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# Adoption of ICT-Based Information Sources and Market Participation among Smallholder Livestock Farmers in South Africa

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**Abstract:** The study explored the contribution of information and communication technology (ICT)-based information sources to market participation among smallholder livestock farmers. Use of ICTs is considered paramount for providing smallholder farmers with required market information, and also to reduce market asymmetries. A double hurdle regression was utilized to analyze data collected from 150 smallholder livestock farmers in the study area. The results show that while use of ICT-based market information sources significantly influenced market participation, the effect of using ICT-based information sources on the intensity of market participation was not significant. Other variables shown to influence both market participation and the intensity of market participation were age, additional income and membership of farmer cooperatives. This suggests the need to consider other associated factors in the application and design of interventions that utilize ICT-based information sources to achieve market engagement among smallholders.

**Keywords:** double hurdle; ICTs; information source; market participation; probit; regression; smallholder; livestock farmer

## 1. Introduction

It has been widely reported that information and communication technologies (ICTs) assist in disseminating information to farmers. This indicates that smallholder farmer's need for relevant and timely market information can be met using ICT-based information sources [1,2]. This has resulted in the development of platforms that use ICTs for disseminating market information to farmers in many African countries. These aim to address the perceived lack of market information, especially among rural smallholder farmers. ICT-based information sources available to smallholder farmers in South Africa include radio, television, mobile-phones, and computers with internet. Proponents of ICT-enabled market information sources envisage ubiquitous information systems that are capable of widespread distribution of market information and result in increased accessibility and the participation of smallholder farmers in markets. This begets the question of whether using ICTs for market information search contributes to increased participation in markets among smallholder farmers. While there are arguments related to the availability, accessibility, costs and benefits from using relevant ICTs, the requirement of smallholder farmers for relevant information is undisputed. While ICTs may not be considered as a solution to all the market challenges of smallholder farmers, they can make a meaningful contribution, especially for information-impacting decisions. The use of ICT-enabled market information sources is associated with increased market transparency through the provision of current market information, while simultaneously improving incomes and leading to other welfare outcomes. However, the currently available studies have mostly examined how ICTs contribute to

improving farmers' access to market information [3,4], their adoption of production technologies [5,6] or the associated livelihoods effects of its use [7]. Although some studies have explored the link between market information and commercialization, such as [8], the effect of adopting ICT-based information sources on market participation among smallholder livestock farmers in South Africa remains a grey area.

Access to market information is considered a key institutional factor that affects the participation of smallholders in markets. The information enables producers to make economic decisions regarding market interactions, either to purchase or sell, and hence enhances their comparative advantages. Farmers therefore require accurate and timely market information to improve their knowledge of the market, as this knowledge provides a fairer spread of the anticipated receipts accruable from a better organized market price formation for all market actors.

In the literature regarding transaction costs, commentators have observed that better market information reduces transaction costs, and also stimulates market participation among smallholder farmers [9–11]. A common opinion suggests that a lack of market information hinders participation in the market among smallholder farmers by increasing their search, screening and bargaining costs. Other costs associated with transactions include the cost of monitoring and ensuring adherence to the terms of agreements, and the costs of adapting to changes in the market environment. These costs are especially significant for smallholder farmers, and occur irrespective of whether a sale or purchase is finalized.

The transaction cost concept has been utilized to explain many economic phenomena, and is regarded as central in highlighting and mitigating market failures in agriculture. Transaction costs encompass various definitions and meanings, including the cost of searching for information, the cost of using the price mechanism, and the cost of exchange, among others. It is a catch-all phrase that is applied to explain the variety of costs involved in the transfer of ownership, the running of an economic system [12], or it can be considered as a direct cost incurred when engaging in any market transaction. Due to the effect of transaction costs on smallholder farmers, market advocates have called for interventions that reduce these costs [13]. These interventions include the provision of adequate market information, which encourages increased farmer participation in markets.

Affirming the importance of market information for smallholder farmers, Janowski et al. [14] submitted that the provision of basic market information increases agricultural market efficiency, and also contributes significantly to market participation. Conversely, poor access to market information increases both personal disadvantages and inimical choices, and is a discouraging factor in market participation among this group of farmers [15,16].

Lack of market information is considered a big challenge in the livestock sector, especially among rural smallholder farmers in South Africa, as it has been noted [17] to be positively and significantly related to their probability of selling livestock. This results to their continued exclusion from formal markets due to low off-take rates, and increases dependence on informal marketing channels where they receive low prices. Hence, the increased use of ICTs has potential for fostering improved business opportunities or market activities [18].

According to Okello et al. [19], the cost of obtaining relevant information affects the decision to enter markets and exacerbates existing disparities. Furthermore, the information source also contributes to the decision-making on market participation. Informal information sources such as relatives, friends and fellow farmers are also a major information source among farmers, and are considered effective in the provision of relevant information that contributes to their market participation. Although the availability of information generally affects market participation, Martey [8] posits that the directional effect of the market information variable differs with the type of information source. This study therefore explored the link between utilization of ICT-based information sources and participation in markets. Few studies have focused on how the use of ICT-based market information sources influence the market participation of smallholder livestock farmers, as most have reported mainly on crop farmers [20–22]. Also, many of the available studies that have focused on the factors influencing market participation among farmers have not emphasized the contribution of market information sources in determining participation [23–25]. Hence, Souter [26] articulated the importance of information

sources while outlining the different values that farmers ascribe to various communication methods and channels. Therefore, the main purpose of this study was to investigate whether using ICT-based information sources contributed to market participation and the intensity of participation among targeted smallholder livestock farmers.

## 2. Materials and Methods

### *2.1. Analytical Framework*

This study adopted the double hurdle model as its main analytical framework. This decision was influenced by studies on factors influencing market participation that consider it a two-stage decision process. These studies utilize variants of two main approaches including a selectivity model introduced by Heckman [27], and the hurdle model pioneered by Cragg [28]. The literature provides analytical methods for determining cause-effect relationships, with the most common being the two-step selectivity models for discrete and continuous decisions reported in [29]. The two-stage econometric method outlined in [30] is based on the ordered probit and tobit models, and current methods for analyzing the effect of identified variables on market participation were incorporated using the truncated, binary and multinomial regression models [30–33].

### *2.2. Specification of Model*

We followed the assumptions in the double hurdle model, where market participation is generally analyzed using a two-step approach. The farmer first needs to decide whether to, or not to participate in the market before deciding on continued participation. Therefore, market participation is commonly assumed to involve two independent problems, the initial problem is a personal decision made by the farmer whether to participate or not (considered as the first hurdle), and the second problem is the obvious intensity of participation, measured by the quantity sold in or purchased from the market (seen as the second hurdle).

The double hurdle model is a form of parametric generalization of the p-tobit model, in which market participation and the intensity of participation are determined by separate stochastic processes. First, a probit model of market participation (MKTPAT) for the selection equation is obtained using a function of the explanatory variables, which also determines market participation intensity using one or more exclusion variables. A truncated least squares regression equation of the MKTPAT intensity, which closely resembles the tobit model is employed in a second step. An inverse mills ratio (IMR) predicted from the probit regression is then included as a regressor to account for the selectivity bias.

The regression equation thus defines the latent variable $MKTPAT_i^*$:

$$MKTPAT_i^* = Z_i\beta + e_i \quad e_i \approx N(0,1) \quad \text{(First hurdle)} \tag{1}$$

$$MKTPAT_i = 1 \text{ if } MKTPAT_i^* > 0, \text{ and } MKTPAT_i = 0 \text{ if } MKTPAT_i^* \leq 0$$

where $MKTPAT_i$ is a categorical variable that takes the value of 1 if a smallholder livestock farmer participates in the market, and 0 if otherwise.

According to [34], a probit model of $MKTPAT_i$ which follows random utility is expressed as:

$$\Pr(MKTPAT_i = 1 \big| Z_{i,}\alpha) = \Phi(h(Z_{i,}\alpha)) + e_i \tag{2}$$

where $MKTPAT_i$ equals 1 for households that participate and 0 otherwise. $Z_i$ represents the vector of ICT-based information sources; $\alpha$, is the vector of parameters to be estimated; $\Phi$ is a standard normal cumulative distribution function; and *ei* is a random error term hypothesized to be distributed normally with unit variance $\sigma^2$ and zero mean.

In the second step (hurdle), the generated sample selection term IMR from the probit model (first hurdle), which accounts for potential selectivity bias is then utilized as an exogenous variable in the truncated model regarding *MKTPAT* intensity, as described by [35].

The second stage (*MKTPAT* intensity) equation is expressed as:

$$E(Q_i/MKTPAT = 1) = f(Z_i, \beta) + \omega\lambda \text{ (second hurdle)} \quad (3)$$

where $Q$ is the quantity sold in the market and is the observed response on intensity; $E$ is the expectation operator; $E$ is a vector of the ICT-based information source; β is a vector of parameters to be estimated; λ is the IMR, which accounts for sample selection bias in the probit model; and $\omega$ is the associated parameter to be estimated.

The IMR can hence be calculated as:

$$\lambda = \frac{\varphi(h(Z_i, \beta))}{\Phi(Z_i, \beta)} \quad (4)$$

where $\varphi(.)$ is the normal distribution and Φ is the cumulative density function. Therefore, $Q$ can be expressed as follows:

$$Q_i^* = \beta' Z_i + \omega\lambda_i + \mu_i, \mu_i \approx N\left(0, l^2\right) \quad (5)$$

where $\mu_i$ is a random error term with zero mean and variance $l^2$; and $Q_i^*$ is the observed response on quantity sold $(MKTPAT = 1)$, in which case $Q = Q_i^*$. The truncated estimation of Equation (2) with the inclusion of λ, gives consistent estimates and accounts for selectivity bias [36]. A primary limitation of the double hurdle method is the decomposition of the effects of the first hurdle onto the second hurdle [37], which occurs in the process of interpreting the results. Therefore, to mitigate this problem, the maximum likelihood function is usually incorporated alongside the partial effects and standard error term as shown in [38].

### *2.3. Description of Variables*

The independent variables and their hypothesized relationship with the dependent variable (market participation) including the expected sign are described in Table 1.

**Table 1.** Variables in the model and their hypothesized relationship.

| Variable | Type | Measure | Relationship with Dependent Variable | Expected Sign |
|---|---|---|---|---|
| Gender | Dummy | 0 = female<br>1 = male | Males more likely to participate in markets | Positive (+) |
| Age | Continuous | Years | Older farmers likely to be market inclined and experienced | Positive (+) |
| Level of education | Continuous | Number of years in school | Increases the ability to seek out markets and partake | Positive (+) |
| Marital status | Dummy | 0 = single<br>1 = Other | Maybe positive or negative | +/− |
| Herd size | Continuous | Number of animals | Indication of wealth status, more likely to sell or purchase | Positive (+) |
| Household size | Continuous | Number of persons | Maybe positive or negative | +/− |
| Membership of farmer coop | Dummy | 0 = no<br>1 = yes | Members have access to information and maybe more inclined to market | Positive (+) |
| Other income source | Dummy | 0 = no<br>1 = yes | Additional income may result to more market interaction | Positive (+) |
| Use of ICT-based sources | Dummy | 0 = no<br>1 = yes | Adequate market information results in more market interaction. | Positive (+) |

Source: [39]

### 2.4. Study Area

The Eastern Cape Province, as shown in Figure 1, is located in the south-eastern part of South Africa, and is the second largest province by surface area in the country. It covers approximately 170,000 square kilometers, which comprise about fourteen percent (14%) of the total land mass in South Africa [40].

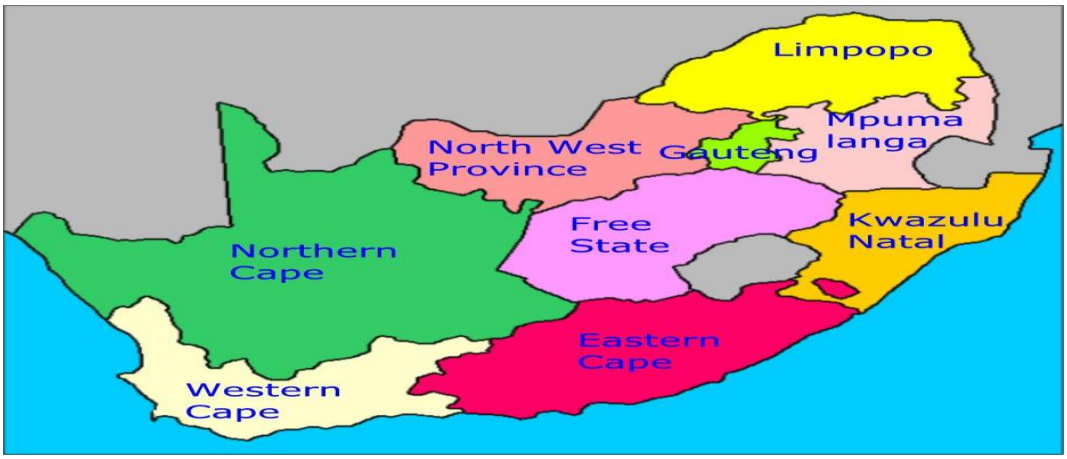


**Figure 1.** Map of South Africa showing the various provinces. Source: [41].

### 2.5. Data Types, Sources and Ethics

Following an extensive review of the literature on market participation, the use of ICTs among farmers and related topics, a draft questionnaire was developed. This schedule was pre-tested and amended as necessary before field data collection. The questionnaire was utilized to capture primary data from smallholder livestock farmer-respondents. The data collected comprised the socio-economic characteristics of the respondents, use of identified ICT sources, livestock numbers owned, market information channels utilized and engagement with markets. A total of 150 livestock farmers were selected and interviewed for the study. The interviewed farmers were informed of the academic purpose of the data collection, and their consent was requested using a signed agreement form before the interview.

### 2.6. Sampling, Sample Size and Analysis

The Eastern Cape Province was purposively selected due to its leading status as the province with the largest number of livestock in South Africa. From the province, Alfred Nzo District was identified for convenience non-random sampling. A multi-stage procedure was utilized in identifying samples from the study population and the collection of data. In the first stage, three local municipalities in the Alfred Nzo District were purposively selected based on the availability of information from the Department of Agriculture and their proximity. In the second stage, one Ward from each local municipality shown in Table 2 was randomly selected from a list of Wards available from the local municipal offices. In the third stage, 150 livestock farmers were selected after determining the required sample size, as outlined in [42]. An adequate number of respondents is critical for any research, as a small number of respondents produce insufficient information for inference making while too many respondents can lead to findings of insignificant value while also wasting resources [43]. The total number of respondents for this study was hence calibrated to meet the confidence and precision levels required [44].

**Table 2.** Number of farmers sampled from each local municipality.

| Municipality | Listed Livestock Farmers | No of Farmer Respondents | % of Total Farmers Surveyed |
|---|---|---|---|
| Umzimvubu | 380 | 37 | 25 |
| Ntabankulu | 470 | 47 | 31 |
| Mbizana | 650 | 65 | 44 |
| Total | 1500 | 150 | 100 |

Source: [39].

Utilizing a snowball selection approach, 150 smallholder livestock farmers were identified and interviewed using a structured pre-tested questionnaire that was administered by trained field personnel.

## 3. Results and Discussion

### *3.1. Demographic Characteristics of Respondents*

The personal characteristics of the survey respondents are presented in Table 3, which shows that male respondents constituted 64% of the total number, while 36% of the respondents were female. Respondents aged less than thirty-six years made up only 7% of respondents; those between thirty-six and fifty-five years represent 33% of respondents, while respondents fifty-six years and older comprise 50% of the study population.

**Table 3.** Demographic characteristics of survey respondents.

| | Category | Total ($n$ = 129) | Percentage (%) |
|---|---|---|---|
| Gender | Female | 47 | 36 |
| | Male | 82 | 64 |
| Age | <36 years | 9 | 7 |
| | 36–55 years | 43 | 33 |
| | 56+ years | 77 | 60 |
| Marital status | Single | 35 | 27 |
| | Married | 59 | 46 |
| | Other | 35 | 27 |
| Education | None | 22 | 17 |
| | Primary | 47 | 36 |
| | High School | 25 | 20 |
| | Post High | 35 | 27 |
| Coop member | No | 112 | 87 |
| | Yes | 17 | 13 |
| Herd size | 50 or less | 43 | 33 |
| | 51–100 | 46 | 36 |
| | More than 100 | 40 | 31 |

Source: [39]

The data suggest that persons aged fifty-six and older constitute the majority of smallholder livestock farmers in the study area. This finding is in agreement with that reported in [45], and is generally reflective of the age of the majority of smallholder farmers in rural areas of South Africa.

Among the survey respondents, 27% were single, 46% were married, and 27% were either widowed or divorced. The number of persons in the respondent's household was also analyzed. This showed that 29% of the respondents had between two and four persons in the household. The majority of survey respondents, about 53%, had between five and seven persons in the household, while 18% of respondents had between eight and ten persons in the household. Large household sizes are common in rural areas, especially in the Eastern Cape Province, as extended families live within the same compound.

Education levels varied among the respondents, with 17% having no formal education, 36% attended schooling for six years or less, while 20% attended schooling for a period of between 6 and 12 years. Respondents who had more than 12 years of formal schooling comprised 27% of the study population. The data shows that among 53% of the survey respondents, approximately 36% only had a primary education, with 17% of these respondents having no formal education. Most of the respondents, approximately 87%, did not belong to any farmer cooperative, and only 13% were members of a farmer cooperative.

The herd sizes among respondents varied widely and the data was compressed as a result to narrow the range with a mean value of 83 animals. Herd size was determined by the total number of livestock owned by the respondent, and the analysis show that 33% of respondents had less than 50 animals in total, 36% of respondents owned between 51–100 animals, while 31% of respondents had more than 100 animals in their herd. Livestock ownership within the study area is considered as a status symbol, with many households keeping different types of livestock.

### 3.2. *Effect of Identified Variables on Market Participation*

The probit model result for market participation (MRKPAT) was used together with the truncated model estimates for the double hurdle regression. As shown in Table 4, the significant variables are age, additional or off-farm income, membership of a farmer's cooperative and the use of ICT-based source.

**Table 4.** Effect of variables including ICT-based information source on market participation.

| Market Participation | Coef. | Std. Err. | *p*-Value | Dy/Dx | Std. Err. | *p*-Value |
|---|---|---|---|---|---|---|
| Age | −0.072 | 0.033 | 0.027 ** | −0.008 | 0.003 | 0.014 ** |
| Gender | 2.141 | 1.253 | 0.412 | −0.337 | 0.120 | 0.335 |
| Marital status | 0.824 | 0.684 | 0.228 | 0.088 | 0.071 | 0.212 |
| Household size | 0.702 | 0.462 | 0.128 | 0.075 | 0.047 | 0.110 |
| Education | −0.305 | 0.558 | 0.585 | −0.033 | 0.059 | 0.582 |
| Off-farm income | 2.556 | 1.270 | 0.044 * | 0.274 | 0.128 | 0.033 ** |
| Membership in Coop | 2.741 | 0.972 | 0.005 *** | 0.294 | 0.084 | 0.000 *** |
| ICT-based source | 3.844 | 0.825 | 0.000 *** | 0.413 | 0.052 | 0.000 *** |
| Log of Herd size | 3.327 | 1.452 | 0.326 | 0.357 | 0.143 | 0.612 |
| Constant | −8.048 | 4.292 | 0.061 * | | | |
| Prob > $Chi^2$ | | | 0.000 *** | | | |
| LR Chi2 (9) | 104.99 | | | | | |

***, ** & * represent level of significance at 1%, 5% & 10%, respectively. Source: [39].

The farmer's age was found to be significant, but negatively correlated to market participation. This finding is supported by other studies such as [46,47], where significant negative relationships between age and market participation were reported, and contrasts with the view [48] that age is an enabler of market participation. These authors allude to risk aversion and conservative attitudes among older farmers versus the market-enthusiasm exhibited by younger farmers to elucidate the negative correlation between age and market participation among some farmers.

In this study, additional or off-farm income is significant and positively correlated to market participation. Although Barrett [49] also emphasized the usefulness of an additional income source in overcoming market entry costs, a number of studies [50–52] have reported a significant but negative effect of additional income on the farmer's market participation. However, this study corroborates the findings in [53], suggesting that an additional income from off-farm activity positively influenced market participation, as well as the findings of Lubungu et al. [54] who inferred that investing additional off-farm income stimulated farm productivity, which translates into increased market participation.

The coefficient of membership of farmer's cooperative had a positive and statistically significant impact on livestock market participation. Cooperatives have been found [55] to provide farmers with requisite platforms for exchanging information, and to serve as a link to buyers at a lower cost. These leads to improvements in their collective bargaining power and production capabilities [56,57], while invariably lowering the transaction costs due to market participation. A similar finding of the positive influence exerted by membership of farmer's cooperative or association has also been reported in [58,59].

ICT-sources are considered indispensable for providing information related to livestock marketing and market prices. The coefficient of access among livestock farmers to ICT-based information sources had a positive and statistically significant impact on market participation. Although there is agreement regarding the importance of ICTs for market information, some studies such as [60] have reported insufficient evidence to indicate the influence of an ICT market information source on farmer's market participation decisions. Nonetheless, other findings have shown the benefits of using ICTs, and how they constitute a viable approach for linking smallholders to markets [61–63]. The finding of a significant positive influence of ICTs on market participation among farmers corroborates other studies that have reported its additional welfare benefits [64], effects on marketing decisions [65], and a significant positive coefficient on the quantity produced and price received [66].

The results from the truncated regression of market participation is reported in Table 5, and the coefficient of the inverse Mills ratio (IMR) was not found to be statistically significant in this model, implying that any bias due to self-selection could be discounted. The variables influencing intensity of market participation among the smallholder livestock farmers are highlighted.

**Table 5.** Truncated model estimates: Intensity of market participation.

| Log of Quantity Sold | Coefficient | Std. Err. | *p*-Value |
|---|---|---|---|
| Gender | −0.457 | 0.217 | 0.035 ** |
| Age | 0.013 | 0.010 | 0.004 *** |
| Marital status | −0.624 | 0.232 | 0.007 *** |
| Household size | −0.660 | 0.170 | 0.277 |
| Education | 1.006 | 0.226 | 0.165 |
| Off-farm income | 0.679 | 0.195 | 0.000 *** |
| Membership in Coop | 0.038 | 0.240 | 0.013 *** |
| ICT-based source | −0.184 | 0.311 | 0.553 |
| Log of Herd size | −0.167 | 0.133 | 0.208 |
| IMR | 0.615 | 0.523 | 0.239 |
| Constant | 7.945 | 0.876 | 0.000 *** |
| Sigma | 0.720 | 0.051 | 0.000 *** |
| Wald $Chi^2$ (10) | 102.78 | | |
| Prob > $Chi^2$ | | | 0.000 *** |

*** & ** represent level of significance at 1% and 5%, respectively. Source: [39].

The variables driving the intensity of market participation were gender, age, cooperative membership, marital status and off-farm income. Respondents' education, use of ICT-based sources, household size and the herd size were not found to be significant in the intensity of market participation (a proxy for the amount received from sale). The independent variables found to

be significant affected the direction of the dependent variable, and the result confirms the effect of a combination of variables in producing outcomes. As reported in [20], the interaction of variables such as gender, membership of cooperatives and use of ICT-sources led to positive commercialization outcomes. This position is also supported by other studies, for example [8], where the explanatory variables jointly influenced the extent of market commercialization. Other relevant studies where combinations of variables were identified as influencing market participation decisions, either positively or negatively, among surveyed smallholder farmers include [23,35] and also [67].

While the use of ICT-based market information sources was not found to be significant in the intensity of market participation, the combination of gender, age, marital status, off-farm income and membership of a cooperative led to more significant market participation outcomes among smallholder livestock farmers in the study area. This finding corroborates the findings of many other studies (for example, [68,69]) that infer that different sets of factors significantly influence market participation and the intensity of participation decisions among farmers. This shows that decisions about market participation and intensity of participation are affected by different factors at various points in the farmer's decision-making process.

## 4. Conclusions

In this study, the key characteristics of smallholder livestock farmers that were found to be significantly associated with their market participation include age, an additional income, membership of a cooperative, as well as the use of ICT-based sources, as determined by results from the first hurdle. However, as shown in the results from the second hurdle, among those participating in markets, membership of a cooperative, having an additional income, marital status, gender and age were found to be significant in driving the intensity of market participation. Use of an ICT-based source, as an independent variable, was not found to be significant in the intensity of market participation. This finding is supported by similar studies, which have reported that market participation and the extent of market participation decisions among farmers were determined by different factors. This confirms that various variables are at play during different stages of the farmer's decision-making process. It is worth noting that independent variables such as age, additional income and cooperative membership were found to be significant in both the participation of farmers in markets as well as the intensity of market participation, in this study.

The results of this study highlight pertinent issues that are relevant to improving market participation among smallholder livestock farmers. Age, additional income source, and membership of a cooperative all have important implications for interventions aiming to progress smallholder livestock farmers on the commercialization pathway.

The findings of the study are important for planning information-dissemination services using ICT-based sources to smallholder livestock farmers, especially within the study area. As shown from the results, market interventions should consider the target group of farmers based on factors such as their age, membership of cooperatives and the possibility of earning an additional income. We recommend the roll out of livestock intervention programs targeting young smallholder farmers, which among others, provides improved breeds of stock and access to relevant input and infrastructure for marketing as younger farmers have been shown to be enthusiastic and more willing to engage with markets than older farmers. Furthermore, it is recommended that membership of cooperatives should be encouraged, as the study results show that cooperative membership was significant for participation in markets. Additionally, it is recommended that planned interventions could support income-generation activities among the targeted farmers, such as eco-farm-tourism projects and grass-fed produce certification for niche markets. Smallholder livestock farmers have shown the aptitude to use ICTs for sourcing market information; it would therefore be practical to provide information related to livestock health and management practices using this ICT media, which also reduces the need for physical visits from livestock extension agents in the area.

The study and its findings have relevant implications for policy and practice, specifically in interventions designed to promote market information usage, support uptake of relevant technologies, and even in the dissemination of extension services among smallholder livestock farmers. While this study used cross-sectional data, it is suggested that for future research, panel data or time series data be used to provide a more in-depth analysis of the variables and how use of ICT-sources affects market participation and intensity of market participation decisions among this group of smallholder livestock farmers.

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