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FACTORS INFLUENCING ADOPTION, INNOVATION OF NEW TECHNOLOGY AND DECISION-MAKING BY SMALL-SCALE RESOURCE-CONSTRAINED FARMERS: THE PERSPECTIVE OF FARMERS IN LOWER GWERU, ZIMBABWE

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ABSTRACT

A study was conducted in Lower Gweru Communal area of Zimbabwe to determine factors affecting small-scale resource-constrained farmers' technology adoption and innovation processes. Specific objectives included determining circumstances when farmers consider learning about and adopting new technologies; documenting challenges faced by farmers in technology adoption; and determining the kind of support farmers require in adopting technologies or innovating. Multistage stratified random sampling was used to select a study sample of 256 farmers who participated in focus group discussions (FGDs). Additionally, semi-structured interviews (SSIs) with 200 farmers, selected from within the 256 FGD participants, were conducted to corroborate data collected in FGDs and participant observation. The study found that farmers were ready to learn and adopt new technologies when proposed technologies were (i) cheaper to acquire and use than their current technologies, (ii) easier and simpler to use, (iii) reduced labor requirements, and (iv) increased crop yields and/or animal productivity. Specifically, the study found high adoption rates of new technologies with traits similar to the farmers' traditional practices such as conservation agriculture (with a 90% adoption rate) and thermal composts (with a 78% adoption rate). In terms of challenges, farmers were hampered mainly by lack of capital to acquire new technologies and lack of access to information, credit facilities and markets. In terms of support, in addition to capital and issues of access, farmers preferred to be actively involved in defining problems and developing solutions, technologies and innovations. Rather than being mere beneficiaries of new technologies developed by others, they want to be included in processes such as field-based participatory learning extension and innovation projects. In keeping with their self-perception as businessmen and women, perhaps most significantly, this study has reaffirmed that small-scale farmers, despite their educational limitations, their age, their constrained circumstances, and their risk profiles – are conscious and deliberate decision-makers. They are rational in their approach to adoption of technology, but are dominated by factors of cost, impact on income, and, of greatest influence, risk.

Key words: extension, innovation, indigenous technologies, learning, perception, small-scale farmers, technology adoption

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INTRODUCTION

Small-scale farmers of developing countries rarely adopt new technology recommended to them [1, 2]. In Zimbabwe, most of the technologies are disseminated by public extension agents from the Department of Agricultural Technical and Extension Services (AGRITEX). This public extension department is mandated to provide a plethora of services, including technical, advisory and regulatory services, to different farm clientele. In addition to these roles, the AGRITEX extension agents play the important role of taking feedback from farmers to technology developers (including seed houses, fertilizer companies, and research institutes) [3].

Several reasons influence poor technology adoption among small-scale farmers including affordability, lack of information support, lack of credit facilities to finance purchasing of the technologies, ineffective methods of dissemination, farmer demographics, perception of the proposed technologies, and exclusion of farmers in developing technologies aimed at helping solve their problems [2, 4]. Farmers' social and biophysical operating environments also influence technology adoption decisions [1, 4].

It is against this background that a study was conducted in Lower Gweru Communal area, Zimbabwe to determine farmers' perceptions on technology adoption. The study investigated the (i) main sources of technologies, (ii) challenges faced in adopting technology, (iii) support needed to promote technology adoption, (iv) farmers' perception of extension agents bringing the technologies, and (v) farmers' participation in innovation and extension projects. Lower Gweru communal area in Zimbabwe was chosen for the study for two main reasons. First, it is an area populated with small-scale resource-constrained farmers, and, second, the area has seen an increased number of technologies disseminated over the last two decades.

MATERIALS AND METHODS

Lower Gweru is a developed communal settlement in the Midlands province of Zimbabwe. The climate is semi-arid to arid with summer rainfall (October to March) ranging from 450mm to 600mm annually, but experiences periodic seasonal droughts and severe dry spells. Lower Gweru is located about 40 km North West of City of Gweru, and stretches a further 50 km to the West.

The population of respondents from all the eight Wards of Lower Gweru Communal area; Sikombingo, Nyama, Mdubiwa, Chisadza, Madikani, Bafana, Nkawane and Communal Ward 16, was derived from the AGRITEX Extension Supervisors to be 776. The sample size was derived from Krejcie and Morgan [5] table of determining sample size as 256. To eliminate bias and ensure representativeness, multi-stage stratified random sampling was used to select 256 participant farmers from all the eight Wards. The strata were Ward and gender. Each Ward contributed 32 farmers (16 men and 16 women). This sampling technique was used to ensure that males and females were equally represented and that all villages within each Ward were represented. The Wards' extension agents assisted in this process.

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Data were solicited using three instruments: focus group discussions [6], semi-structured interviews [7, 8], and participant observation [9]. These methods were used sequentially, each building on the results of the previous data collection exercise; each validating the data of the previous session. Further, data gathered at each session was reviewed with the relevant extension personnel and key informants for validation. The data were found to be consistent with information available to the public extension personnel and NGOs personnel operating in the area. The use of multiple methods as outlined provided the framework for the validity and reliability of the data [10].

Two focus group discussions (FGDs) were held in each of the eight Wards to gather general information about technologies disseminated to farmers over the last several years, sources of technology, and their perceptions of extension services. Thus, a total of 16 FGDs were conducted. Each FGD comprised 16 farmers (eight men and eight women). Thus, 256 farmers participated at all the 16 FGDs held in the eight Wards. Similar but more specific information was collected using semi-structured interviews (SSIs) with 200 farmers (100 men and 100 women) selected, using another stage of stratified random sampling (to cater for Ward and gender), from among the study sample of 256 farmers. Hence, 56 farmers who participated in the FGDs were not participants in the SSIs. The data collected included farmer demographics, farmer circumstances and livestock resources, technologies adopted and rating extension services. Participant observation, in the form of physical verification of technologies adopted by farmers in their fields and/ at their homesteads, was conducted to corroborate information gathered in FGDs and SSIs.

Due to the qualitative nature of the findings, the emergent theme method was used to analyze data gathered. Further, the demographics of respondents and their technology adoption behaviors were analyzed using descriptive statistics. Tables and graphs were used to present findings.

RESULTS AND DISCUSSION

Farmer demographics and circumstances

Three broad age categories emerged from the SSIs: young farmers (less than 35 years old), middle-aged farmers (35 to 50 years old) and older farmers (above 50 years old). Of these three groups, the older farmers accounted for (47%) of the respondents, while the middle-aged and young farmers accounted for 43.5% and 9.5% respectively (Table 1). Most of the farmers in rural areas of Zimbabwe are generally older (over 50 years) as most young people migrate from rural farming areas into towns and neighboring countries in search of non-agricultural work [11].

Most of the farmers (89.5%) have some formal education, with 35% having reached the Ordinary Levels or higher (Table 1). Only 10.5% of the farmers did not have any formal education; of these, the majority were the oldest women within the study population. Irrespective of the levels of formal education, most of the farmers were highly experienced in farming, with 66% having more than 10 years of farming experience.

Most of the Lower Gweru farmers (65.5%) were farming on very small farms ranging from 0.5ha to 2ha, while 33.5% having farms greater than 2ha. The farmers had limited

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resources, particularly livestock. Livestock is important. Cattle are very useful as sources of draft power for various field operations and also for food (milk and meat). Goats are usually used as a form of insurance for income and are quickly sold to cover short-term income shortfalls. While 95% of the farmers either have goats or cattle or both, the numbers per farmer are small. Forty-four percent (44%) had between one to five cattle, 20% owned between six and 10 cattle, 17.5% had more than 10 cattle and 18.5% did not own any cattle (Table 1). Similar ownership figures were reported for goats.

Crops grown and reasons for growing them

Lower Gweru farmers grew a variety of crops (cereals, legumes, tubers and vegetables) in their fields and gardens (Table 2). These crops were grown in all the eight Wards. The proportion of farmers growing each crop is shown in Figure 1. The most important cereal, legume and tuber, according to the SSIs, were maize, groundnuts and sweet potatoes, respectively (Figure 1). Respondents highlighted four main reasons for growing these crops (Figure 1). These were: household consumption; income generation; livestock feeds and as ingredients for brewing beer for traditional functions (particularly sorghum and rapoko). In addition to consumption and income, legumes were grown to improve soil fertility. The respondents highlighted that they usually use income generated from selling their farm produce to acquire inputs (seeds and fertilizers) for the following season as well as for non-agricultural expenses including household supplies and paying school fees for their children and grandchildren.

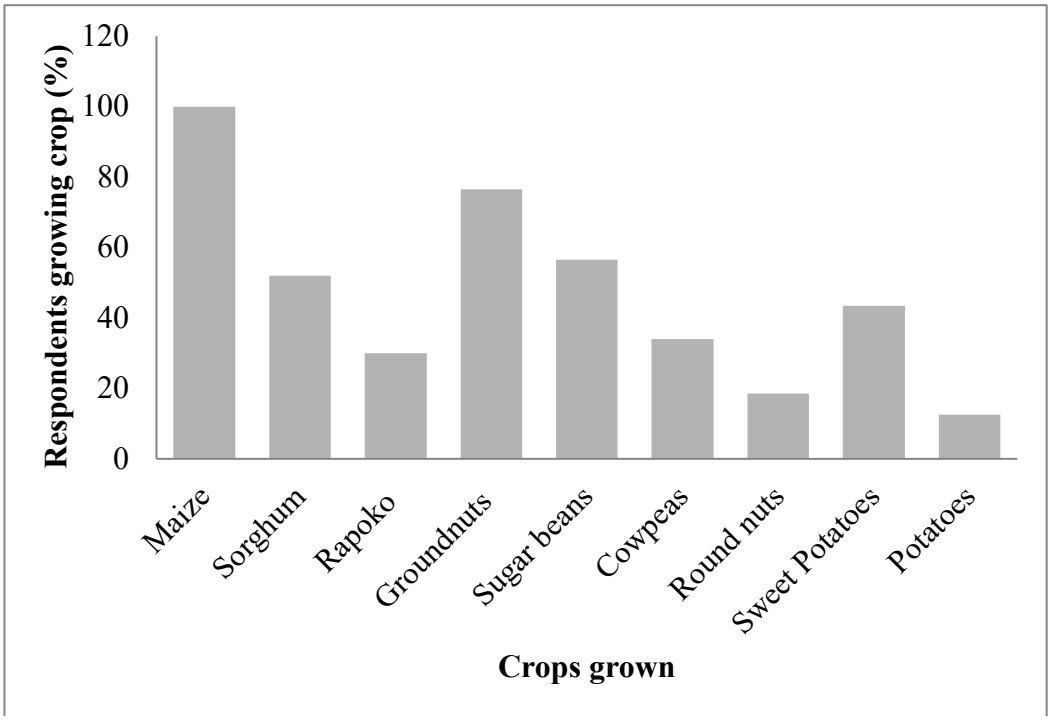

Figure 1: Proportion of respondents growing different crops in Lower Gweru Communal area

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Apart from these reasons, the respondents felt they have an obligation to contribute to the country's food security by selling some of their crop produce to the state-controlled Grain Marketing Board (GMB) despite its prices being generally lower than open market prices. In addition to selling to GMB, farmers sold their crop produce in their local communities as well as in Gweru City Centre. However, they complained that they were facing stiff competition in Gweru CBD due to increased influx of cheaper, similar products from South Africa.

Farmers' evaluation of extension services

In the FGDs held in all the Wards, farmers highlighted that extension agents visited them at least once a week during the growing season. Researchers observed that field extension agents resided in their respective Wards, thus making it possible to visit or meet farmers frequently particularly those residing closer to them. However, in the SSIs, 18.5% of the farmers indicated that agents visited them once every fortnight (Table 3). Most of these farmers reside in Nyama and Communal Ward 16. A possible reason for this could be that these two Wards are the largest in terms of land area, thus taking it longer for the extension agents to reach all the farmers.

The FGDs respondents identified several services they expected from extension agents. These included sourcing and distributing inputs, introducing and demonstrating technologies or new practices, training, and advisory services as demanded by farmers. Advisory services expected included seasonal climate forecasts information and advice on crop protection, fertilizing and selection of crops and varieties suited for biophysical conditions (soil types and prevailing weather). Farmers also expected extension agents to link them with donors and NGOs who bring technologies, inputs and when necessary, food aid.

The vast majority of the farmers interviewed (85.5%) rated extension services to be 'good' while 7.5% perceived services to be 'average' (Table 3). Reasons given for rating services as 'good' included: agents visited regularly, they responded to farmers' calls to meet, and always advised them. One respondent captured this well by declaring that extension agents "do not let us down." Only 6% rated services as poor; the reasons for that rating were that agents sometimes brought inputs and seasonal climate forecast information late into the season, and they sometimes brought expired and/ poor quality seed and they recommended outdated technologies. It was noted that AGRITEX and its extension agents were mostly recommending outdated technologies – some of which were discovered and developed two decades ago [4, 12].

Farmers perceived extension agents to play a number of roles within their farming systems including that of teacher/instructor, advisor, facilitator and partner in research (Table 3). Conversely, 85% of the farmers perceived that extension agents viewed farmers as their students who are eager to learn from them, while 82% of farmers imagined extension agents saw them as partners in research. Reasons for these assertions were based on the perception that extension agents were non-dictatorial, acknowledged farmers' indigenous knowledge and experience in their operating environment and have always engaged farmers as team members in identifying farmers' problems and sharing information. Only 12.5% of the farmers perceived that

extension agents viewed farmers as mere beneficiaries of their expertise and technologies.

In keeping with these perceptions, the most preferred and appropriate extension approaches by respondents were the learning (97%) and participatory (89%) models. While there is no single extension approach/model that is appropriate at all times [13], this study found the preference is moving away from technology transfer models. This is consistent with findings by Cloete *et al.* [14], Kulyakwave *et al.* [15] and Cook *et al.* [16] who posited that learning in small-scale farming systems should be more of interactive, experiential, field-based and participatory in nature.

In terms of the extension modes, all the SSIs respondents preferred and valued the group extension mode. The most common examples of group extension modes preferred by farmers during the FGDs were group meetings, demonstrations, field days and on-farm experiments. Reasons given for the respondents' preference for the group extension mode included: learning from other farmers' experiences, affords opportunities to brainstorm, discuss problems and possible solutions, and that it makes it easier, better and faster to share ideas and to 'spread the agricultural gospel'. These farmer interactions were noted to be beneficial for the development of farmers' decision-making, leadership and management abilities [17], as well as in bringing together farmers with common challenges which usually demand concerted action, thereby giving farmer groups a voice to demand extension services [18]. This was clearly exhibited by Madikani farmers who successfully requested for and got more information about contour ridges as a soil erosion control mechanism, despite the extension agents recommending buffer strips for their Ward.

Despite their relatively lower preference, individual farm visits and mass media modes were still important to some farmers. Individual farm visits were noted to be necessary as it complements, and affords agents a chance to follow up on, what was learnt in groups by offering assistance in implementing technologies in the farming system on a case-by-case basis. This approach is noted for fostering confidence, trust and credibility between the agent and the farmer [19]. Although the mass media mode is useful for creating awareness among many farmers within a short period of time because of its wide coverage [19], most of Lower Gweru farmers did not favor it. Their reasons for this included: lack of electricity to power radios and televisions (most of them do not have radios and televisions). Secondly, most of the farmers were advanced in age and were less literate; they learnt better by observing or doing than by reading [14, 15, 19].

It was submitted that farmers' rating of the extension agents had a lot do with the agents' personal attributes and working skills (Table 4). This was also evidenced by the fact that 86% of the farmers highlighted that the personality and conduct of the extension agent sharing new technology influences the decision to adopt or not (Table 3). Farmers highlighted that they were put off by agents with 'I know it all' attitude, who did not respect them or their knowledge. Conversely, farmers were more likely to trust agents who were humble, approachable, impartial, honest and mature, who can identify with their values (Table 4). This finding is similar to findings by Asiedu-Darko [20] and Chowdhury *et al*. [21] who referred such attributes as 'soft skills' which

transcend formal technical knowledge and skills. These skills are critical for extension agents to gain the trust and credibility of the farmers [21]. Without these soft skills, chances are high that technologies and advice shared will be dismissed [21].

Sources of technologies and farmer adoption

The major sources of technology for Lower Gweru farmers include NGOs, public extension services (AGRITEX) and research institutes. Non-governmental organizations, particularly 'Help Germany' and 'Zimbabwe Agricultural Income and Employment Development' (Zim-AIED) were responsible for most technologies disseminated in Lower Gweru (Table 5). According to the SSIs, 'Help Germany' and 'Zim-AIED' provided technologies at subsidized prices, and sometimes offered them freely at Ward level for farmers to test the efficacy of technologies in their farm conditions.

Table 5 highlights three important aspects about technology adoption. First, there were four key factors that influenced adoption: cost of the technology and the resultant impact on income, efficacy (that the technology is useful or creates efficiency), ease of use, and risk. Of these, risk appeared to be the most influential factor. For example, bee farming was understood to be inexpensive, generates income (and contributes to health), but came with a risk that outweighed the potential benefits. Similarly, cost is a key negative factor. No matter how highly regarded a technology might be, if the cost of acquisition is too high or the added value is low, then the technology will probably not be adopted [2].

Second, the SSI responses clearly indicated that farmers were rational in their decision-making. They were not convinced by the technology on its own; they consciously considered it in the light of risk (for example rainfall availability for technologies which depend on rainfall to be profitable) and cost. Third, the source of the technology did not overly influence the decision to adopt. 'Help Germany', for example, offered technology options that saw 100% adoption (value addition) and options that saw only 6% adoption (bee farming). This is despite the claims that the farmers prefer public extension agents over NGO agents. From another perspective, the data in Table 5 suggest that farmers adopted technologies which require less labour, have low initial costs of setting up, are time and energy saving, are easy to learn, and to implement, and improve yields. These findings are consistent with Rogers' diffusion of innovation theory [22].

Conservation agriculture was highly adopted (90%) mainly because farmers found it to increase crop yields, reduce soil erosion and make more efficient use of resources. More important to the Lower Gweru farmers, it does not require draught power to implement, thus it was very popular among farmers with fewer or no cattle. However, it was noted that even farmers who owned cattle also adopted it. Similarly, thermal compost was highly adopted (78%) due to its numerous advantages. It is a cheap and locally available alternative to inorganic fertilizer and cattle manure (particularly for farmers owning few or no cattle). Using compost resulted in high crop yields; similar to yields normally obtained when they applied inorganic fertilizers. Compost use also helps to reduce leaching of nutrients from the soil. Further, soil fertility is maintained

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or improved by using composts as opposed to using inorganic fertilizers, which some farmers argued that, it hardens the soil.

The high adoption rates of the conservation agriculture and thermal composts can also be attributed to the fact that they are very similar to farmers' own indigenous technologies like *gatshombo*[1] and using grass and crop residue to make compost. Respondents felt they owned these technologies although they acknowledged the technologies had been upgraded and improved by experts. Similarly, Asiedu-Darko [20] found that farmers easily adopt technologies with traits associated with their own traditional practices.

The foregoing speaks directly to the decision-making framework of small-scale farmers. These findings are consistent with the notion that small-scale farmers are essentially rational and can generally be expected to make rational decisions about their farms and other activities in which they are engaged [1, 23].

Circumstances for considering learning about and adopting new technology

Generally, the FGDs indicated that respondents (farmers) consider learning about new technology as soon as it is made available to them. Three main reasons were given for this. First, farmers consider their farming operations as a business. They will consider learning any technology disseminated to them to assess if it has potential to improve their production and profitability. Second, farmers cited the need to keep on improving and upgrading the management of their farms, including trying new technologies that come their way. In other words, they do not want to be 'left behind' or stuck with old and traditional ways of doing things when there are new or improved alternatives. This dispels the general notion that small-scale farmers are resistant to change. Third, they stated *"our livelihoods depend on farming and we believe any technology may strengthen our livelihoods and our country's economy".* This concurs with findings by Masere and Worth [1], that farmers are keen to learn new or modern technologies if they perceive their livelihoods are at stake.

Respondents reiterated the need for field-based learning in demonstrations, on-farm trials and field days where results of tested technologies or new practices are reported and farmers can ask more questions and discuss [14, 15, 24], before they can make the decision to adopt or not. In terms of learning areas preferred, Nyama Ward farmers indicated marketing, market prices and innovativeness. Chisadza, Mdubiwa, and Nkawane Ward farmers preferred to learn about processing of raw crop produce into more valuable products (value addition). Collectively, the learning requirements of the Lower Gweru farmers are similar to the learning areas encapsulated in the Extension Carousel of Learning and the Facilitated Learning Agenda framework [25]. In the Carousel the major learning areas relate to production, economic and managerial factors.

As shown in Table 6, findings from FGDs and SSIs showed that farmers assumed different technology 'adoption categories' for different technologies and also under

[1] Gatshombo is a strategy of tilling only where crops are planted

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different circumstances. Innovators in one set of circumstances will not automatically be innovators in other circumstances [22]; they might even be very conservative under different circumstances. The circumstances identified by the farmers determining when they are innovators, early adopters, late adopters and very conservative are set out in Table 6.

Challenges faced and support needed by farmers in technology adoption

Three major challenges affected adoption of technology: lack of capital to acquire technologies, lack of information and support systems to enable adoption, and a flooded market for most crops grown by farmers. The flooded market often forced farmers to sell most of their crop produce at low prices. Farmers also mentioned that they lost a lot of their surplus crop produce, especially perishables, as they neither have access to cold storage facilities nor electricity in their homes. Moreover, farmers ended up travelling about 50km to Gweru City Centre, the nearest city to sell their surplus, where they often ran into thieves and middlemen who exploited them by paying less than the optimum prices for their produce.

The semi-arid climatic conditions of Lower Gweru were also identified as a major challenge as farmers were generally reluctant to adopt technologies which required sufficient and reliable rainfall to succeed. The riskiness of technology adoption in such a low and erratic rainfall area is too great for these farmers who are generally resource-constrained.

Farmers who adopted some mechanized technologies, like the treadle pump, indicated the challenge of unavailability of spares locally. The manufacturing industry sector in the Gweru City is non-functional or non-existent, thus placing farmers at a disadvantage (additional costs) as they have to travel long distances (about 345km) to the Capital City, Harare, to purchase spares. This makes farmers wary of technologies that may require spares; the risk and the cost are too high.

To counter some of their challenges, farmers identified the kind of support they require to adopt some of the recommended technologies: (i) information support and training; (ii) access to capital (for example credit facilities); and (iii) input and output market support. Similar findings were noted by Pindiriri [2] and Kunzekweguta *et al.* [26]. Farmers felt their extension agents were generally competent enough to train them on most technologies. They can also facilitate experts and specialists to train them, if and where necessary. This leaves access to capital and markets as the main areas where farmers really need support in order to consider adopting new technologies. Consequently, farmers highlighted the need to have access to credit facilities offering loans at reasonable interest rates to enable them to acquire new technologies. Additionally, they preferred that such services be offered by the government or one of its initiatives because they believe the government should write-off their debts in the event a drought occurs. Alternatively, farmers suggested they would adopt technologies if they were offered at subsidized prices or if deferred payments could be arranged.

Farmers also proposed the setting up of value addition companies in their Wards or within Gweru, to maximize income from their crop produce through processing into

more valuable products. They argued that such products are usually easy to market and sell leading to more profits. Such products can also be stored or preserved for longer periods of time, giving them greater marketing flexibility. Other options identified by farmers included reviving local manufacturing industries to restore the manufacturing of spares, machinery and equipment.

These challenges and proposed solutions are consistent with the findings presented in Table 5. They reaffirm that cost and the fear of risk are key factors in technology adoption. Subsidized prices, credit, protection against the risk (particularly drought), and value-adding all surfaced again when discussing constraints and solutions. They also reaffirm that it is not generally the technology itself that is the problem, but a range of factors surrounding it, that most heavily influence their adoption behavior.

Farmer organization and participation in innovation and extension projects

Findings from the FGDs showed that Lower Gweru farmers are generally organized into farmer groups. These groups are formed on the basis of determination and willingness to succeed in farming. Respondent farmers found it easier to work in groups because they have good working and social relationships. This is contrary to findings by Hellin [27], who noted that farmers rarely self-organize or work collectively; but is consistent with findings by Van An [28] that farmers prefer to work in similar groups where group members have common resource constraints and interests. According to respondents, such groups can have a minimum of 10 members, usually residing in the same Ward. The groups select their leaders, usually a chairperson, deputy chairperson, secretary and treasurer. The group leaders are responsible for communicating with extension agents or demanding certain services on behalf of the group. A main activity of farmer groups is holding regular meetings to discuss and learn from one another including sharing experiences and exchanging information about innovations and technologies. Group members also help each other in field operations like weeding. They often pool their resources to buy inputs which they will later share. Other activities include social action such as caring for orphans by contributing food and cooking for them.

Farmer groups also offer an excellent platform which extension agents and others can use to introduce and disseminate new technologies to a relatively larger number of farmers at once. This was evidenced by the majority of the respondent farmers who preferred to be participants in innovation and extension projects rather than being beneficiaries of innovations developed without their input.

Farmers noted several benefits of participating in innovation or extension projects. It is good for their own development; it improves skills to generate income and leads to more informed decision-making. Sharing information and experiences improves their knowledge of managing their farm businesses. Specifically, farmers in Mdubiwa Ward highlighted that experience gained from participatory learning in innovation projects has led to improved crop yields, increased number of calves per cow and improved quality of their livestock. They further indicated that their livestock is now attracting better grades at the markets, resulting in more income. The farmers highlighted that through such participation and its resultant benefits, they were moving away from total

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dependence on donors, NGOs and Government for handouts, to greater self-sufficiency, self-reliance and improved crop and livestock management decision making.

Technologies developed by and with other farmers

Small-scale farmers have a history of developing their own small-scale technologies through their farming experiences and those of other farmers [1, 17, 29, 30]. Most of these technologies have been successful and have served and continue to serve them well [29, 30]. The main advantages of such technologies include their low-cost, ease of use and there is farmer ownership. Some of these small-scale technologies have been upgraded or improved by extension services and other modern technology developers. The farmers in this study identified the following successful technologies they have developed, or which were developed by other farmers:

- Preservation of seed for main crops like maize and cowpeas. Maize cobs of high yielding local open pollinated varieties (OPVs) are selected, stored in their grass-thatched kitchens where they are continuously treated by smoke from fire. Grains from such cobs are then used as seed in the next season. They explained that this technology is easy to operate and there are no costs involved, instead they save the cost of buying hybrids. For treating and preserving cowpeas seed from weevils, farmers use a mixture of paraffin and ash.
- Pest and disease control in field crops, for example control of maize stalk borer using sand and donkey manure.
- Livestock breeding control through castration of bulls using knives. They modified this technology by using the burdizzo and injections which make the process less painful to the animals.
- Crossbreeding of livestock.
- Rainfall forecasting through studying local indigenous indicators like fruiting of certain indigenous tree species, position of the moon, wind direction and behavior of birds.
- Preservation of harvest through burning gumtree leaves and cow dung to repel weevils inside the granaries. The burning is aimed at eliminating oxygen in the granary to ensure no weevils will survive.
- In Madikani Ward, farmers developed their own irrigation by flooding gardens. This has expanded their gardens to the point of needing to hire workers. Flooding minimizes irrigation labor requirements, and avoids destruction of the environment by doing away with holes. Farmers have also extended this technology to develop ‘showers’ for bathing.
- Live fencing for marking homestead and field boundaries and protecting crops from straying animals.
- Mixing poultry droppings with water to form what Lower Gweru farmers call ‘chicken soup’ which they use as a top dress fertilizer.

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- Crop rotation.
- Intercropping: growing cover crops and runner crops like pumpkins to control soil erosion through ensuring total ground cover.
- Digging wells
- Spot irrigation: applying water to immediate areas around a plant only as opposed to the whole garden.

CONCLUSION

Despite the generally low rates of adoption for many technologies, small-scale farmers appear ready to learn about new technologies if given a chance and the right conditions. A decision on adoption is generally based on affordability, information support, availability of markets and credit facilities offering loans with lower interest rates. Biophysical conditions, including availability of rainfall, also present major challenges to adoption as most technologies depend heavily on rainfall to succeed.

Simplicity, availability, low risk and affordability are the major attributes that attracted Lower Gweru farmers to adopt technology. Further, new technology with similar traits to the farmers' own or their counterparts' indigenous practices or technologies like conservation agriculture and thermal compost were more readily adopted. Additionally, technologies which utilize locally available resources effectively and efficiently as well as those which offer all-year-round production are more likely to be adopted.

Adoption is also influenced by how farmers have learned about the new technology. Farmers prefer to learn about new technologies in groups where they can discuss, share experiences and innovate. Related to this is the preference of farmers to actively participate in defining their agricultural problems and in developing solutions. They are more likely to adopt the resulting technologies than when they are mere recipients of technologies developed by others without their input.

Farmers perceive themselves as businessmen and women who aim to take their businesses to the next level – which is processing their raw/primary products into secondary products of more value. In keeping with their self-perception as businessmen and women, perhaps most significantly, this study has reaffirmed that small-scale farmers, despite their educational limitations, age, resource-constrained circumstances and risk profiles – are conscious and deliberate decision-makers. They are rational in their approach to adoption of technology, but are dominated by factors of cost, impact on income, and, of greatest influence, risk.

Extension agents play multiple roles in small-scale resource-constrained farming systems as demanded by circumstances. The roles include training, instructing, facilitating and brokering among different stakeholders within innovation network systems. Understanding the learning, technology adoption and decision-making framework, factors and influences among small-scale farmers – and keeping an eye on the uniqueness of each farmer – will increase the effectiveness of the extension agents

in serving the farmers. Above all, extension agents are challenged to recognize and respect the position of the farmers when considering disseminating new technologies. Wherever possible, the farmers should be engaged as active and equal partners with extension and technology developers from the problem defining stage up to the solution/technology development stage. This will facilitate stronger ties of trust, give farmers the opportunity to address the factors that inhibit adoption and provide a platform for furthering the self-reliance of the farmers.

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Table 1: Distribution of Respondents according to their demographics and circumstances

Factor	Category	Frequency	%
Gender	Male	100	50
	Female	100	50
	Total	200	100
Age	Young (≤ 35 years)	20	9.5
	Middle aged (35-50 years)	85	43.5
	Old (50 years and above)	95	47
Formal Education level	Did not attend	25	10.5
	Primary school	75	39
	Junior Certificate	30	15.5
	Ordinary level	65	33
	Advanced level	5	2
Farming experience	Up to 10 years	68	34
	10-30 years	87	43.5
	>30 years	45	22.5
Number of cattle	0	35	18.5
	1-5	90	44
	6-10	40	20
	>10	35	17.5
Goats	0	50	23.5
	1-5	85	43.5
	6-10	45	22.5
	>10	20	10.5
Farmers without cattle and goats		10	5
Farm size (Ha)	<1	30	15.5
	1-2	105	51
	2-3	45	22.5
	>3	20	11

Source: Farmers' SSIs responses

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Table 2: Crops grown by Lower Gweru small-scale farmers and reasons for growing them

Crop type	Crop grown	Reasons for growing
Cereals	Maize	Household consumption, income generation from selling surplus. Stock feeding.
	Sorghum	Household consumption and income generation from selling surplus. Beer brewing for selling and traditional ceremonies.
	Rapoko	Beer brewing for selling and traditional ceremonies.
Legumes	Groundnuts	Household consumption, income generation from selling surplus. Fixing nitrogen into the soil.
	Sugar beans	Household consumption, income generation from selling surplus. Fixing nitrogen into the soil.
	Cowpeas	Household consumption, income generation from selling surplus. Fixing nitrogen into the soil.
	Round nuts	Household consumption, income generation from selling surplus. Fixing nitrogen into the soil.
Tubers	Sweet potatoes	Household consumption and income generation from selling surplus.
	Potatoes	Household consumption.
Vegetables	Including butternuts, onions, tomatoes, cabbage, spinach, chomolia, tsunga, pumpkins, carrots, tomatoes.	Income generation and household consumption.

Source: Farmer FGDs and SSIs responses

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Table 3: Farmer perceptions of extension agents and their preferred extension approaches

Factor	Category	Frequency	%
Frequency of visit	Weekly	163	81.5
	Fortnightly	37	18.5
Extension rating	Poor	12	6
	Average	17	8.5
	Good	171	85.5
Farmer perception of extension agents	Teachers/Trainers	133	66.5
	Advisors	200	100
	Facilitators	74	37
	Partners in research	112	56
How extension agents perceive you	Students	170	85
	Beneficiary of their knowledge and advice only	23	12.5
	Partners in research	164	82
Does an agent's personality and conduct influence your technology adoption decision	Yes	172	86
	No	9	4.5
	Indifferent	19	9.5
Preferred extension approach	Advisory	109	54.5
	Participatory	178	89
	Facilitation	49	24.5
	Learning	194	97
Preferred extension modes	Group	200	100
	Individual	96	48
	Mass media	23	11.5

Source: Farmers' SSIs responses

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Table 4: Personal attributes and working skills desired by respondent farmers in extension agents

Personal attributes	Work conduct/skills
Humble – should not have an "I know it all" attitude	Ability to communicate effectively including in vernacular/mother language of farmers.
Mature	Respectful and values farmers' skills, experiences and decisions– and treat us as elders not children.
Technically competent – they should be more advanced than us (farmers)	Committed to farmers and extension work – being time conscious with regards to start of season and all agronomic processes including sourcing inputs, SCF, keeping schedules and
Approachable	Impartiality to all farmers.
Patient and good listener	Sympathize with farmers in social problems like funerals (should be part of us and our community).
Honest and God fearing (Christian)	Should be an encourager and motivator.
Decent and well behaved (not promiscuous)	Ability to work with our traditional leadership.
	Ability to teach us and also to learn from us.

Source: Farmers' response from FGDs and SSIs

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Table 5: Technology adoption by small-scale farmers of Lower Gweru

Source of Technology	Technology	Adoption rate (%)	Reasons for adoption rate
Help Germany	Value addition	100	No costs involved, many products from sweet potatoes.
Network providers	Cell phone	93	Useful in conveying messages on time. No information distortions as farmers get message from agents directly.
Help Germany	Conservation agriculture	90	No costs involved. Helpful especially to farmers without draft power as there is no need for ploughing.
Met Services /Extension agents	Seasonal climate forecast	84	Farming decisions are influenced by seasonal forecast information.
Zim-AIED	Thermal compost	78	Cheap source of fertilizer and highly favored by farmers without cattle.
AGRITEX Extension agents	Castration of bulls	73	Less painful to cattle, easy to use.
Zim-AIED	Livestock feeds (stover rakes	67	Easy to make, reduce wastages.
Extension agents	Livestock dehorning	56	Improved health of cattle and reduced injuries due to less fights.
Zim-AIED	Seedbed management	54	High quality seeds and it is easy and cheap.
Extension agents	Fertility management (application at planting station)	47	It makes efficiently use of resources, improved yields.
Extension agents	Raised beds (on wetlands)	43	It has ensured all year production in areas where it was previously not possible.
Help Germany	Poultry Layer production	37.5	Relatively high costs of setting up and prices of feeds.
Help Germany	Groundnuts roasters	24.5	Highly regarded because it is easier, smarter, faster and less risk of getting burnt; saves fuel as large quantities are processed at once. The cost of technology is high.

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Research Institutes	Crop simulation models/outputs	17	Introduced to fewer farmers. Not easy to use outputs without experts
ICRISAT	Moisture conservation	15	Not clearly understood by older farmers and its costly.
Zim-AIED	Crop protection/herbicides	15	They are effective and reduce labor for weeding but costs are a major challenge.
Zim-AIED	Treadle pump	12	Costly although it eases labor requirements of fetching from long distances. Most farmers cannot afford it.
Help Germany	Metal Silos	11	Highly regarded but costly.
Zim-AIED	Solar driers	9	Highly regarded but costly.
Help Germany	Bee farming	6	Although it is cheap, there is a high risk of getting bitten. Honey is also medicinal and a source of income.

Source: Adoption rates were generated from the 200 SSIs responses and verified by researcher where feasible

Table 6: Circumstances when respondents are innovators, early adopters, late adopters, very conservative

Adoption category	Circumstances
Innovator	When a farmer has knowledge, is confident about a technology and its potential for increasing production, resources are not limiting or when they are easily available.
Early adopter	When a farmer fully understands the benefits of a technology through demonstration and when the costs involved are minimum.
Late adopter	When a farmer is not sure of a technology, when he/she need to see the actual benefits from trials, when the costs are relatively higher and there is a greater risk in adopting the technology.
Very conservative	When a farmer can neither afford the technology nor understand it. Also where there is no other information support or they doubt the competence of the extension agents recommending the technology.

Source: Farmers' responses from FGDs and SSIs

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