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Awareness and Willingness to Adopt Livestock Tracking Devices to Mitigate Stock Theft Among Eastern Cape Communal Farmers

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ABSTRACT

Stock theft has become increasingly versatile, disrupting rural economies and livelihoods, and jeopardising food security. Animal tracking devices, such as GPS collars, have been suggested as one of the technologies that could help minimise crime by enabling owners to keep track of their animal's live location. Therefore, the objective of this study was to assess the awareness and willingness of communal livestock farmers to adopt livestock tracking devices for that purpose. A further objective was to determine the factors influencing the adoption of livestock tracking devices. Results from the data collected from 137 farmers in two villages show that 28% of farmers were aware of this technology and 42% were willing to purchase it, highlighting its affordable cost of R2500. The results underscore the poor quality of extension services, whose primary role is the dissemination of technology. Results from two logit and tobit models, which were used to determine the probability and extent of willingness to purchase, suggest that several factors, including household size, herd size, keeping sheep, and unfenced rangelands, play significant roles in influencing the farmers' decisions whether to purchase the animal tracking technology or not.

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These findings underscore the need for enhanced extension services and targeted awareness campaigns to promote the adoption of tracking technologies and reduce stock theft.

Keywords: Animal Rustling, Communal Farmers, Digital Technologies, South Africa.

1. INTRODUCTION

Keeping livestock represents a major contributor to the livelihood of most smallholder farm households in most rural areas of South Africa. According to the latest (2021) General Household Survey, 26% of households in South Africa keep livestock. Livestock rearing also constitutes an additional food source (Stats SA, 2021) for several farming households. Shackleton and Ntshudu (2023) established that, in the Eastern Cape, smallholder farmers keep mostly cattle, goats, and sheep for various purposes. Cattle and goats are primarily kept for cultural purposes, such as participating in ritual ceremonies, while sheep are kept for a specific financial practice akin to saving. This latter has been described as a strategic decision since wool in the province is a thriving and lucrative farming enterprise. It is estimated that in 2018, a communal farmer received an average monthly income of R15,000 from wool (Beinart, 2024).

However, this source of livelihood in the province and many parts of South Africa is undermined by stock theft. Stock theft appears to be perpetrated by a syndicate of organised crime, which has been persistent and growing over the years. Data from the South African Police Service (SAPS) reports more than 6000 stock theft cases in the 2022/23 season in the Eastern Cape alone (Clack, 2023). Furthermore, in 2011, stock theft was designated a priority crime in the National Rural Safety Strategy (SAPS, 2023).

Several suggestions have been made to mitigate stock theft in the country. These include branding, tattooing, and the frequent counting of animals, as well as the use of GPS animal tracking devices (Doorewaard, 2020; Lombard *et al.*, 2017). Although the latter (GPS collars) has been recommended, very few studies have explored this possibility, especially in smallholder farming. The few existing studies include Zantsi and Kunjana (2021), who have considered the possibility of adopting and using GPS animal tracking devices in smallholder farming systems. Having conducted a comprehensive literature review and analysed data on stock theft, they concluded that the adoption of GPS animal tracking devices depends on four key factors; firstly, awareness about the devices and knowledge of how they work; secondly, the severity of stock theft for a farmer; thirdly, the extent to which livestock contributes to the livelihood of the farmer; lastly, the farmer's income level, access to mobile phones, and his/ her risk behaviour.

However, Zantsi and Nkunjana's (2021) study lacked primary data from smallholders to ascertain if smallholder farmers would be willing to adopt this technology. Hence, in the absence of primary related data, the aforementioned study was speculative and general in its approach to determining the factors that could influence the adoption of livestock tracking devices. Therefore, this study aims to determine whether smallholder livestock farmers are willing to adopt this technology and to identify factors that could increase the likelihood of adoption. This study utilises primary data from 200 communal livestock owners in two villages, one in Alice and the other in Lusikisiki, both located in the Eastern Cape province, where most stock theft hotspot areas are found.

The rest of the paper unfolds as follows: Section 2 reviews relevant literature on the prevalence of stock theft and the extent of livestock tracking devices and smallholder technology adoption. Section 3 presents the data collection and analysis methods, followed by the study's results. Section 4 presents the conclusions drawn from the research results.

2. LITERATURE REVIEW

2.1. Prevalence and Seriousness of Stock Theft

According to the Stock Theft Act 57 of 1959 (now the Judicial Matters Amendment Act 55 of 2002), livestock is defined as 'any horse, mule, ass, bull, cow, ox, heifer, calf, sheep, goat, pig, poultry, domesticated ostrich, domesticated game or the carcase or portion of the carcase of any such stock'. Furthermore, the Act itself refers to stock theft 'as any person who is found in possession of livestock or produce to which there is reasonable suspicion that it has been stolen and is unable to give a satisfactory account of such possession. Importantly, the Act also refers to any person who enters any enclosed land (i.e., fence or any kraal, shed, stable or other walled place) with the intent to steal as guilty of an offence.

Stock theft is a serious crime that affects both smallholder and commercial farmers in South Africa. The Victim of Rural Crime report shows that 0,77% of all households in South Africa incur losses due to livestock during the 2017/18 financial year (StatsSA, 2018). The report further reveals that sheep were the most commonly stolen livestock type, with 270,000 from about 19% households, followed by goats. The number of goats stolen during the year was estimated at just over 170,000 from 30,6% of households. While 177,000 head of cattle were stolen from 23.8% of the households that suffered losses due to livestock theft (Lombard, 2020).

Anthrobus (2002) estimated that the loss due to stock theft in the Eastern Cape amounted to R600 million per year, which was approximately 20% of the province's agricultural GDP. The aforementioned author also estimates that stock theft may be higher in the communal sector than in the commercial sector. Clack (2023) utilised data from the South African Policy Service to demonstrate that rural crime has been a persistent issue for some time, and it remains stubborn, as evidenced by the fact that the numbers have not decreased significantly (Figure 1). The aforementioned author, who has been researching stock theft for over a decade, does not believe that the decline in cases is actually occurring; however, he suspects underreporting, which is also common in the country. The main reason is a lack of trust in the policy system.

For example, a country-wide household-level survey of citizens' attitudes established that more than 60% of South Africans view police as the most corrupt government officials in South Africa (South African Social Attitudes Survey [SASAS], 2013). In the Northwest, Breetzke *et al*. (2022) also observed that farmers did not trust the police and viewed them as incapable of reducing the risk of livestock theft. In some instances, this leads to frustrations and petitions. For example, in 2015, angry farmers in Mpumalanga held a protest against the Ermelo Stock Theft Unit (STU), which, according to them, was failing to arrest perpetrators of stock theft (Viljoen, 2015).

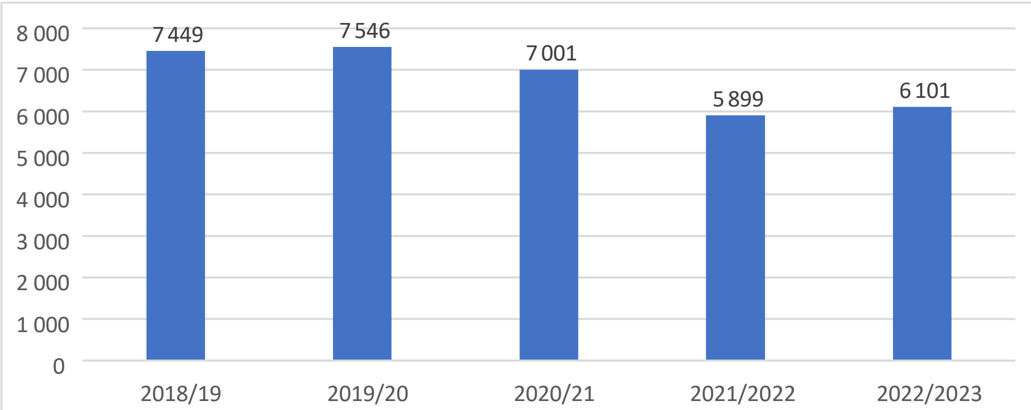

FIGURE 1: Reported Livestock Theft Cases in the Eastern Cape Between 2018/9 -2022/3

In the OR Tambo district municipality, Bahta *et al*. (2016) found that security and safety issues resulting from stock theft were a significant challenge for communal farmers and suggested that communication between communal farmers, community police forums, and police should be improved to reduce this challenge to some extent.

Other communities have already taken action by engaging with the police. Pasiwe *et al*. (2021) report that in 2015, the Amagqunukhwebe Royals (Middledrift, Alice, and Debe Nek areas) chose to share their concerns about stock theft with the provincial police headquarters.

In communal farming areas where grazing is communal, livestock can be stolen from the veld in addition to those stolen from the household kraals at night (Pasiwe *et al*., 2021). The geographical location of rural communities also makes policing very challenging due to their isolation from towns, where most police stations are located (Doorewaard, 2016). These issues make rural communities more prone to stock theft than commercial farming areas, which often have electric fences, security guards on the premises, and conduct regular farm patrols (Maluleke & Mofokeng, 2018).

While the livestock thieves have different motives, for example, some steal and slaughter livestock for their own consumption, while opportunists financially benefit from the theft. However, it is worth noting that most stock theft crimes are organised crime syndicates (Doorewaard, 2020; Pasiwe *et al*., 2021). These syndicates involve ‘insiders’ who possess knowledge of the farming industry, such as individuals with the skills and expertise in how to herd. Additionally, individuals who know how to slaughter and sell the animals, as well as where or to whom to sell their products, need to be investigated (Bunei *et al*., 2016).

Doorewaard's (2020) study, which interviewed 35 offenders convicted of livestock theft at several correctional facilities across three provinces (Gauteng, KwaZulu-Natal, and the Eastern Cape), found that perpetrators often work in groups, with some operating at a highly organised level that consists of a criminal network. The findings of this research also confirmed that livestock theft perpetrators come from diverse socio-economic backgrounds and that the crime is not limited to any particular race, class, or gender (Doorewaard, 2020).

This organised crime activity is profitable because many of these illegally slaughtered animals end up in the supply chain and are frequently used as a substitute for more expensive animal meat (Manning *et al*., 2016). This is a major concern because, if left unaddressed, it could drive most farmers out of business. This syndicate crime, which not only causes economic loss but also leads to many farm murders, is also associated with poverty and unemployment. In Lesotho, Kynoch *et al*. (2001) found that the level of livestock theft increases following poor yields and in regions with high unemployment rates.

2.2. Strategies for Curbing Stock Theft

Following the intensity and the harmful effects of stock theft, there have been suggestions on how to prevent this crime. They include factors such as livestock branding, keeping and maintaining a livestock register, community and police patrols, employee vetting, the use of security guards, security measures taken on the farm, and the utilisation of technology (Lombard, 2015).

Maluleke (2018) suggested various technologies, such as DNA and Livestock Radio Frequency Identification (RFID), but he also stressed that the value of utilising these technologies is still unknown to livestock owners who prefer to use conventional methods. Studies such as Doorewaard (2020) and Zantsi and Nkunjana (2021) recommended the use of these technologies and have taken the first steps in exploring the possibility of using them, especially GPS collars, among smallholder farmers.

2.3. Strengths of GPS Livestock Tracking Devices

GPS livestock tracking devices offer several key strengths that contribute to enhanced livestock management and improved overall farm efficiency. These include the real-time location and monitoring of livestock, allowing farmers to instantly track their animals' movements, which is crucial for preventing theft, locating lost animals, and ensuring they stay within designated grazing areas (Aquilani *et al*., 2022). Furthermore, GPS livestock tracking devices enable farmers to implement improved grazing management practices. Using these devices, farmers can set up virtual boundaries and receive alerts if animals wander outside predefined areas, helping to manage grazing patterns and prevent overgrazing (Hlimi *et al.,* 2024). Efficient grazing management can lead to healthier pastures and improved utilisation of available resources (Rivero *et al*., 2021).

These devices also offer enhanced security, acting as a deterrent and providing a means of recovering stolen animals by quickly locating their whereabouts (Aquilani *et al*., 2022). Some advanced GPS trackers offer additional features, such as monitoring the health and behaviour of livestock. Abnormalities in movement patterns or changes in activity levels may indicate potential health issues (Hlimi *et al.*, 2024). Many GPS tracking systems come with data analytics tools that allow farmers to analyse historical movement patterns, helping them make informed decisions about pasture rotation, breeding strategies, and overall herd management (Rivero *et al.,* 2021). By preventing livestock losses due to theft or reducing the time spent searching for animals, GPS tracking devices contribute to cost savings and increase overall farm profitability.

In summary, GPS livestock tracking devices offer a range of benefits, including improved security, enhanced management practices, and the ability to make data-driven decisions for more efficient and profitable livestock farming.

2.4. Awareness and Technology Adoption Among Smallholder Farmers

Awareness and the adoption of technology among smallholder farmers can significantly impact agricultural productivity, efficiency, and overall livelihoods. Several factors influence the adoption of technology in this context (Aquilani *et al.,* 2022). On many occasions, Smallholder farmers may not be aware of the available technologies or their potential benefits. Furthermore, limited education and literacy levels among smallholder farmers can hinder their ability to understand and adopt new technologies (Hlimi *et al.,* 2024). Affordability is a significant concern for smallholder farmers. Many advanced technologies can be expensive, making them inaccessible to those with limited financial resources. Inadequate infrastructure, such as a lack of reliable electricity or internet connectivity in rural areas, can impede technology adoption (Aquilani *et al.,* 2022).

Central to the awareness and diffusion of technology is the extension service. Traditional technology reaches farmers through extension officers (Anderson & Feder, 2004). This implies that the effectiveness of extension becomes a factor in how farmers learn about and adopt new technologies. A review of case studies on technology adoption in Sub-Saharan Africa has shown that there are profitable technologies that are not widely diffused due to a weak extension system (Takahashi *et al*., 2019).

In their study of 250 smallholder farmers in the Eastern Cape, Bontsa *et al*. (2023) found that the highest positive perception towards digital technologies was associated with cattle rearing (23.53%), a combination of cattle and goat rearing (21.43%), and maize production (12.32%). This study builds upon this literature and examines the awareness and willingness to consider GPS collars among communal livestock farmers.

3. METHODOLOGY

3.1. Study Sites

The Eastern Cape has a high incidence of stock theft cases in South Africa. Data from the South African Police Service indicate that in 2021, six of the ten hotspot areas in the country were located in the Eastern Cape (SAPS, 2025). Additionally, the Eastern Cape is home to approximately 40% of the country's livestock, yet it is also one of the poorest provinces in South Africa. In 2023, the South African Human Rights Commission (SAHRC) found, following an in-depth investigation, that child hunger in the Eastern Cape qualifies as a disaster and should be declared as such under the Disaster Management Act. This is what compelled us to focus our study on the Eastern Cape. We conducted our research in two villages in different municipalities: Msobomvu, located in the Raymond Mhlaba Local Municipality, and Nkunzimbini, situated in the Ingquza Hill Local Municipality. However, our sample does not allow us to compare these villages.

Msobomvu, located in GPS coordinates (32.6967 S, 26.8595 E), has a population of 1762 in 482 households with an average household size of four persons per household. The working-age population (15-64 years old) makes up 56% of the population in Msobomvu. The village has an almost four-fifths (79%) dependency ratio, implying that few people are economically active. The village is quite populated, with 711 people per square kilometre (StatsSA, 2012).

Nkunzimbini, located in GPS coordinates: (31.3436 S, 29.6701 E), has a population of 5,728 in 1,168 households with an average household size of five persons per household. The working-age population (15-64) makes up 32% of the population in Nkunzimbini. The village has a 96% dependency ratio, implying that there are very few economically active people. The village is not very populated, with a population density of 553 people per square kilometre (StatsSA, 2012).

3.2. Research Design

To capture the views of our respondents (communal livestock farmers), we have designed a questionnaire which was administered to household heads by native Xhosa speakers, a language spoken in the study areas. The questionnaire was designed in English, and the respondents' views were recorded in English, translated from Xhosa by trained enumerators, most of whom were postgraduate students. The questionnaire captured farmer demographics, in addition to core information about the livestock kept by farmers, as well as their reasons for keeping the animals. Moreover, most importantly, they have not encountered any stock theft in the past 12 months. The questionnaire was pre-tested with ten respondents before validation and then used in the larger sample.

Also, which animals were stolen and from where they were stolen (kraals or grazing lands). This is important because communal farmers graze their animals together in a single common area. Other questions pertained to whether respondents were aware of the livestock tracking devices and whether they would be willing to purchase such devices. Those who were not familiar with the devices were shown a picture of a GPS collar, and we verbally explained how the device works. We then asked if the respondent, now that they knew, would be willing to purchase it. No practical demonstrations were done. The GPS collar device had a retail value of R2 500. A total of 137 household heads who keep stock were interviewed, 69 from Msobomvu in Alice and another 68 from Nkunzimbini in Lusikisiki.

3.3. Data Analysis - Model Description and Estimation Strategy

To ascertain farmers' awareness of livestock tracking devices, we use summary statistics from our data. The logit and probit regression models are used to determine the factors influencing farmers' willingness to purchase livestock tracking devices, where the dependent variable is binary (i.e., willing or not willing). To ascertain the reliability and consistency of our results, both the logit and probit models provide similar results. The logit model uses the cumulative standard logistic distribution function to model the regression function when the dependent variable is binary. The standard form of the logit model is:

$$p(y = 1|x_1, x_2, \dots \dots, x_k) = \frac{1}{1 + e^{-(\beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_k x_k).}}$$

Here, $p(y = 1|x_1, x_2, \dots \dots, x_k)$ is the probability of the event occurring given the predictor variables $x_1, x_2, \dots \dots, x_k$. The β values are the coefficients to be estimated. The probit model uses the cumulative standard normal distribution function to model the regression function when the dependent variable is binary. The standard form of the probit model is:

$$E(Y|X) = P(Y = 1|X) = \mu(\beta_0 + \beta_1 x)$$

Here, $E(Y|X)$ is the expected value of Y given X, $P(Y = 1|X)$ is the probability of the event occurring given X, and μ is the cumulative standard normal distribution function. The specified logit and probit models in R version 4.3.2 are:

$$\begin{aligned} logit <- \ logit \ <- glm(formula \\ = \ Purchase \sim Hsize \ + \ RangFenc \ + \ TypeAnimal \ + \ No.Anim \\ + \ TypeStol \ + \ StolFrm \ + \ `T.No\ Anim`, family \ = \ binomial) \end{aligned}$$

$$\begin{aligned} probit \ <- \ logit \ <- glm(formula \\ = \ Purchase \sim Hsize \ + \ RangFenc \ + \ TypeAnimal \ + \ No.Anim \\ + \ TypeStol \ + \ StolFrm \ + \ `T.No\ Anim`, family \ = \ binomial) \end{aligned}$$

We conducted a studentised Breusch-Pagan test to check for heteroscedasticity. The null hypothesis is that, if the p-value is greater than 0.05, the data exhibit homoscedasticity; the alternative is that the data do not exhibit homoscedasticity. The results from the logit and probit models have a p-value greater than 0.05, indicating the presence of heteroscedasticity. Therefore, we corrected the heteroscedasticity by transforming the model.

$$logit < -glm(formula \\ = Purchase \sim Hsize + RangFenc + TypeAnimal + No.Anim \\ + TypeStol + StolFrm + `T.No\ Anim`, family = binomial\ (link\ "logit")$$

$$probit < -glm(formula \\ = Purchase \sim Hsize + RangFenc + TypeAnimal + No.Anim \\ + TypeStol + StolFrm + `T.No\ Anim`, family = binomial\ (link\ "probit")$$

The coefficients in these models do not have a straightforward interpretation, as they do in linear regression, but they can be used to calculate the change in the predicted probability of the outcome for a one-unit change in the predictor variable. In this study, we further calculated the marginal effect.

The marginal effect of a variable in a regression model is the change in the expected outcome that results from a one-unit change in that variable, while holding all other variables constant. In a simple linear regression model without interactions or polynomials, the marginal effect of a variable is simply its coefficient. For example, consider the model:

$$y = \beta_1 x_1 + \beta_2 x_2$$

Here, $\beta_1\ and\ \beta_2$ are the marginal effects of $x_2\ and\ x_1$respectively.

However, in models with interactions or non-linear terms, the marginal effect of a variable is not constant but depends on the values of other variables. For example, in the model:

$$y = \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_1^2$$

The marginal effect of $x_1$on y is $\beta_1 + 2\beta_3 x_1$. The marginal effects were calculated using R version 4.3.2

$logitm < -margins\ (logit, type =$ "link")

$probitm < -margins\ (probit, type =$ "link")

The dependent variable, 'willing to purchase,' is regressed against a set of independent variables listed in Table 1 below. Based on the literature, we have hypothesised the influence of each variable in the far-right column.

TABLE 1: Description of Variables Used in the Quantitative Phase

Dependent variable:	**Description**	***Data***	***Expected sign***
Purchase	Farmers' willingness to purchase the GPS collar for tracking livestock	Binary	
Independent Variable			
No. of animals	Herd size		+
Age	Is the age in years of the respondent	Scale	+/-
Gender	Is the sex of the respondent	Binary	+
Mstatus	Is the family status of the respondent	Category	+
Hsize	Is the number of people living with the respondent	Scale	-
RangeFenc	Whether communal rangelands are fenced or not	Binary	+
Landsize	Number of hectares a household has access to	scale	+
Farming activity	Is the level of involvement a farmer has with everyday farming	Category	+/-
Typestol	Is the type of animal stolen from the farm	Category	+

4. RESULTS AND DISCUSSION

4.1. Descriptive Analysis

The farmers' awareness of new technologies determines the likelihood and potential extent of their adoption. Table 2 provides a statistical summary of the variables used in the empirical models. Twenty-eight percent (28%) of respondents in this study were aware of livestock tracking devices. After the respondents had been taught about how the livestock GPS tracking devices work, their use, as well as the unit price of the device, 42% were willing to purchase and try them on their animals. The lack of awareness about the tracking device highlights the poor dissemination of technology by the relevant agricultural extension advisory service, whose major role precisely includes technological dissemination. This inefficiency appears to be typical of rural settings, as Ngcobo *et al*. (2020) also reported a lack of awareness of biogas technologies among rural households in Alice.

A vast majority of respondents in this study were married (82%) and male (75%). Male-headed households tend to dominate livestock rearing in rural communities (see also Ndzungu & Jaja, 2024). Furthermore, respondents in this study fell within the smallholder farmer category, with an average age of 50 and an average household size of eight persons, in line with Statistics South Africa's General Household Survey report (Stats SA, 2022). On average, our respondents have access to 16 hectares of arable land and share grazing land as a community with no restrictions on the number of animals a household can keep.

In terms of livestock keeping, our respondents kept cattle (23%) on average herd (29%), followed by sheep (15%), with an average flock size of 46 animals, and goats (46%) with an average flock size of 35 animals. Of these herd sizes, our respondents lost an average of six animals in the last 12 months to stock theft. By far, sixty-four percent (64%) of the stolen animals were missing from the rangelands on communal grazing lands. Approximately 33% of the rangelands where our respondents grazed their livestock were unfenced, meaning that animals roamed freely without control.

TABLE 2: Summary Statistics for a Range of Variables Used in the Empirical Models

Variable	Mean	Minimum	Maximum
Age	56	23	89
Household Size	8	2	31
Land Size	16.16	0.5	100
Number of animals	48.4	4	121
No of stolen animals	6.4	1	18
Categorical variables (frequencies)			
Do you graze on fenced rangelands	Yes=46 No=91		
Type of animal	Cattle=32, Goat=20, Sheep= 64, Other=21		
Number of animals (average)	Cattle=40, Goat =35, Sheep, 62		
Stolen from	Kraal=46, Range land= 89, Other =2		
Gender	Male=104, Female=33		
Mstatus	Married =112, Single = 21, Widowed =4		

4.2. Determinants of Smallholder GPS Livestock Tracking Devices Adoption

Table 3 below describes the relationships between purchasing a tracking technology (dependent variable) and the independent variables, as well as the additional information on the overall fit of the logistic and probit regression models. Table 4 presents the marginal effect, which represents the change in the probability of the event (in this case, purchasing the device) for a one-unit change in the predictor variable, while holding all other variables constant.

TABLE 3: Determinants of Communal Farmers' Willingness to Purchase Livestock Tracking Devices

Variable	Logit Model	Probit Model
(Intercept)	-0.45 (1.47)	-0.26 (0.85)
Household Size	-0.11 (0.06)	-0.07 * (0.03)

10.17159/2413-3221/2026/v54n1a20517

Grazing on un-fenced rangelands	-2.92 ** (1.00)	-1.68 ** (0.54)
Cattle	2.09 (1.39)	1.20 (0.78)
Sheep	3.24 ** (1.26)	1.90 ** (0.68)
Goat	-3.65 * (1.78)	-2.11 * (1.03)
Other animals (horses)	3.99 ** (1.54)	2.26 ** (0.80)
Herd size or no of animals	0.02 ** (0.01)	0.02 ** (0.01)
Goat	-0.03 (0.75)	-0.01 (0.43)
Sheep	3.21 * (1.32)	1.91 ** (0.73)
Stolen from Kraal	0.31 (0.62)	0.16 (0.36)
Stolen from rangelands	-2.51 (1.86)	-1.47 (1.11)
Herd size	0.04 (0.08)	0.02 (0.05)
N	137	
Pseudo R2	0.30	0.31
*** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$.		

Smaller household sizes are associated with a higher willingness to adopt, as indicated by the negative coefficient, which is statistically significant. The issue of purchasing power seems to be at play. For any given household income, the per capita income for each household member

Vol. 54 No. 1, 2026: 40-61
10.17159/2413-3221/2026/v54n1a20517

depends on the household size. Thus, smaller households could afford to buy more goods and services than larger households with similar incomes (Maitra & Ray, 2006).

However, the household size, represented by 'Hsize', has a negative impact on the willingness to adopt technology, with marginal effects of -0.11 for the logit model and -0.07 for the probit model, both significant at the 0.05 level. Although a smaller household size has a significant probability of purchasing the technology, its marginal effect is small, meaning that it has a lower probability of being purchased.

Unfenced rangelands have a negative coefficient in both models, indicating that farming on unfenced rangelands reduces the likelihood of purchasing a livestock tracking device, and this effect is statistically significant (Table 3). The unfenced rangelands decrease the probability of communal farmers' willingness to purchase the livestock tracker by 2-3 units, as suggested by the negative marginal effect in both models, which is statistically significant (Table 4). Monitoring cattle movement in a fenced grazing land is much more convenient than doing so in an unfenced communal grazing land, where animals wander all over. The alternative to this decision would be to hire a livestock herder, as most households in the Eastern Cape do (Zantsi, 2023).

However, whether an animal was stolen from the homestead kraal or rangelands does not explain the farmers' willingness to purchase the livestock tracker. Even adding an extra livestock unit does not significantly influence the likelihood of purchasing the device, as the coefficient and marginal effects for this variable are not statistically significant in either model (see Tables 3 and 4). As expected, the number of animals - specifically, cattle, sheep, and goats - a farmer keeps is associated with an increased likelihood of purchasing the device (Table 3). Marginal effect results (Table 4) also suggest that the probability of purchasing livestock tracking devices increases with the number of animals, as indicated by the positive marginal effect in both models, which is statistically significant. However, it can be inferred that knowledge of the type of livestock increases the likelihood of purchasing an animal tracking device. As predicted by Zantsi and Nkunjana (2021), farmers with larger herd sizes may find it more worthwhile to purchase livestock trackers than those with fewer animals, as they would not lose many animals.

This study found statistical significance in both models for sheep and goats. Sheep show a positive coefficient, implying that farmers who keep sheep are more likely to purchase livestock tracking devices because sheep are more vulnerable to theft than goats and cattle. Conversely, goats are associated with a decreased likelihood of purchasing the device, and this is statistically significant in both models.

TABLE 4: Logit and Probit Marginal Effects for the Determinants of Willingness to Purchase Livestock Tracker

Variable	Logit Marginal effect	Probit Marginal effect
Hsize	-0.11 (0.06)	-0.07 * (0.03)
No.Anim	0.02 ** (0.01)	0.02 ** (0.01)
RangFenc1	-2.92 ** (1.00)	-1.68 ** (0.54)
StolFrm1	0.31 (0.62)	0.16 (0.36)
StolFrm2	-2.51 (1.86)	-1.47 (1.11)
T.No Anim	0.04 (0.08)	0.02 (0.05)
TypeAnimal1	2.09 (1.39)	1.20 (0.78)
TypeAnimal2	3.24 ** (1.26)	1.90 ** (0.68)
TypeAnimal3	-3.65 * (1.78)	-2.11 * (1.03)
TypeAnimal4	3.99 ** (1.54)	2.26 ** (0.80)

TypeStol1	-0.03 (0.75)	-0.01 (0.43)
TypeStol2	3.21 * (1.32)	1.91 ** (0.73)
*** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$.		

5. CONCLUSIONS AND RECOMMENDATIONS

This article aims to assess the awareness of communal farmers regarding animal tracking devices, in light of the alarming stock theft crime in the Eastern Cape, which accounts for approximately 40% of South Africa's livestock. The other objective of the article was to determine the factors that influence the willingness of communal farmers to purchase animal tracking devices to mitigate stock theft and improve animal management. The data from two villages in the Eastern Cape show that only 28% of farmers were aware of the livestock tracking devices, and 42% were willing to purchase them after we demonstrated the devices and their potential to track animals, sharing information on the unit price of the device. These findings have implications for agricultural extension services, which have the mandate of disseminating technology.

Results from two binomial models suggest that the following factors, such as household size, herd size, keeping sheep, and unfenced rangelands, play significant roles in influencing farmers' decisions to purchase or not purchase animal tracking technology. This information could help drive and direct awareness about technologies that can minimise stock theft cases and improve the recovery of stolen animals. Extension officers could drive these awareness initiatives. Since South Africa has the highest extension-to-farmer ratio (Aliber, 2019), it would be more practical and cost-effective to target local farmer organisations or dip tanks to disseminate information about livestock tracking devices.

However, this information would need to be accompanied by awareness of animal identification, which entails branding animals with registered brands and reporting them to the relevant agricultural department to enable the prosecution of offenders and the recovery of animals. Future studies could investigate the farmers' knowledge and awareness of the importance of branding and registering their animal brands.

Vol. 54 No. 1, 2026: 40-61
10.17159/2413-3221/2026/v54n1a20517

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Vol. 54 No. 1, 2026: 40-61
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