or ability to invest in mobile technology. For example, subsistence farmers with limited disposable income may prioritize more immediate household needs over the acquisition of mobile technology, whereas market-oriented farmers may view mobile phones as critical tools for accessing price information, logistics, and other market-related services.

The findings suggest that, when designing digital services for farmers, it is essential to adopt a holistic approach that considers the diverse information-related needs of farmers beyond agricultural advisory services alone. In particular, farmers tend to view mobile devices as multi-functional communication tools rather than solely as instruments for farming. This observation challenges the notion, often emphasized in development literature, that mobile phones in rural contexts

are primarily used for agriculture. In reality, mobile devices are central to social investment, allowing farmers to communicate with relatives and other social networks, which in turn influences how farmers allocate their financial resources for mobile usage.

For farmers with higher incomes from horticulture or frequent market engagements, communication needs extend beyond production information to include market prices, transport logistics, and buyer negotiations. These farmers indicated that their mobile usage was largely driven by the need to stay connected to market information flows, which directly affects their farming business outcomes. This finding underscores the importance of designing digital advisory services that cater not only to production-focused needs but also to the broader economic activities in which farmers are engaged.

In conclusion, while farmer motivation remains a key factor influencing mobile usage, it is imperative to consider other socio-economic factors such as income, access to technology, and the multiple roles that mobile devices play in farmers' lives. By addressing these broader factors, digital service providers can develop more targeted, user-centric solutions that meet the holistic needs of smallholder farmers, thereby improving adoption rates and maximizing the impact of mobile-based advisory services.

3.2.5. Constraints of Farmers Using Mobile Devices

The dataset represented by Table 7 outlines the major challenges that farmers encounter when utilizing mobile devices for agricultural activities. Below is a summary of the data:

Table 7. Farmers' mobile usage constraints.

The primary constraint of farmers using mobile devices for agriculture extension and business	Frequency	%	Valid %
Affordability of airtime	343	40.16%	40.16%
Network challenges	337	39.46%	39.46%
Cost of devices	99	11.59%	11.59%
Gadget problems	39	4.57%	4.57%
Phone recharging	36	4.22%	4.22%
Total	854	100%	100%
Invalid	0	0%	
Total	854	100%	

Key Observations

1) Affordability of Airtime:

- Affordability of airtime was identified as the most significant barrier to mobile technology usage, affecting 40.16% of respondents. Although many farmers

possess mobile devices, the recurrent costs of airtime and data bundles represent a substantial financial burden, limiting the practical use of these devices for accessing agricultural extension services.

- This constraint likely reduces the frequency with which farmers utilize mobile services for accessing agricultural information, thus diminishing the potential impact of mobile advisory systems on agricultural productivity.

2) Network Challenges:

- 39.46% of farmers reported facing network-related challenges, including inconsistent signal reception, inadequate coverage, and slow internet speeds. These issues are particularly pervasive in rural areas where telecommunications infrastructure development has lagged behind that of urban centers.
- Poor network connectivity limits farmers' ability to receive real-time updates on essential agricultural information such as weather forecasts, market prices, and pest management advisories. As a result, network challenges undermine the effectiveness of mobile advisory services.

3) Cost of Devices:

- The cost of mobile devices was reported as a constraint by 11.59% of farmers. While most farmers own basic mobile phones, the cost of purchasing more advanced devices, such as smartphones, remains prohibitive for a significant proportion of the farming population.
- Ensuring affordable access to mobile technology is critical for expanding the reach of mobile extension services, particularly in under-resourced rural areas where device ownership remains uneven.

4) Gadget Issues:

- 4.57% of farmers cited gadget-related issues, including hardware malfunctions, software difficulties, and general usability challenges. Although a smaller proportion of farmers are affected, these issues underscore the importance of providing reliable and durable mobile devices that can withstand the demands of rural environments.
- Addressing these issues is essential to ensuring the long-term usability of mobile devices, thereby facilitating sustained engagement with digital advisory services.

5) Phone Recharging:

- 4.22% of farmers reported challenges related to phone recharging, primarily due to limited access to reliable electricity. This is particularly acute in off-grid rural areas, where farmers often need to travel significant distances to charge their devices, reducing the frequency of mobile service usage.
- This barrier highlights the need for off-grid power solutions, such as solar-powered charging stations, to improve the consistency with which farmers can engage with mobile advisory services.

Analysis and Implications

1) Airtime Affordability and Network Challenges as Dominant Barriers:

- The two most significant constraints—the affordability of airtime and network

challenges—account for nearly 80% of the reported issues, indicating that these are the primary obstacles to the widespread adoption of mobile-based agricultural services. These challenges reflect both economic and infrastructural limitations prevalent in rural areas, where farmers often lack the financial resources and telecommunications infrastructure necessary to fully leverage mobile technologies.

- To address these constraints, targeted policy interventions are required. These could include subsidizing airtime costs, investing in rural telecommunications infrastructure, and promoting affordable data plans. Such interventions would help mitigate the financial and infrastructural barriers that currently prevent farmers from accessing vital agricultural information through mobile advisory platforms.

2) Device Cost as a Significant Barrier:

- The cost of mobile devices remains a critical barrier for 11.59% of farmers, particularly for those who do not own smartphones. This suggests a need for programs that provide low-cost or subsidized smartphones, particularly for farmers in remote or economically disadvantaged areas.
- Public-private partnerships between governments, telecommunications companies, and NGOs could facilitate the distribution of affordable mobile devices, thereby enhancing access to digital extension services. Such partnerships could help bridge the digital divide and ensure that farmers across different socioeconomic strata can benefit from mobile-based agricultural advisories.

3) Gadget Reliability and Power Supply Issues:

- Although only a smaller proportion of farmers (4.57%) reported gadget-related problems, these issues highlight the necessity for durable and reliable devices designed for use in rural conditions. Addressing these issues will require ensuring that the mobile devices provided to farmers are not only affordable but also robust enough to withstand the challenges posed by rural farming environments.
- Furthermore, the lack of access to reliable power sources affects 4.22% of farmers, particularly in off-grid areas. This presents an opportunity for the introduction of sustainable power solutions, such as solar charging stations, which could significantly enhance farmers' ability to consistently engage with mobile advisory services. Providing technical support for device maintenance and repair could also improve the long-term functionality of mobile devices.

3.3. Objective 3: Opportunities for Improvement from the Farmers' Perspective (Qualitative Insights)

Across all districts, farmers expressed a strong demand for a dedicated AGRITEX SMS and WhatsApp platform that could deliver localized, context-specific advisory messages. Farmers emphasized that for such a platform to be truly effective, it must also allow multi-stakeholder access—enabling a broader spectrum of community-relevant messaging. For instance, farmers advocated for the integration of

agricultural advice with community-level information such as children's immunization program schedules, local council meeting announcements, and other public service alerts. Such a holistic messaging system would not only streamline communication but also enhance the platform's value by addressing a wider array of rural community needs beyond agriculture.

From a private sector perspective, farmers highlighted the success and widespread approval of the now-disbanded ZFU-Ecofarmer platform. This service was particularly valued because it combined agricultural advisory messaging with life insurance policies, thereby offering both practical agronomic support and financial security. Focus group discussions revealed that this dual-purpose platform provided farmers with the right incentives to invest in the service, promoting both economic resilience and agricultural productivity. Farmers indicated a willingness to invest their resources into such comprehensive solutions, underscoring the importance of delivering multi-benefit services that address both livelihood and personal security concerns.

Extension workers, particularly in the Midlands and Mashonaland West districts, observed that providing them with airtime and data bundles—as is sometimes done by NGOs—would enable them to engage more consistently and effectively with farmers through targeted, digital messaging. These extension workers emphasized that the current group training models could be significantly enhanced with a digital track, which would allow for a broader reach and more personalized advice. However, they noted that digital extension delivery is not currently part of the formal reporting metrics, resulting in fragmented and uncoordinated use of digital tools across the extension workforce. Extension workers suggested that farmers' frequent practice of sharing photos of their crops and reporting seasonal performance via digital platforms could be harnessed to augment national crop assessment exercises, providing visual evidence that enhances the accuracy of traditional sample-based assessments.

In the southern regions, extension workers and farmers identified livestock management information as an area where advisory services could be improved. Currently, most livestock-related information is only provided during cattle sales days or at dip tank meetings, which limits its timeliness and effectiveness. Farmers and extension workers proposed that regular, high-quality livestock management content be delivered through partnerships with veterinary departments, allowing for more systematic dissemination of critical information. For example, outbreaks of diseases like lumpy skin and January disease are often communicated too late, leading to significant financial losses for farmers. Real-time, digitally-delivered advisory services could play a crucial role in mitigating these risks by enabling farmers to implement proactive disease prevention and management strategies.

4. Conclusions and Recommendations

1) High Mobile Penetration among Smallholder Farmers

Digital penetration in Zimbabwe's smallholder farming communities is notably

high, with only 9% of farmers not possessing a mobile device, translating to a mobile penetration rate of 91%. This is higher than previously reported figures in literature, which estimate mobile penetration in sub-Saharan Africa to be around 85% (20, 21). Zimbabwe's mature digital landscape presents an opportunity for crafting scalable digital advisory policies aimed at smallholder farmers. Smartphone penetration, indicated by approximately 35% of WhatsApp users, also suggests a high potential for interactive, low-cost chatbots and AI-powered advisory services. It is recommended that the government establish a digital advisory alliance with development partners (donors, NGOs, and private sector players) to address funding gaps and leverage these digital opportunities.

2) Investment in Digital Literacy

While mobile penetration is high, digital literacy remains a critical barrier to realizing the benefits of digital extension services. Some NGOs, like Welthungerhilfe and CTDO, have initiated digital literacy campaigns, but a national, government-driven effort is necessary. The development of nationwide digital literacy programs with a standardized curriculum, regularly reviewed by key ministry staff, will help build the necessary skills for the farming population to effectively use digital tools.

3) Incentivizing MNOs for Improved Connectivity

Feedback from farmers indicates a strong appetite for digital engagement, which transcends socio-economic boundaries. However, network connectivity remains a significant limiting factor in rural areas. To address this, the government should consider incentivizing Mobile Network Operators (MNOs) to invest in rural infrastructure. Providing derisking incentives could encourage private sector investment in improving network connectivity, ultimately unlocking the industrial capacity of rural areas and supporting widespread digital advisory service adoption.

4) Human-Centered Design in Digital Solutions

Despite several digital solutions targeting smallholder farmers, there is an emerging need for human-centered design to ensure usability and scalability. The study revealed that current applications often do not align with farmers' practical needs, particularly regarding off-farm advisories like weather updates and market prices. Future digital solutions should bundle agronomic advice with more practical, off-farm information to increase usage and relevance for farmers.

5) Coordination and Collaboration between Stakeholders

There is a lack of coordination among key stakeholders—including the private sector (e.g., ZFC, Windmill, SeedCo) and various NGOs—all of whom have developed digital solutions targeting the same issues. Instead of duplicating efforts, stakeholders should collaborate on a harmonized, scalable industry solution. This would prevent fragmentation and allow for broader adoption of digital tools that benefit all players.

6) Prioritization of Market Linkages

For smallholder farmers, access to market linkages and guidance on ensuring product quality ranks higher in importance than general agronomic advice. Strengthening market information systems that provide real-time, reliable content on market

prices, buyer demand, and quality standards is crucial. Such systems would enhance the value of digital platforms and significantly drive up their usage.

7) Integration of AI with Popular Messaging Platforms

Smallholder farmers are showing a growing appetite for interactive digital solutions. There is an opportunity to integrate AI-powered advisory tools with widely used messaging platforms like WhatsApp. This integration would enable farmers to engage at scale and receive localized, site-specific advisories on farming practices, market prices, and weather updates, enhancing both the relevance and effectiveness of digital advisory services.

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Authors' Contributions

For this research, Mthintwa Tawanda Hove was the lead author who designed and conducted the research. Hlamalani Ngwenya was the academic supervisor who advised how the study should be executed and supported aspects of the data analysis. Kinwell Madhazi supported qualitative data collection and its subsequent analysis.

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Conflicts of Interest

The authors declare no conflicts of interest whatsoever with regard to this study.

References

[1] Beltran-Pena, A. and D'Odorico, P. (2022) Food Security in Sub-Saharan Africa under Population Pressure: Can Agriculture Keep Pace? *Global Food Security*, **25**, 87-99.

[2] Scoones, I. (2016) Livelihoods and Rural Transformations in Zimbabwe: A Review. *Journal of Southern African Studies*, **42**, 295-310.

[3] Muzerengi, T. and Tirvangasi, H.M. (2019) Climate Shocks and Agricultural Productivity in Zimbabwe: A Call for Action. *African Journal of Food, Agriculture, Nutrition and Development*, **19**, 14710-14725.

[4] Porciello, J., MacCarthy, M. and Heinemann, A. (2022) Leveraging Digital Advisory Services for Smallholder Farmers: Lessons from Sub-Saharan Africa. *Global Agricultural Informatic Journal*, **8**, 65-78.

[5] World Bank (2023) Agricultural Productivity in Zimbabwe: Current Challenges and

Future Outlook. World Bank Agricultural Development Report.

[6] Anderson, J.R. (2008) Agricultural Advisory Services. The World Bank.

[7] Manzeke-Kangara, M.G., Chikowo, R. and Mapfumo, P. (2024) Transforming Agricultural Extension in Zimbabwe: Challenges and Opportunities for Smallholder Farmers. *Agricultural Systems*, **176**, 102-114.

[8] Masere, T. and Worth, S.H. (2021) Agricultural Extension Services in Zimbabwe: Trends and Future Directions. *Journal of Agricultural Extension and Rural Development*, **15**, 78-95.

[9] Muzenda, T. (2019) Public-Private Partnerships in Zimbabwe's Agricultural Extension Services: Successes and Limitations. *Journal of Agrarian Change*, **19**, 132-149.

[10] Christoplos, I. (2010) Mobilizing the Potential of Rural and Agricultural Extension. Food and Agriculture Organization of the United Nations (FAO).

[11] Ndoro, J., Mudhara, M. and Chimonyo, M. (2017) Revisiting the Master Farmer Program: Assessing the Socio-Economic Impact on Zimbabwe's Smallholder Farmers. *Development Southern Africa*, **34**, 232-246.

[12] GFRAS (2022) Global Forum for Rural Advisory Services: Trends in Extension Services in Zimbabwe and beyond. GFRAS Publications.

[13] Feder, G., Willett, A. and Zijp, W. (1999) Agricultural Extension: Generic Challenges and the Ingredients for Solutions. World Bank Policy Research Work Paper No. 2129.

[14] Farooq, U., Ishaq, M. and Waheed, A. (2007) The Role of Demonstration Plots in Technology Dissemination: An Empirical Analysis. *Pakistan Journal of Agricultural Sciences*, **44**, 512-518.

[15] Birner, R., Davis, K., Pender, J., Nkonya, E., Anandajayasekeram, P., Ekboir, J., *et al.* (2009) From Best Practice to Best Fit: A Framework for Designing and Analyzing Pluralistic Agricultural Advisory Services Worldwide. *The Journal of Agricultural Education and Extension*, **15**, 341-355. https://doi.org/10.1080/13892240903309595

[16] Food and Agriculture Organization of the United Nations (2024) The Role of Extension Services in Sustainable Agricultural Development. https://www.fao.org/publications

[17] Anteneh, M. and Melak, B. (2024) Adoption of Digital Advisory Services in Smallholder Agriculture: Barriers and Opportunities in Sub-Saharan Africa. *Journal of Innovative Agriculture*, **12**, 45-62.

[18] Ayim, G., Osei, E. and Fosu, M. (2022) ICT Infrastructure Challenges in Smallholder Agriculture in Sub-Saharan Africa. *Journal of Rural Development and Applied Technology*, **19**, 88-103.

[19] Baig, M.B. and Aldosari, F. (2013) Agricultural Extension through Digital Tools: A Case of Sub-Saharan Africa. *International Journal of Extension Education*, **9**, 59-67.