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EDITED BY
Carol Kerven,
University College London,
United Kingdom

*CORRESPONDENCE
Patrick Okello,
pokellop@gmail.com

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Farmers knowledge, attitude, and practices towards compliance with beef safety standard practices in Uganda

Patrick Okello[1]*, John Ilukor[2,3], Kanifa Kamatara[4] and Nelson Turyahabwe[1]

[1]Department of Extension and Innovation Studies, Makerere University, Kampala, Uganda, [2]Department of Agribusiness and Natural Resource Economics, Makerere University, Kampala, Uganda, [3]The Living Standards Measurement Study (LSMS), Survey Unit, Development Data Group, World Bank, Kampala, Uganda, [4]Department of Animal and Range Sciences, Makerere University, Kampala, Uganda

This study examines the compliance of cattle farmers with Beef Safety Standard Practices (BSSPs), focusing on their knowledge, attitudes, willingness, and ability to comply, as well as the socio-economic characteristics of the farmers and the determinants influencing compliance with BSSPs. Utilizing data collected from 1,411 livestock farmers across six districts along the cattle corridor of Uganda, the study employed descriptive T-tests and estimated a Multivariate Probit (MVP) regression model. The findings indicate that approximately 85% of farmers possess knowledge about BSSPs, and 87% exhibit positive attitudes toward compliance. However, only 78% expressed willingness to comply, and a mere 60% demonstrated the actual ability to adhere to these standards. On average, only 46% of the farmers fully complied with the Beef Safety Standard Practices. Further analysis revealed that farmers who engaged in group activities, had received education, and participated in training programs on BSSPs were more likely to comply. The MVP analysis highlighted the significance of administrative capacity and willingness to comply, showing that years of schooling and training had a notably positive impact on compliance rates. Conversely, factors such as deterrence failures and cultural beliefs were found to negatively influence compliance. In conclusion, while farmers exhibit foundational knowledge, positive attitudes, and a willingness to adopt BSSPs, various barriers including weak administrative capacity, inadequate legislation, deterrence failures, and the costs associated with adoption have hindered full compliance. The study recommends that the government and development partners undertake a review of the Meat and Disease Act to implement stringent penalties for non-compliance and to enhance the enforcement of beef safety regulations. These measures are crucial for promoting the adoption of BSSPs and ensuring the production of high-quality beef.

KEYWORDS

beef safety, standard practices, farmer practices, compliance, cattle corridor

Introduction

Globally, beef production serves as a cornerstone of the agricultural sector, contributing significantly to food security, economic development, and livelihoods (Michalk et al., 2019). The consumption of beef is widespread, with demand driven by cultural preferences, dietary habits, and protein requirements (Hodges et al., 2019). Global beef consumption reached approximately 59.1 million metric tonnes and is expected to grow at an average annual rate of 2.5% through 2026 (Beckman et al., 2025; Beckman et al., 2025 attributes this growth to increases in population, urbanization, and income levels. In Africa, the average rate of beef consumption is estimated at 13% in rural areas and 24% in urban areas (Paulo et al., 2025). Specifically, in Uganda, *per capita* beef consumption is predicted to increase by more than 150% by 2040 (Hove-Sibanda et al., 2025). This rapid growth in beef consumption across Africa, particularly in Uganda a phenomenon referred to as the livestock revolution is expected to provide attractive opportunities for small-scale farmers, investors, and the economy. Potential benefits include an increased market size for beef, rising cattle prices, job creation, enhanced household income, and overall economic growth (Hodges et al., 2019).

However, alongside the increasing global consumption of beef, concerns regarding food safety, quality assurance, and sustainability have emerged. These concerns primarily stem from the failure of beef value chain actors to comply with established beef safety standards, which has contributed to consumer reluctance to purchase and consume beef and related products (Randolph et al., 2007). Unsafe beef may contain microbiological, chemical, or physical hazards that can adversely impact human health, leading to acute or chronic illnesses and, in extreme cases, death or permanent disability (Jeffer et al., 2021). According to Grace, (2015), 66.5% of beef sold in developing countries, particularly in Africa and Asia, contains harmful bacteria and pathogens such as *Campylobacter*, *Escherichia coli* O157:H7, *Staphylococcus aureus*, *Salmonella*, and Enterococci, which account for an estimated 230,000 deaths globally each year. To ensure the delivery of safe beef for human consumption in Uganda, the government, through the Uganda National Bureau of Standards (UNBS), has established Beef Safety Standard Practices (BSSPs) that all actors along the beef value chain are required to conform to. For farmers, the BSSPs stipulate that they must purchase veterinary drugs from licensed shops, adhere to recommended drug withdrawal periods as prescribed by manufacturers or competent veterinarians, refrain from selling sick animals for slaughter, and avoid using human drugs to treat livestock (UNBS, 2016).

Despite the existence of these standards, the quality and safety of beef available in Ugandan markets have remained subpar. A study by Kyayesimira et al. (2020) revealed alarming levels of contamination, with beef samples across East Africa showing 100% positivity for Aerobic Plate Counts (APCs), 97.9% for *Staphylococcus aureus*, 93.8% for coliforms, 83.3% for *E. coli*, and 4.2% for *Salmonella*. Similarly, Njoga et al. (2018) identified that the majority of chemical hazards in beef are due to drug residues resulting from the indiscriminate and irrational use of veterinary drugs and growth hormones. While the use of veterinary drugs is essential for preventing and treating livestock diseases (Falowo and Akimoladun, 2019a), challenges arise when farmers fail to observe recommended drug withdrawal periods or sell sick animals. Common antimicrobials used in livestock production—such as tetracycline, penicillin, and sulfonamides are often related to those used in human medicine, increasing the risk of antimicrobial resistance among humans. There is also significant health risks associated with drug residues, including carcinogenic effects, disruption of normal intestinal flora, and congenital malformations during pregnancy (Falowo and Akimoladun, 2019a).

Compliance with beef safety standards is vital for safeguarding public health, preventing foodborne illnesses, and ensuring the quality and integrity of beef products throughout the supply chain. This compliance is not merely a regulatory obligation but also a moral and ethical responsibility shared by all stakeholders involved in beef production, from farmers to consumers. In Uganda, known for its vibrant agricultural sector and rich livestock diversity, beef production holds significant promise for economic growth and rural development. However, aligning traditional farming practices with modern food safety, hygiene, and quality control standards presents a considerable challenge. As Uganda seeks to expand its beef industry and access international markets, enhancing compliance with beef safety standards becomes increasingly imperative.

Farmers are integral to the beef production process, exerting a substantial influence on the safety and quality of beef products through their knowledge, attitudes, and practices. Ncayiyana, (2017) posited that if farmers refrain from selling sick animals and adhere to appropriate veterinary protocols such as utilizing licensed veterinarians for treatment and observing drug withdrawal periods there would be no pathway for diseased meat to enter the market. Consequently, it is essential to understand farmers' perspectives on compliance with beef safety standards, along with their knowledge, attitudes, and practices regarding Beef Safety Standard Practices (BSSPs). However, there exists a literature gap on the practices, knowledge and attitudes of farmers towards compliance with BSSPs. Existing studies on beef safety have primarily focused on assessing the quality of beef sold (Bogere and Baluka, 2014a; Bogere and Baluka, 2014b.) rather than evaluating the compliance levels of beef producers and the drivers of such compliance.

Therefore, this paper aims to determine compliance levels with BSSPs among farmers, assess their knowledge, attitudes, and practices regarding compliance, and identify the drivers

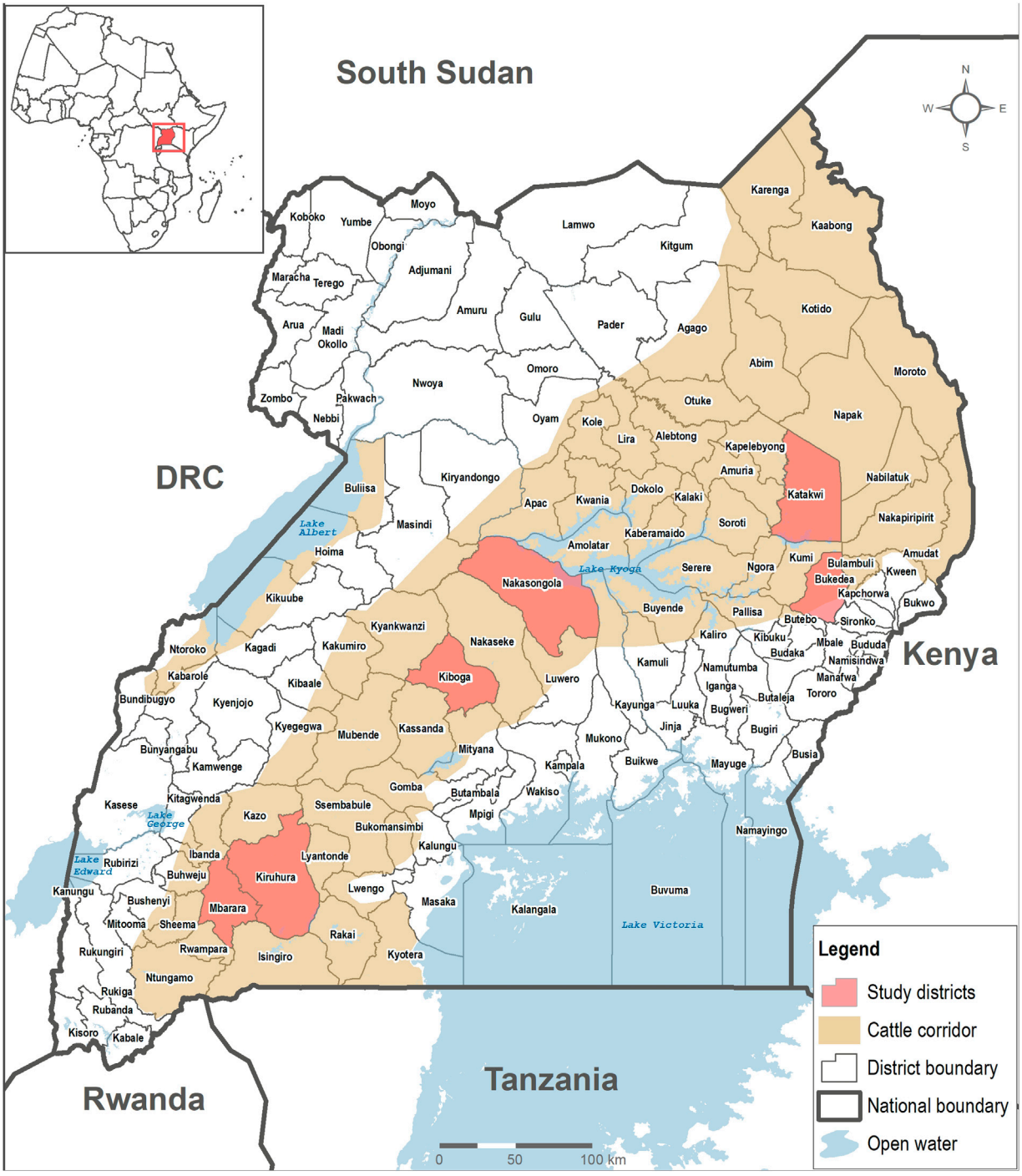

FIGURE 1
Location of the study districts along the cattle corridor of Uganda.

influencing these behaviors. The findings will provide valuable insights for policymakers and regulators seeking to enhance enforcement of these standards, either by increasing compliance levels when necessary or maintaining satisfactory standards when warranted. The key research questions for this study are: (i) Are cattle farmers knowledgeable, possess positive attitudes, and are they willing and able to comply with BSSPs? (ii) Are farmers complying with BSSPs? (iii) Which farmers are

complying with BSSPs? and (iv) Does farmer knowledge, attitude, willingness, and ability influence compliance with BSSPs? To address the research questions, this study employed T-tests and Multivariate Probit (MVP) regression as the primary analytical tools. T-tests were utilized to assess farmers' knowledge, attitudes, willingness, and ability to comply with Beef Safety Standard Practices (BSSPs).

Materials and methods

Study area

The study was conducted in six districts within Uganda's cattle corridor, a vast region extending from Southwestern to Northeastern Uganda, characterized by pastoral rangelands (Figure 1). This corridor encompasses approximately 40% of Uganda's land area and is marked by low and erratic rainfall, which contributes to frequent and severe droughts, as well as fragile soils with weak structural integrity (Crumpler et al., 2022). Pastoralism serves as the primary economic activity in this region, where rangelands are traditionally utilized as common pool resources. Additionally, the corridor is ecologically, ethnically, and institutionally diverse (Nanfuka et al., 2020). The selected districts for this study include Katakwi and Bukedea in Teso Sub region, Eastern Uganda, and Nakasongola, Kiboga in Buganda Sub region, Central Uganda, along with Kiruhura and Mbarara in Ankole Sub region, Western Uganda. These districts were purposively chosen due to their significance in the livestock trade, with live cattle being sold to major urban centers in Uganda, including Kampala and Mbarara, as well as for export to South Sudan. Notably, Kiruhura and Mbarara are recognized as leading suppliers in this trade (Kyayesimira et al., 2020). Furthermore, these districts boast substantial livestock herds; for instance, Nakasongola has a herd population of 265,386, ranking second to Gomba (279,038), while Kiboga is fifth with 203,237 (Baguma, 2018). In Teso Sub region, Katakwi and Bukedea were selected not only for their prominence in livestock production but also for hosting significant cattle markets that contribute substantially to the supply of animals for slaughter in Uganda's capital, Kampala (Ilukor et al., 2022). Kampala is home to the largest slaughterhouse, the City Abattoir, located on Old Port Bell Road, which processes between 500 and 700 cattle daily, in addition to approximately 200 goats and sheep, as well as several chickens (Kyayesimira et al., 2020).

Research and sample design

This study employed a cross-sectional survey design to assess the Knowledge, Attitudes, and Practices (KAP) of farmers concerning compliance with Beef Safety Standard Practices (BSSPs). The cross-sectional survey was selected for its effectiveness in gathering data from a diverse sample of farmers at a single point in time, enabling the analysis of various factors influencing compliance in a relatively efficient manner (Wang and Cheng, 2020). This design facilitated the collection of quantitative data, which could be systematically analyzed to identify patterns and correlations among the KAP dimensions. The target population for this study comprised all cattle farmers within the six selected districts of Uganda's cattle corridor. To ensure accurate representation of this population, a two-stage sampling technique was employed. In the first stage, purposive sampling was utilized to select the districts. This approach ensured that the districts were chosen based on specific criteria relevant to the study, including their significance in cattle farming, existing beef production practices, and prior reports on compliance with safety standards. By concentrating on these strategically important districts, the study aimed to capture a diverse array of practices and perspectives among cattle farmers.

In the second stage, a sampling frame derived from the UBOS, (2016) was used to determine the intended sample size proportionately to the number of livestock farmers in each selected district. This allowed for a more equitable distribution of farmers in the sample, ensuring that each district was represented according to its proportion of the total cattle farming population. The required sample size for each district was calculated using Kish's formula (Bethmann, et al., 2019), which is designed to provide a scientifically valid sample size based on the desired level of precision, the population size, and the estimated variability within the population. This formula helped ensure that the study's findings would be statistically robust and generalizable to the broader population of cattle farmers in Uganda's cattle corridor. By employing this two-stage sampling technique, the study not only enhanced the representativeness of the sample but also facilitated a deeper understanding of the dynamics at play within the beef safety practices of farmers across different districts. This methodological rigor was vital for drawing meaningful conclusions and making informed recommendations for improving compliance with Beef Safety Standard Practices in the Sub region. The sample size for each district is given by:

$$n = \frac{z^2 pq}{e^2} \quad (1)$$

Where n is the sample size, Z is the reliability coefficient at 95% confidence interval (1.96), p is the population proportion of livestock keeping households in the district, q is equal to 1−p, and e is the acceptable error (0.05). Using this formula, a total of 1,411 farmers participated in the study of which 352 were from Buganda Sub region, i.e., Kiboga (154) and Nakasongola (198); 472 from Ankole Sub region, i.e., Kiruhura (244) and Mbarara (198) whereas 587 were from Teso Sub region of Uganda, Bukedea (345) and Katakwi (242) farmers.

Data collection

Primary quantitative data was collected using a semi-structured questionnaire administered to the randomly sampled cattle farmers. The data collected included social demographic information about the farmers, such as their age, gender, marital status, level of education and experience in keeping animals, as well as socioeconomic and institutional data such as membership to a farmers' group. Other questions in the questionnaire tool administered were related to farmer's knowledge, attitudes, and practices regarding beef safety. Ten enumerators who could fluently speak the native languages in the study area districts were recruited to help with the data collection. The enumerators were first trained using paper questionnaires to familiarize them with the flow of the questions and the key study variables. The enumerators also received training on the use of Computer-Aided Personal Interviewer (CAPI) devices, including handling the tablets, managing settings, and synchronizing data, and they participated in role-playing exercises to simulate the field environment and further prepare for data collection.

To ensure accuracy of the data, the questionnaire preparation took into account factors that are likely to minimize non-sampling errors, such as clarity of expression, potential for respondent recall, cultural specific conceptions, sensitive questions and the time required to complete an interview (an interview should be precise not to inconvenience the respondent) following concerns raised in (Nicholas, 1991). The questionnaire was pre-tested on 10 farmers in Bukedea district so as to increase its robustness and scope to capture all the requisite information. To test the reliability of the questionnaire, internal consistency techniques were applied using Cronbach's Alpha as adopted in a study by Izah et al. (2023). The feedback from the pre-test was used to revise and modify the questionnaire to enhance its validity. Face to face interviews were the mode of data collection used. Data was collected from December 2023 to February 2024. Consent from each of the respondent was sought before interviewing them. The completed questionnaires were checked to ensure validity and follow-up of some farmers was done using their phone numbers included on the questionnaire, to seek clarification on some ambiguous responses. A total of 1,411 farmers participated in the study of which 352 were from Buganda Sub region, 472 from Ankole Sub region whereas 587 were from Teso Sub region of Uganda.

Data analysis

To assess farmers' Knowledge, Attitude, Willingness, and Ability (KAWA) levels regarding compliance with Beef Safety Standard Practices (BSSPs), cattle farmers were asked a series of questions designed to evaluate their familiarity with and adherence to each of the six BSSPs. These practices included: (1) purchasing veterinary drugs from licensed veterinary drug shops, (2) observing the recommended drug withdrawal periods as prescribed or advised by competent veterinarians, (3) refraining from selling sick or suspected sick animals for slaughter, (4) avoiding the use of human drugs to treat animal diseases, and (5) not consuming dead animals. Each question presented respondents with two options: "YES," which received a score of 1, and "NO," which received a score of 0. In addition, to determine the overall KAWA levels of farmers, modified Bloom's cut-off points were employed. The scoring system ranged from 0 to 6 points based on responses to the six BSSPs, which were categorized into two levels: high and low. Specifically, a score of 5-6 indicated a high level (favorable or satisfactory) of knowledge, attitude, willingness, ability, and compliance, corresponding to 80%–100%. Conversely, a score of less than 5 indicated a low level (unfavorable or unsatisfactory), equating to ≤79%.

Descriptive statistics were computed using Stata version 17SE to summarize the findings and characterize the KAWA levels among farmers. To determine significant differences in knowledge, attitudes, willingness, and ability to comply with BSSPs, t-tests for differences in proportions and means were conducted. These statistical tests helped to compare compliance and non-compliance groups based on various socio-demographic characteristics of the farmers. The level of statistical significance was set at $P < 0.05$ to ensure rigorous analysis. This analytical approach provided a comprehensive understanding of farmers' KAWA levels, enabling the identification of gaps in knowledge and areas requiring targeted interventions to enhance compliance with BSSPs. By correlating these factors with socio-demographic characteristics, the study aimed to inform policymakers and stakeholders about critical areas for capacity building and resource allocation in the pursuit of improved beef safety standards in Uganda.

To estimate the factors influencing compliance with Beef Safety Standard Practices (BSSPs) among farmers, a Multivariate Probit (MVP) regression model was employed. Statisticians and econometricians regard the multivariate probit model as a generalization of the standard probit model, enabling the simultaneous estimation of multiple correlated binary outcomes (Greene, 2002). This approach is particularly relevant in the context of compliance with BSSPs, as farmers often draw from diverse sources of information when making decisions related to regulatory adherence. Consequently, the decision to comply with one BSSP can influence the decision to comply with others, rendering compliance inherently multivariate. Using univariate techniques in this scenario may lead to the omission of critical information regarding the interdependencies and simultaneous nature of compliance decisions. The MVP model allows for the identification of potential complementarities (positive correlations) and substitutability (negative correlations) between the independent variables and compliance with the various BSSPs.

This capability is essential for understanding the dynamics of compliance behavior among farmers.

Compliance decisions can be path-dependent, meaning that recent compliance choices may be influenced by earlier decisions. Failing to account for these interdependencies could lead to either an underestimation or overestimation of the factors affecting compliance (Assaye et al., 2020; Donkoh et al., 2019; Kassie et al., 2015; Teklewold et al., 2013). Therefore, it is essential to assess whether farmers' multiple compliance decisions are interrelated with previous encounters with the law, including deterrence actions or failures. In this study, socio-economic data were collected through structured interviews, encompassing variables such as income, education level, and group membership. Additionally, the study incorporated questions exploring deterrence failure, regulatory failure, and cultural beliefs to gauge farmers' perceptions and experiences with compliance and enforcement. For deterrence failure, questions assessed farmers' awareness of penalties for non-compliance, past experiences with enforcement actions, perceptions of the likelihood of inspections, and the impact of penalties on future compliance decisions. Regarding regulatory failure, the investigation examined farmers' understanding of current regulations, the accessibility of regulatory information, the perceived effectiveness of these regulations, and the support provided by regulatory bodies for compliance. Cultural beliefs were addressed through questions that focused on traditional practices influencing cattle management, community attitudes toward compliance, and potential conflicts between adopting BSSPs and traditional methods. In light of these considerations, the study applied a multivariate probit model to analyze the joint factors affecting farmers' compliance with BSSPs. By accommodating the possibility of correlation between compliance decisions across different BSSPs, the model provided a nuanced understanding of the influences on compliance behavior, ultimately informing strategies for improving adherence to beef safety standards among farmers in Uganda. This comprehensive analytical framework not only enhances the robustness of the findings but also contributes to the development of targeted interventions that can effectively address the complexities of compliance in the agricultural sector.

Multivariate probit model specification

The multivariate probit model was employed to estimate the factors influencing compliance with Beef Safety Standard Practices (BSSPs) among farmers. The multivariate probit model is particularly well-suited for analyzing compliance decisions in the agricultural sector due to its ability to handle interdependent binary outcomes. This model allows for the simultaneous analysis of multiple binary dependent variables, capturing the correlations between different compliance decisions, which is crucial in understanding how one decision may influence another (Ngenoh et al., 2019). Given that compliance behaviors often do not occur in isolation, employing a multivariate probit model enhances the robustness of the findings by accounting for the potential correlations among the outcomes, thereby providing a more comprehensive view of the factors influencing compliance (Shah and Alharthi, 2024). Additionally, this approach is beneficial in exploring the complexities of decision-making processes influenced by socio-economic status, regulatory frameworks, and cultural beliefs, allowing researchers to derive insights that can inform targeted interventions. Ultimately, the model's capacity to reveal interdependencies among compliance decisions is invaluable for policymakers aiming to design more effective regulations and support mechanisms tailored to the specific needs of farmers (Sánchez-Zamora et al., 2014).

The multivariate probit econometric approach utilized in this study is characterized by a set of six binary dependent variables, denoted as y^*_{im} where $m = 1, \ldots, M$. The model can be mathematically represented as follows:

$$y^*_{im} = \beta_m X_{im} + \epsilon_{im}, m = 1, \ldots, M$$

where $y_{im} = 1 \, if \, y^*_{im} > 0$ and 0 otherwise. The error terms ϵ_{im} are assumed to be distributed as multivariate normal, each with a mean of zero and a variance-covariance matrix V. This matrix V has ones on the leading diagonal and correlations $\rho_{jk} = \rho_{jk}$ as the off-diagonal elements. In this context, y_{im} represents the compliance status of farmer i for BSSP m at a specific point in time specifically, whether the farmer adheres to each of the six BSSPs. The multivariate probit model thus allows for the fitting of a univariate probit model for cross-sectional time-series data while accommodating a flexible correlation structure among the compliance decisions.

The Wald test is commonly employed within the multivariate probit framework to evaluate the null hypothesis of no correlation across the equations (Shah and Alharthi, 2024). If there is insufficient statistical evidence to reject the null hypothesis, it implies that the choices are mutually independent, allowing for the possibility of fitting m independent univariate probit models for each BSSP. Conversely, rejection of the null hypothesis indicates that estimating m independent univariate probit models would yield inefficient estimates due to the interdependencies among the compliance decisions. The dependent variables in the MVP model consist of six dummy variables that correspond to the recommended BSSPs for farmers. Specifically, compliance with BSSPs stipulates that farmers must: (1) purchase veterinary drugs from licensed veterinary drug shops, (2) observe the recommended drug withdrawal periods as prescribed by competent veterinarians, (3) refrain from selling sick or suspected sick animals for slaughter, and (4) avoid using human drugs to treat animal diseases (UNBS, 2016). Farmers classified as "compliers" are those who meet 80% or more of the

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TABLE 1 Description of variables and how they are likely to influence compliance with the BSSPs at the farm level.

Variable	Variable description	Measurement	Expected sign	Results (%)
*X*1	Gender of the respondent	Binary variable (1 = Female, 0 = Male)	+−	21.5
*X*2	Marital status	Binary variable (1 = Married, 0 = others)	+−	77
*X*3	Average number of years of schooling	Continuous variable measured in number of years	+	9(4.9236)
*X*4	Literacy status of the farmer	Binary variable (1 = Literate, 0 = Illiterate)	+	81.2
*X*5	Membership to farmer's group	Binary variable (1 = Yes, 0 = No)	+	15.1
*X*6	Cattle keeping experience	Continuous variable measured in number of years	+	15.7
*X*7	Received training on BSSPs	Binary variable (1 = Yes, 0 = No)	+	20.4
*X*8	Whether farmer is Knowledgeable about BSSPs	Binary variable (1 = Knowledgeable, 0 = otherwise)	+	84.6
*X*9	Whether farmer is willing to comply to BSSPs	Binary variable (1 = Willing, 0 = otherwise)	+	78.3
*X*10	Whether farmer is able to comply with BSSPs	Binary variable (1 = Able, 0 = otherwise)	+	59.5
*X*11	Administrative capacity/sanctions	Binary variable (1 = Yes, 0 = No). Proxied by animal being rejected in the slaughter facility or market because of illness or drug residues	−	9.9
*X*12	Failure of civil society	Binary variable (1 = Yes, 0 = No). Proxied by absence of farmers group from the community	−	42.6
*X*13	Deterrence failure	Binary variable (1 = Yes, 0 = No). Proxied by absence of penalty for slaughtering sick animal	−	58.8
*X*14	Regulation at odds with culture	Binary variable (1 = Yes, 0 = No)	−	2.9
*X*15	High cost of compliance	Inability to comply to a BSSP because of high cost (1 = Yes, 0 = No)	−	82.4

BSSPs, while "non-compliers" are those who either do not adopt any BSSPs or whose compliance levels fall below 80%.

The explanatory variables considered in modeling farmers' compliance decisions with BSSPs include a range of demographic and farm characteristics, as well as factors related to knowledge, willingness, and ability to comply (Donkoh et al., 2019; Araya, 2020; Yirga et al., 2015). Based on a thorough review of the relevant literature, this study hypothesizes that various demographic and institutional factors significantly influence compliance with BSSPs among farmers in the study area. Detailed definitions of these explanatory variables are presented in Table 1, providing clarity on their operationalization in the analysis.

Results

Farmer's knowledge, attitude, willingness and ability to comply with BSSPs

The results of this study indicated that majority (83.4%) of the farmers understand that using recommended personnel to treat animals when they fall sick reduces the risk of disease outbreak and spread on a farm while 87.5 had a positive attitude regarding the use of recommended and qualified personnel when animals fall sick to ensure production of quality meat or beef. In addition, 86.3% were willing to use recommended personnel to treat animals when they fall sick. However, only 48.8% of the respondents were able to comply with using of recommended personnel to treat animals when they fall sick. This implies that Farmer knowledge, attitude, willingness regarding recommended personnel to treat animals when they fall sick was high (satisfactory) but the ability to comply was low (unsatisfactory). Regarding buying drugs from licensed veterinary drug shops, 76.9% were knowledgeable while 81.1% had a positive attitude that buying drugs from licensed veterinary drug shops ensures they are using good-quality approved products. However, only 57.7% and 39.1% were willing and able to buy drugs from licensed veterinary drug shops, respectively. The results suggest that, although farmers are knowledgeable and have positive attitude to buy veterinary drugs from licensed shops, their willingness and ability to comply was low (unsatisfactory).

TABLE 2 The knowledge, perception, willingness and ability of farmers to comply with BSSPs.

Serial	Variable	Knowledge (%)	Perception (%)	Willingness (%)	Ability to comply (%)
1	Observed treatment of animals by recommended personnel when they fall sick	83.4	87.5	86.3	48.8
2	Bought veterinary drugs from recommended sources (Vet, Paravet, licensed drug shop)	76.9	81.1	57.7	39.1
3	Eating dead animals is harmful to human health	90.4	92.0	91.2	74.6
4	It is not allowed by law to sell a sick animal	84.7	86.0	78.5	64.6
5	You are not supposed to slaughter a sick animal for sale	86.7	86.4	80.2	66.3
6	You only slaughter an animal that has recovered from sickness after a specified period of time	85.3	86.7	75.6	63.4
AVERAGE SCORE		84.6	86.6	78.3	59.5

Source. computed by researcher.

Concerning the BSSP of "Not eating beef from dead animals" as it is harmful to human health, 90.4% of the farmers understand that eating beef from dead animals is harmful to human health and 92% had a positive attitude that indeed eating beef from dead animals is harmful to human health. In addition, 91.2% were willing not to eat beef from dead animals. On the other hand, only 74.6% of the respondents were able not to eat beef from dead animals. This implies that farmer knowledge, attitude and willingness to comply with the BSSP was high (satisfactory) but the ability to comply was low (unsatisfactory). Furthermore, 84.7% of the farmers were aware that it is not allowed by law to sell a sick animal and 86.0% had a positive attitude that indeed a sick animal should not be sold in order to ensure production of quality meat/beef. On the other hand, 78.5% were willing not to sell sick animals while only 64.6% are able not to sell sick animals Table 2. This implies that while Farmer knowledge and attitude were high (satisfactory), willingness and ability to comply were unsatisfactory.

The study also found out that 86.7% of the respondents were aware that they should not slaughter a sick animal for sale or consumption, 86.4% had a positive attitude that this is indeed right in assuring quality of beef and 80.2% were willing not to slaughter sick animals for sell or consumption. However, only 66.3% of the respondents reported being able not to slaughter a sick animal for sale or consumption. This implies that while Knowledge, attitude and willingness were satisfactory, ability was low (unsatisfactory).

Furthermore, the study found that 85.3% of the respondents were aware that you only slaughter an animal that has recovered from sickness after a specified period of time, 86.7% had a positive attitude that indeed an animal that has recovered from sickness has to be slaughtered after a specified period of time. However, only 75.6% of the respondents were willing to comply and 63.4% of the respondents were able to comply implying that the willingness and ability to comply with slaughtering an animal that has recovered from sickness after a specified period of time was low (unsatisfactory). Overall, about 85% of farmers are knowledgeable of BSSPs at farm level and a higher percentage (87%) have a positive attitude to complying with BSSPs. On the other hand, those that are willing to comply with BSSPs are 78% while only 60% are able to comply. In general, knowledge and attitude are high (satisfactory) but the challenge is willingness and ability to comply with the specific BSSPs.

Compliance with BSSPs

Practices of farmers towards compliance with BSSPs

Cattle farmers who complied with treatment of animals by recommended personnel when they fell sick were 79% and 70% of the farmers bought veterinary drugs from recommended sources whereas 33% and 31% observed withdrawal periods for slaughtering and selling cattle after treatment, respectively. On the other hand, 45% observed recommended practices on what to do with the carcass if a sick animal dies, i.e., burry or incinerate while 19% complied with BSSPs after treatment and animal fails to get better (Table 3).

Farmers that are likely to comply

This study found out that, the proportion of farmers who are likely to comply with having their animals treated by recommended personnel was higher among farmers who were not members of a farmers group than those who were not. In addition, farmers who acknowledged deterrence failure regarding

TABLE 3 Practices of farmers towards compliance with BSSPs.

Variable	Frequency	Percentage
Observed treatment of animals by recommended personnel when they fall sick	1,115	79.0
Bought veterinary drugs from recommended sources (Vet, Paravet, licensed drug shop)	984	69.7
Observed drug withdrawal period before slaughtering cattle	467	33.1
Observed drug withdrawal period before selling cattle off alive	444	31.2
Complied with BSSPs after treatment and animal fails to get better	274	19.4
Buried or incinerated a sick animal when it dies	638	45.2

Source. computed by researcher.

the BSSP and being at odds with culture were less likely to comply with having their animals treated by recommended personnel. On the other hand, the proportion of farmers who were knowledgeable about having their animals treated by recommended personnel, those farmers that acknowledged presence of administrative capacity proxied by their facing of administrative sanctions were more likely to comply (Table 4).

The proportion of farmers who were more likely to comply with buying veterinary drugs from the recommended sources are those that are knowledgeable, have positive attitude and are willing to comply, and who are schooled or educated. Similarly, those that cite deterrence failure were less likely to comply with buying veterinary drugs from the recommended source Furthermore, the proportion of farmers who were less likely to comply with buying veterinary drugs from recommended sources was significantly high among farmers in group, farmers with higher cattle keeping experience, higher number of cattle kept and those that are able to comply or afford veterinary drugs (Table 4).

This study findings also reveal that the proportion of farmers who complied with observation of drug withdrawal period before slaughtering for beef was higher among those who were those who were knowledgeable, had positive attitude, willing to comply and those that acknowledged deterrence failure. On the other hand, farmers who were less likely to comply with drug withdrawal periods before slaughter were literate, more schooled, members of the group, trained in BSSPs, experienced in cattle keeping and those that had ability to comply. Farmers who: were knowledgeable, had a positive attitude, were willing to comply, had experienced administrative sanctions and acknowledged failure of civil society were significantly higher in proportion than those who were not regarding compliance with drug withdrawal period before selling an animal. In addition, farmers who were literate, more schooled, willing to comply, trained, knowledgeable, had higher cattle numbers, a positive attitude, were significantly higher in terms of proportion of farmers who were likely to comply with BSSP for animal that is treated and fails to get better than those who were not.

This study's findings revealed that the practice of burying or incinerating a sick animal whenever it dies was more prevalent among farmers who complied with the recommended guidelines than among those who did not. More specifically, farmers who complied, demonstrated a significantly higher average number of cattle kept and were literate, more schooled and trained. Furthermore, there were proportionately more farmers who cited failure of civil society and high costs of compliance as reasons for their non-compliance compared to those who did not identify these barriers. These findings underscore the importance of literacy, years of schooling, Cattle keeping Experience, membership of farmer's group, training, knowledge, attitude, willingness to comply, administrative capacity, presence of civil society, deterrence failure, among others, in influencing compliance with beef safety practices.

Factors influencing farmers' compliance with BSSPs

The multivariate probit model's estimates, as summarized in Table 5, provide valuable insights into the factors influencing farmers' compliance with Beef Safety Standard Practices (BSSPs).

The Wald chi-square test demonstrated that the overall significance of the variables included in the model was significant at the 5% level, indicating that the explanatory variables collectively have a meaningful impact on compliance decisions. Furthermore, the likelihood ratio test for the null hypothesis of independence among compliance decisions yielded significant results at the same significance level, leading to the rejection of the null hypothesis that all correlation coefficients (ρ values) are jointly equal to zero. This outcome suggests a robust goodness-of-fit for the model, confirming that compliance decisions regarding BSSPs are indeed interdependent rather than independent. Consequently, the decision to employ a multivariate probit model was justified, as it effectively captures the complex relationships among compliance decisions and facilitates a nuanced understanding of the factors influencing adherence to specific BSSPs. This

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TABLE 4 Mean Statistical differences in compliance levels on BSSPs among farmers.

Farmer Characteristics	Compliance with Beef Safety Standard Practices					
	Farmers complied with treatment of animals by recommended personnel when they fall sick (n = 1,411)	Farmers complied with buying of veterinary drugs from recommended sources (Vet, Paravet, licensed drug shop) (n = 1,411)	Farmers Complied with drug withdrawal period before slaughtering for Beef (n = 1,411)	Farmers Complied with drug withdrawal period before selling (n = 1,411)	Farmers Complied with BSSP for animal that is treated and fails to get better (n = 1,411)	Farmers complied with what to do when sick animal dies (n = 1,411)
Gender	−0.0024	0.0475	0.0306	0.0141	−0.0091	−0.0135
Marital status	0.0039	0.0122	0.0511	0.1124***	0.1005***	0.1191***
Literacy	−0.0148	−0.0116	0.0647*	0.0199	−0.1513***	−0.6526*
Years of schooling	−0.6597*	−0.7559**	0.3302*	−0.1907	−2.5355***	−1.0476***
Cattle keeping Experience	5.4304***	8.9020***	2.9793***	2.4865**	1.3989	3.9881***
Cattle number	−0.6871	34.9601***	4.4410	6.9215	−13.1146*	−0.6526*
Membership of farmers group	0.1179***	0.0804*	0.08016*	0.1439***	−0.0367	−0.0378
Training on BSSPs	0.0069	-0.0356	0.1890***	0.2078***	−0.0876**	−0.0697*
Knowledgeable about BSSPs	−0.1456***	−0.2365***	−0.1337***	−0.1819***	−0.0795***	−0.0869*
Opinion regarding	0.0268	0.0668*	−0.0007	−0.0817**	−0.1088***	0.1281***
Willing to comply with BSSP	−0.1155***	−0.2727***	−0.1435***	−0.1470***	−0.8711***	0.0599*
Able to comply with BSSP	0.1730	0.0673*	0.0080**	0.0337	0.1829***	−0.0148
Administrative capacity/sanctions	−0.0970**	−0.0564	−0.0159	−0.1457***	0.0877*	−0.0339
Failure of civil society	−0.0304	−0.0039	−0.2152***	−0.2132***	0.0997***	−0.1616***
Deterrence failure	0.1536***	−0.1459***	−0.1775***	0.0418	0.0245	−0.2434
Regulation at odds with culture	0.4068***	0.4998***	0.1827	0.1186	−0.1775*	0.0684
High cost of compliance	−0.0043	0.1585***	−0.0403	−0.2343***	0.0007	−0.2541***
Eastern versus Central Region	−0.0654**	0.2413***	−0.2298***	−0.4219***	0.1768***	0.4746***
Eastern versus Western Region	−0.2473***	−0.3462***	−0.3415***	−0.3285***	0.1024***	−0.0993***
Central versus Western Region	−0.1819***	−0.5875***	−0.1117***	0.0933***	−0.0744**	−0.5740***

***p value < 0.001, **p value < 0.01, *p value < 0.05.

methodological approach enhances the reliability of the findings, providing a solid foundation for developing targeted interventions aimed at improving compliance among farmers in the agricultural sector.

The estimates derived from the multivariate probit model, as summarized in Table 5, provide critical insights into the factors influencing farmers' compliance with Beef Safety Standard Practices (BSSPs). The analysis revealed that the presence of

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TABLE 5 Multivariate Probit Model for factors determining farmers' compliance with BSSPs.

	Farmers complied with treatment of animals by recommended personnel when they fall sick	Farmers bought drugs from a veterinarian, paravet or licensed drug shop	Farmers complied with drug withdrawal period before slaughtering for Beef	Farmers complied with drug withdrawal period before selling	Farmers complied with BSSP for animal that is treated and fails to get better	Farmer complies with what to do when sick animal dies
Years of schooling	0.0141(0.0085)	0.0352***(0.0095)	0.0024(0.0080)	0.0060(0.0081)	0.0452***(0.0093)	0.0334***(0.0079)
Cattle farming experience	−0.0029(0.0029)	−0.0112(0.0029)	−0.0027(0.0030)	−0.0020(0.0029)	−0.0054(0.0035)	−0.0045(0.0029)
Membership of Farmers group	−0.1351(0.1179)	0.1218(0.1360)	0.2647*(0.1200)	−0.0314(0.1253)	0.0699(0.1303)	0.2256*(0.1136)
Training	0.0909(0.1113)	0.3221**(0.1221)	−0.3457**(0.1130)	−0.6760***(0.1223)	−0.0502(0.1112)	0.1012(0.1069)
Knowledgeable of BSSPs	0.1032(0.1484)	−0.3124(0.1690)	−0.1746(0.1277)	0.1794(0.1323)	0.3366*(0.1576)	−0.1914(0.1290)
Opinion/ Attitude regarding BSSPs	−0.1891(0.1139)	0.0622(0.1218)	0.1349(0.1104)	0.0580(0.1108)	0.0706(0.1271)	−0.0754(0.1072)
Willingness to comply with BSSPs	−0.0861(0.1303)	0.5091***(0.1458)	0.0560(0.1087)	−0.0123(0.1135)	0.1335(0.1317)	−0.3290**(0.1110)
Ability to comply with BSSPs	−0.0694(0.1284)	−0.0116(0.1341)	0.0986(0.1258)	0.2047(0.1288)	0.4535**(0.1347)	0.3020*(0.1218)
Administrative capacity/ sanctions	0.3185*(0.1576)	0.2622(0.1471)	0.0020(0.1312)	0.3518**(0.1253)	−0.3555(0.1685)	0.3609**(0.1248)
Failure of civil society	0.0455(0.1028)	0.1711(0.1019)	0.3324***(0.0950)	0.1449(0.0948)	0.0490(0.1143)	0.0431(0.0936)
Deterrence failure	−0.6014***(0.1278)	−0.5368**(0.1620)	0.7767***(0.1225)	0.6018***(0.1324)	−0.9683***(0.14859)	−0.5041***(0.1284)
Regulations at odds with culture	−0.5860*(0.2960)	−0.4916(0.3248)	−0.3898(0.3628)	−0.4304(0.3423)	0.7164*(0.3330)	0.35480(0.2982)
Cost of compliance	−0.1612(0.1115)	0.03630(0.1264)	−0.0766(0.1038)	0.0914(0.1083)	0.1180(0.1233)	−0.1188(0.1037)
Central Region	0.0063(0.1425)	2.3993***(0.2937)	−0.8639***(0.1312)	−1.379363***(0.1443)	1.1933***(0.1387)	1.6490***(0.1356)
Western Region	−0.8315***(0.1553)	−0.8428***(0.1556)	−0.9550***(0.1450)	−0.6485***(0.1421)	0.6844***(0.1782)	−0.7016***(0.1406)
Constant	1.3956***(0.1711)	0.3013(0.1836)	−0.2262(0.1539)	−0.3302*(0.1588)	−2.1234***(0.1975)	−0.3293**(0.1523)
Log likelihood value						−3654.7871
Wald test X^2 (90)						1245.29
LR test of ρ_{ki}						468.822
Number of observations						1,355

administrative capacity and effective sanctions positively correlated with compliance regarding the treatment of animals by recommended personnel when they become ill. Conversely, several factors negatively impacted compliance with this particular BSSP, including cultural conflicts with existing regulations, failures in deterrence mechanisms, and geographic

differences, specifically farmers from the Ankole Sub region compared to those from the Teso Sub region. Interestingly, the analysis found no significant evidence linking years of schooling, cattle farming experience, membership in farmers' groups, or training to compliance with this specific BSSP. In contrast, compliance with the BSSP related to purchasing drugs from veterinarians, paravets, or licensed drug shops was positively influenced by factors such as years of schooling, training, a willingness to comply with BSSPs, and being from the Buganda Sub region. However, similar to the previous findings, deterrence failures and affiliation with the Ankole Sub region were associated with lower compliance levels for this BSSP. Additionally, the evidence did not support significant influences from other factors, including cattle farming experience, membership in farmers' groups, knowledge of BSSPs, or attitudes toward BSSPs. These findings highlight the complexity of compliance behavior among farmers and suggest that targeted interventions focusing on enhancing administrative capacity and addressing cultural conflicts may be essential for improving adherence to BSSPs in the agricultural sector.

In the context of compliance with the Beef Safety Standard Practice (BSSP) concerning the observation of drug withdrawal periods before slaughtering beef, membership in farmers' groups emerged as a significant positive influencer of compliance. Notably, the findings revealed a counterintuitive relationship where both failures in civil society and deterrence mechanisms were also associated with increased compliance, suggesting that these factors may inadvertently motivate adherence to regulations under specific circumstances. Conversely, several factors negatively impacted compliance with this BSSP, including training and regional affiliation, particularly for those from the Ankole and Buganda Sub regions compared to their counterparts in the Teso Sub region. This unexpected outcome raises questions about the effectiveness of training programs in these Sub regions and highlights the need for further investigation into the contextual factors at play. Regarding compliance with the BSSP on drug withdrawal periods before selling animals, the presence of administrative capacity and sanctions, alongside deterrence failures, again demonstrated a significant positive impact, despite the counterintuitive nature of these relationships. In contrast, similar to the previous analysis, being from the Buganda or Ankole Sub regions and the influence of training were identified as factors that negatively affected compliance with this BSSP. Overall, the analysis did not reveal significant associations between a range of demographic and institutional factors and compliance decisions. These findings underscore the complexity of compliance behavior within the agricultural sector and suggest that further research is needed to explore the nuanced interactions between social, cultural, and institutional influences on adherence to BSSPs. Targeted strategies that address these dynamics may enhance compliance rates and improve the overall effectiveness of beef safety standards.

The findings further revealed that factors such as years of schooling, knowledge of Beef Safety Standard Practices (BSSPs), and the ability to comply with these practices positively influenced compliance with the BSSP of burying or incinerating sick animals that die after they have been treated but ultimately fail to recover. Conversely, deterrence failure was found to have a detrimental effect on compliance with this particular BSSP, suggesting that ineffective deterrents may undermine adherence to recommended practices. In line with previous results, the analysis indicated that no significant impacts were observed for a range of other factors. This highlights the importance of focusing on educational and informational interventions to enhance knowledge and compliance among farmers. For the BSSP addressing the appropriate actions to take when a sick animal dies, several variables, including years of schooling, membership in farmers' groups, the ability to comply with BSSPs, the presence of administrative capacity and sanctions, as well as deterrence failure, were all found to exert significant positive effects on compliance. Overall, the analysis did not uncover significant evidence linking various demographic or institutional factors to compliance decisions. These findings underscore the multifaceted nature of compliance behavior in the agricultural sector, suggesting that targeted educational initiatives and strengthened administrative frameworks could enhance adherence to BSSPs. Further research is necessary to unpack the intricate dynamics influencing farmers' compliance and to develop effective strategies for promoting adherence to beef safety standards.

Discussion

The objective of this study was to assess whether cattle farmers are knowledgeable, have positive attitudes, are willing, and are able to comply with Beef Safety Standard Practices (BSSPs); to evaluate the actual compliance of farmers with BSSPs; and to determine the influence of farmers' knowledge, attitudes, willingness, and ability on compliance with BSSPs. The results of the study indicated that approximately 85% of farmers were knowledgeable about BSSPs, and 87% had a positive attitude towards complying with these practices. This finding aligns with previous research that emphasizes the importance of knowledge and positive attitudes in promoting compliance with agricultural safety standards. However, despite this satisfactory level of knowledge and attitude, only 78% of farmers expressed willingness to comply, and a mere 60% demonstrated the ability to do so. This discrepancy suggests that while farmers understand the importance of BSSPs and believe in their efficacy, external factors may hinder their compliance. This has affected compliance with BSSPs significantly, as high knowledge and positive attitudes do not necessarily translate into action. The observed phenomenon of high knowledge and positive attitudes among farmers regarding Beef Safety Standard Practices (BSSPs),

coupled with moderate willingness and low ability to comply, can be attributed to several interrelated factors:

External barriers

Despite farmers' understanding of Beef Safety Standard Practices (BSSPs), external barriers such as economic constraints and lack of resources can significantly hinder their ability to comply. The costs associated with implementing safety practices can be prohibitive, particularly for small-scale farmers who often operate with limited budgets. For example, the purchase of high-quality veterinary drugs from licensed sources can represent a substantial financial burden. While these products are essential for ensuring animal health and safety, their prices are often higher than those of unregulated alternatives available in local markets. This creates a dilemma for farmers who may opt for cheaper, potentially inferior products due to budget constraints, thereby compromising compliance with BSSPs. Additionally, the costs of training and education programs aimed at improving farmers' knowledge of BSSPs can be significant. Many farmers may not have the time or financial resources to participate in these programs, which can limit their understanding of best practices and reduce their willingness to comply. A study by Khan et al. (2024) emphasized that financial limitations often restrict compliance with safety standards in agricultural settings, particularly when training programs require fees or transportation costs.

Additionally, infrastructure costs also pose a challenge. Farmers may need to invest in facilities such as proper storage for veterinary drugs, equipment for safe handling and disposal of animal carcasses, or modifications to their barns to comply with safety standards. These infrastructure upgrades can require substantial capital investment, which many farmers may not be able to afford. Moreover, ongoing compliance costs, such as regular veterinary visits and health monitoring of livestock, can add to the financial strain. Farmers may need to budget for these recurring expenses, which can detract from their overall profitability, especially during lean seasons or in the event of unexpected veterinary emergencies. An additional economic pressure arises from the losses incurred when farmers opt not to sell diseased animals or carcasses. While compliance with BSSPs mandates that sick animals be treated appropriately and not sold, the immediate financial impact of not selling these animals can be significant. Farmers may face substantial losses, particularly if they have invested time and resources in raising these animals. The decision to refrain from selling a diseased carcass, although ethically and legally sound, can lead to a direct loss of income, further complicating their financial situation.

In summary, the economic barriers to compliance with BSSPs are multifaceted and include costs related to purchasing quality inputs, participating in training, upgrading infrastructure, and maintaining ongoing veterinary care. The potential losses from not selling diseased animals or carcasses exacerbate these challenges, leading farmers to prioritize immediate economic survival over long-term compliance with safety standards. This ultimately affects the overall effectiveness of BSSPs in enhancing food safety and animal health.

Lack of trainings on BSSPs and Support

While farmers may possess knowledge about Beef Safety Standard Practices (BSSPs), the absence of practical training can create a significant gap in their ability to implement these practices effectively. Knowledge alone is insufficient if it is not paired with the skills necessary for real-world application. Training programs are crucial for translating theoretical knowledge into actionable practices, as they equip farmers with the hands-on experience and confidence required to comply with BSSPs. For instance, training sessions can cover a range of essential topics, including proper animal handling, effective disease management, and safe use of veterinary drugs. Workshops that incorporate demonstrations and practical exercises allow farmers to engage directly with the practices they are expected to adopt. This experiential learning approach is vital, as it helps to solidify understanding and encourages farmers to apply their knowledge in everyday situations. Moreover, the benefits of training extend beyond individual farmers; they can have a ripple effect on entire communities. When farmers are trained in BSSPs, they are more likely to share their knowledge with peers, fostering a culture of safety and compliance within their social networks. This community-based approach to training can amplify the impact of educational initiatives and lead to widespread improvements in compliance rates.

However, the current training landscape often falls short. Many farmers lack access to comprehensive training programs due to logistical challenges, financial constraints, or insufficient outreach by agricultural extension services. In many Sub regions, training may be sporadic or poorly structured, leaving farmers without the ongoing support they need to adapt to evolving standards and practices. The importance of continuous education is underscored by findings from a study by Tefera Mekasha et al. (2024) which emphasized that ongoing training is essential for enhancing compliance of veterinary care professionals to guidelines. Similarly, in agriculture, continuous education can help farmers stay updated on the latest safety standards, technological advancements, and best practices in animal husbandry. Additionally, mentorship programs that pair experienced farmers with those who are less knowledgeable can also play a significant role in bridging the training gap. These relationships can provide practical insights and foster a supportive environment where less experienced farmers feel comfortable seeking guidance.

Social and cultural influences

Social norms and cultural beliefs can significantly impact farmers' willingness to adopt Beef Safety Standard Practices (BSSPs). If the prevailing attitudes within a community do

not prioritize safety practices, individual farmers may feel less inclined to comply, even if they understand the importance of these practices. This is supported by research indicating that social networks play a significant role in shaping compliance behaviors, as farmers often look to their peers for cues on acceptable practices and behaviors. Moreover, cultural factors can influence how farmers perceive the necessity and relevance of BSSPs. In communities where traditional practices are deeply rooted, there may be resistance to adopting new standards, even when they are scientifically validated. This resistance can stem from a lack of trust in external regulations or a belief that existing practices are sufficient. Additionally, social capital, which encompasses the relationships and networks among individuals, can facilitate or hinder the adoption of BSSPs. Farmers who are part of strong social networks may be more likely to share information and resources related to BSSPs, thereby increasing their willingness to adopt these practices. Conversely, those who are isolated or lack supportive networks may struggle to implement BSSPs effectively. All this is in agreement with studies by Castillo et al. (2021) and Hayden et al. (2021) who reported that social and cultural influences are critical factors that shape farmers' willingness to adopt BSSPs, highlighting the need for community engagement and tailored interventions that consider local norms and values.

Perceived efficacy and trust in regulations

Farmers' willingness to comply with Beef Safety Standard Practices (BSSPs) is significantly influenced by their perceptions of the efficacy of these regulations and their trust in the associated regulatory bodies. When farmers perceive that BSSPs are ineffective or poorly enforced, their motivation to adhere to these standards diminishes, which can have detrimental effects on overall compliance rates. A critical aspect of this dynamic is the belief in the tangible benefits of compliance. Farmers are more likely to engage with BSSPs if they see clear, measurable outcomes, such as improved animal health, increased market access, or enhanced profitability. If compliance with BSSPs does not yield noticeable advantages, farmers may question the necessity of adhering to these practices. This skepticism can be exacerbated in environments where compliance costs are high and the perceived return on investment is low.

According to Igbinenikaro and Adewusi (2024), trust in regulatory frameworks is paramount for compliance to take effect. Farmers who lack confidence in the integrity and effectiveness of regulatory bodies may feel that compliance is futile. For example, if farmers believe that regulations are inconsistently enforced or that non-compliance goes unpunished, they may be less inclined to invest time and resources into meeting these standards. This lack of trust can stem from past experiences with regulatory oversight or a perception that regulatory bodies do not adequately understand the challenges faced by farmers in their specific contexts. In addition, Mack et al. (2024) highlighted the importance of trust in regulatory frameworks as a critical factor for promoting compliance in agricultural practices. They reported that when farmers perceive regulatory bodies as transparent, supportive, and responsive to their needs, their willingness to comply increases. Effective communication and engagement strategies can enhance this trust, allowing farmers to feel more valued and understood. Furthermore, fostering a collaborative relationship between farmers and regulatory agencies can lead to more effective implementation of BSSPs.

Factors influencing compliance of farmers with BSSPs

Farmers who were likely to comply with BSSPs were those who were members of farmers' groups, had received training on BSSPs, and possessed higher levels of education and farming experience as discussed below.

Educational level and compliance with BSSPs

Higher education levels are positively associated with better compliance with Beef Safety Standard Practices (BSSPs), as educated farmers possess a greater capacity to comprehend the complexities of these regulations. This understanding enables them to navigate compliance requirements more effectively, ensuring adherence to safety standards that protect both animal health and consumer safety. Education fosters critical thinking and problem-solving skills, allowing farmers to adapt practices to their specific contexts and address challenges in a dynamic agricultural environment. Furthermore, higher education often correlates with improved access to information and resources, including research findings and best practices in animal husbandry, which enhances compliance rates. Educated farmers are generally more aware of the benefits of adhering to safety standards, such as increased market access and enhanced consumer trust, leading to a more proactive compliance approach. Additionally, higher education facilitates stronger social networks among farmers, promoting knowledge sharing and collective action through participation in agricultural organizations. Collectively, these factors underscore the significant role that education plays in driving compliance with BSSPs in the agricultural sector. This finding is in agreement with those by Delgado-Demera et al. (2024) who found a direct correlation between education and compliance with regulations, suggesting that higher education levels enhance farmers' understanding of BSSPs and their importance for animal health and food safety.

Experience in cattle keeping

Experience in cattle farming exhibits a complex relationship with compliance to Beef Safety Standard Practices (BSSPs), as evidenced by the negative coefficients present in the data. Specifically, the coefficients indicate a

decline in adherence to critical practices, such as purchasing drugs from veterinarians or licensed drug shops, which is reflected in a coefficient of −0.0112. This suggests that increased experience does not necessarily correlate with improved compliance; in fact, seasoned farmers may develop complacency, relying on entrenched practices that could be misaligned with current safety regulations (Creamer and Horback (2024).). Such complacency might stem from a false sense of security regarding traditional methods, leading experienced farmers to underestimate the importance of adhering to updated safety protocols (Charlebois and Summan, 2014). Additionally, resistance to change is often observed among long-term practitioners, who may be reluctant to adopt new practices or comply with evolving regulations, preferring to stick to familiar methods that they believe have worked in the past (Buckley, 2015). This phenomenon underscores the importance of ongoing education and engagement strategies that not only promote compliance but also encourage experienced farmers to embrace new evidence-based practices. By addressing these challenges, stakeholders can significantly enhance adherence to BSSPs across the farming community, ensuring better animal health and safety outcomes.

Membership in farmer groups

The findings concerning membership in farmers' groups reveal a nuanced relationship with compliance to Beef Safety Standard Practices (BSSPs). Notably, the negative coefficient associated with seeking treatment from recommended personnel suggests that group dynamics may foster a reliance on informal networks, which could divert farmers from adhering to established formal recommendations. This reliance on peer networks may lead to the perpetuation of traditional practices that do not align with contemporary safety standards, thereby hindering compliance. Conversely, the positive association between group membership and compliance related to drug purchases indicates that farmers' groups can serve as vital sources of support and resources, creating an environment in which members feel empowered and well-informed about appropriate agricultural practices. This duality underscores the complex role that group membership can play in agricultural compliance; while shared knowledge and collective engagement can enhance adherence to safety standards, informal practices may simultaneously present challenges to achieving comprehensive compliance. These findings resonate with Pretty (2003), who highlights that while farmers' groups can be instrumental in promoting compliance, they may also inadvertently contribute to non-compliance when informal dynamics overshadow formal safety protocols. Addressing this complexity is crucial for designing effective interventions that harness the strengths of group membership while mitigating its potential drawbacks.

Receiving trainings on BSSPs

The analysis of training's impact on compliance with Beef Safety Standard Practices (BSSPs) reveals a nuanced relationship across various compliance measures. Notably, the coefficient for training demonstrates a positive effect on purchasing drugs from veterinarians or licensed drug shops, indicating that farmers who receive training are more likely to adhere to this critical safety practice. However, the training also correlates negatively with compliance regarding drug withdrawal periods before slaughtering and selling suggesting that trained farmers may face challenges in applying these specific regulations effectively. This discrepancy may arise from a misalignment between the training content and the practical realities of compliance, highlighting the importance of ensuring that training programs are relevant and applicable to farmers' operational contexts. Moreover, the variability in training outcomes emphasizes the need for comprehensive educational initiatives that not only enhance knowledge but also facilitate the practical application of BSSPs in daily farming activities. By addressing these complexities and tailoring training to meet the specific needs of farmers, stakeholders can significantly improve adherence to BSSPs, ultimately promoting better animal health and safety standards within the beef industry (Charlebois and Summan, 2014; Buckley, 2015).

Cost of compliance

The findings indicate that the cost of compliance significantly affects adherence to Beef Safety Standard Practices (BSSPs), as evidenced by a negative coefficient of associated with compliance in seeking treatment from recommended personnel. This suggests that higher compliance costs deter farmers from accessing veterinary services and purchasing necessary medications, thereby leading to a reliance on informal treatment methods that may not align with established safety standards. While compliance costs represent a barrier, the lack of significant effects on other compliance measures implies that these costs are not the sole determinant of adherence behavior. Factors such as knowledge, willingness to comply, and administrative support may play a more pivotal role in influencing compliance decisions (Charlebois and Summan, 2014; Buckley, 2015). Moreover, farmers who recognize the long-term benefits of compliance, including improved animal health and enhanced market access, may perceive compliance costs as necessary investments rather than obstacles. Therefore, addressing financial barriers while simultaneously enhancing farmers' understanding of the value of compliance is crucial for improving adherence to BSSPs in the beef industry.

Farmers' attitude regarding BSSPs

Farmers' attitudes toward Beef Safety Standard Practices (BSSPs) significantly influence their compliance with various safety measures, as indicated by the coefficients in the provided table. The negative coefficient for attitude regarding BSSPs

correlates with compliance in treating animals by recommended personnel when they fall sick, suggesting that a negative or indifferent attitude may hinder adherence to safety protocols in this critical area. According to Nyokabi et al. (2023), if farmers do not perceive the value or importance of BSSPs, they are less likely to seek appropriate treatment for sick animals, jeopardizing animal health and safety. Conversely, while the coefficient for attitude towards BSSPs shows no statistically significant impact on purchasing drugs from licensed sources it demonstrates a slight positive influence on compliance with practices related to animals that fail to improve after treatment. This indicates that a favorable attitude could lead to better compliance in critical decisions regarding animal welfare. Moreover, the negative correlation for willingness to comply with BSSPs suggests that even with a positive attitude, external factors or perceived barriers may still undermine farmers' commitment to compliance. In summary, farmers' attitudes toward BSSPs play a crucial role in shaping their compliance behaviors. A negative or indifferent attitude can lead to decreased adherence to essential safety practices, while a more positive outlook may enhance compliance, particularly in critical decision-making scenarios. Therefore, fostering supportive and positive attitudes toward BSSPs through targeted education and outreach is essential for improving compliance and promoting higher standards of animal health and safety in the beef industry.

Farmers' willingness to comply with BSSPs

Farmers' willingness to comply with Beef Safety Standard Practices (BSSPs) plays a pivotal role in determining their adherence to safety measures, as evidenced by the coefficients in the provided table. The coefficient for willingness to comply with BSSPs shows a significant positive impact on compliance in purchasing drugs from veterinarians or licensed drug shops indicating that farmers who express a strong willingness to comply are much more likely to seek appropriate veterinary care and medications for their livestock. This suggests that fostering a culture of compliance and reinforcing the importance of BSSPs can lead to better outcomes in animal health and safety. However, the willingness to comply also presents a nuanced picture in other areas. For instance, the negative coefficient for willingness to comply related to the protocol for what to do when a sick animal dies indicates that despite a general willingness to follow BSSPs, farmers may still face barriers or lack the necessary knowledge to act appropriately in specific situations. This discrepancy highlights the complexity of compliance behavior; while general willingness may be high, practical application can still be inconsistent.

Furthermore, the varying impacts of willingness to comply across different compliance measures suggest the necessity for targeted interventions. These interventions should not only promote a positive attitude toward BSSPs but also provide farmers with the practical tools and knowledge they need to implement these practices effectively. By addressing both the psychological and practical aspects of compliance, stakeholders can enhance the overall adherence to BSSPs, ensuring better outcomes for animal health and safety in the beef industry.

Administrative capacity/sanctions

Administrative capacity and sanctions play a crucial role in influencing farmers' compliance with Beef Safety Standard Practices (BSSPs), as indicated by the coefficients in the provided table. The coefficient for administrative capacity/sanctions shows a significant positive impact on compliance in several key areas, particularly in purchasing drugs from veterinarians or licensed drug shops and adhering to drug withdrawal periods before selling. This suggests that a strong administrative framework, coupled with clear enforcement of sanctions, encourages farmers to comply with safety regulations, highlighting the importance of governance in promoting adherence to BSSPs (Bunei et al. (2023). Moreover, the positive coefficient of for compliance with treatment protocols when animals fall sick indicates that effective administrative mechanisms can foster a sense of accountability among farmers, leading them to follow recommended practices more consistently. This accountability is essential for ensuring that farmers prioritize animal health and safety, which can have significant implications for public health and market access.

However, the coefficient for compliance with animal health protocols for treated animals that do not improve shows a negative correlation suggesting that while administrative capacity can promote compliance in certain areas, it may not be universally effective across all practices. This could indicate that specific challenges or barriers exist that prevent farmers from following through on recommendations, even in the presence of administrative support. In summary, the administrative capacity and enforcement of sanctions significantly affect farmers' compliance with BSSPs, promoting adherence to critical safety measures through accountability and governance. However, the varying impacts of administrative capacity across different compliance measures underscore the need for tailored strategies that address specific barriers to compliance. By enhancing administrative frameworks and ensuring that sanctions are effectively communicated and enforced, stakeholders can improve compliance and ultimately enhance animal health and food safety standards.

Deterrence failure

Deterrence failure significantly influences farmers' compliance with Beef Safety Standard Practices (BSSPs), as evidenced by the coefficients presented in the table. The negative coefficients for deterrence failure in multiple compliance areas suggest that inadequate enforcement of regulations and the perceived ineffectiveness of sanctions deter farmers from adhering to safety protocols. For example, the coefficients show substantial negative impacts on compliance with treatment protocols when animals fall sick and when

purchasing drugs from licensed sources. This indicates that when farmers believe that there will be little to no consequences for non-compliance, their motivation to follow established safety practices diminishes (Herzfeld and Jongeneel, 2012). Moreover, the significant positive coefficient for compliance with drug withdrawal periods before slaughtering and selling highlights a complex relationship: while deterrence failure negatively impacts compliance in some areas, it could indicate that when farmers perceive a risk of penalties for specific practices, they may comply more rigorously in those instances. This suggests that effective deterrence mechanisms can enhance compliance when farmers believe that non-adherence could lead to significant repercussions.

The overall trend indicates that failure in deterrence not only leads to lower compliance rates but also reflects a broader issue of trust in regulatory frameworks. If farmers do not perceive enforcement as credible or effective, they are less likely to take safety standards seriously, resulting in a cycle of non-compliance that can compromise animal health and food safety. In summary, deterrence failure emerges as a critical factor affecting compliance with BSSPs. Strengthening enforcement mechanisms and ensuring that penalties for non-compliance are perceived as credible could enhance adherence to safety practices among farmers, ultimately leading to better outcomes for animal health and public safety.

Sub regional differences

Sub regional differences significantly affect farmers' compliance with Beef Safety Standard Practices (BSSPs), as illustrated by the coefficients for the Buganda and Ankole Sub regions in the provided table 5. Farmers from the Buganda Sub region show a notable positive coefficient for compliance with purchasing drugs from veterinarians or licensed drug shops. This suggests that farmers in this Sub region are significantly more likely to adhere to this specific safety measure compared to farmers from other Sub regions. Additionally, the Buganda Sub region has a positive impact on compliance regarding drug withdrawal periods before selling indicating strong adherence to regulatory practices associated with livestock management in this area. However, the coefficient for compliance with drug withdrawal periods before slaughtering is negative suggesting that while there is a strong inclination to purchase drugs from licensed sources, compliance with other safety measures may be weaker. This discrepancy points to potential challenges or barriers specific to practices surrounding slaughtering, which may require further investigation.

In contrast, farmers in the Ankole Sub region exhibit significant negative coefficients across multiple compliance measures. For instance, the coefficient for compliance with treatment of animals by recommended personnel when they fall sick is indicating a strong tendency toward non-compliance in this area. Similarly, farmers from the Ankole Sub region show negative coefficients for purchasing drugs from licensed sources and for compliance with drug withdrawal periods before slaughtering. These findings suggest that farmers in the Ankole Sub region are less likely to follow BSSPs, reflecting potential systemic issues in compliance, such as lack of access to resources, inadequate training, or cultural barriers. The pronounced differences between the Buganda and Ankole Sub regions highlight the influence of Sub regional factors on compliance behaviors. The stronger compliance observed in the Buganda Sub region may be attributed to better access to resources, more effective governance, or stronger community support systems. Conversely, the challenges faced by farmers in the Ankole Sub region may indicate a need for targeted interventions, such as enhanced training, better access to veterinary services, and community engagement strategies to improve adherence to safety practices.

Conclusion and recommendations

Conclusion

This study aimed to assess cattle farmers' knowledge, attitudes, willingness, and ability to comply with Beef Safety Standard Practices (BSSPs), evaluate their actual compliance, and determine the factors influencing this compliance. While farmers exhibit satisfactory levels of knowledge and positive attitudes towards BSSPs, the challenges of willingness and ability to comply remain significant barriers. These findings underscore a critical gap: high levels of knowledge and positive attitudes do not necessarily translate into effective compliance. External barriers, such as economic constraints, lack of practical training, social and cultural influences, perceptions of efficacy, and trust in regulatory frameworks, play substantial roles in hindering compliance.

Recommendations

To enhance compliance with BSSPs among farmers, targeted interventions are necessary. First, addressing economic barriers through financial assistance programs or subsidies for purchasing veterinary drugs and upgrading infrastructure could alleviate the financial burden on farmers, enabling them to invest in compliance. Additionally, comprehensive training programs that emphasize practical application and are tailored to the specific needs of farmers should be prioritized. Such programs can bridge the gap between theoretical knowledge and real-world application, fostering a culture of compliance. Furthermore, enhancing community engagement and support for farmers through mentorship programs could facilitate knowledge sharing and promote best practices. By integrating social networks into compliance strategies, farmers may feel more empowered to adopt BSSPs. Building trust in regulatory

frameworks is also crucial; this can be achieved through transparent communication and involving farmers in the development of safety standards, ensuring that regulations are relevant and practical.

Finally, addressing Sub regional disparities in compliance is essential. Tailored interventions that consider the unique challenges faced by farmers in different Sub regions such as better access to veterinary services in the Ankole Sub region can significantly improve adherence to BSSPs. In summary, while the knowledge and attitudes of cattle farmers towards BSSPs are promising, the ability and willingness to comply remain critical challenges. By implementing targeted strategies that address economic, educational, social, and regulatory factors, stakeholders can enhance compliance rates, ultimately leading to improved animal health, food safety, and overall sustainability within the beef industry.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

This study involved interviewing cattle farmers and was reviewed and approved by the Institutional Review Board (IRB) of Makerere University, Uganda. The researchers ensured that the ethical principles and guidelines for the protection of human subjects were strictly adhered to throughout the study. The participants, who were beef value chain actors, were fully informed about the purpose and procedures of the study. They were provided with clear and comprehensive information regarding their involvement, the voluntary nature of their participation, and their right to withdraw at any time without penalties. Written informed consent was obtained from each of the farmers prior to their participation in the study interviews and data collection activities.

Author contributions

PO, JI, KK, and NT, conceptualized and designed the study, supervised the study, and performed the analytical work. PO analyzed the collected data and wrote the first draft of the manuscript. JI, KK, and NT reviewed the manuscript. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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References

Araya, G. B. (2020). Impact of Ethiopia's productive safety net program on manure use by rural households: evidence from Tigrai Northern Ethiopia. *Agric. Econ.* 51 (5), 725–742. doi:10.1111/agec.12588

Assaye, A., Ketema, M., and Bekele, A. (2020). Smallholder farmers' adaptation strategies to climate change: The case of ankesha guagusa district of awi zone, northwestern Ethiopia. *J. Agric. Econom. Rural. Dev.* 6 (2), 760–772.

Baguma, J. (2018). *An assessment of food availability and access at household level in Busongora county north, Kasese district Doctoral dissertation*. Uganda Martyrs University.

Beckman, J., Johnson, M. E., Ajewole, K., Kaufman, J., and Sabala, E. (2025). The growing demand for animal products and feed in India: future prospects for production, trade, and technology innovation. Report No. ERR-347. doi:10.32747/2025.9015821

Bethmann, A., Bergmann, M., and Scherpenzeel, A. (2019). SHARE sampling guide–wave 8. SHARE Working Paper Series 33-2019.

Bogere, P., and Baluka, A. S. (2014a). Microbiological quality of meat at the Abattoir and butchery levels in Kampala city, Uganda. *Internet J. Food Saf.* 16 (January), 29–35.

Bogere, P., and Baluka, A. S. (2014b). Microbiological quality of meat at the Abattoir and butchery levels in Kampala city, Uganda. *Internet J. Food Saf.* 16 (January), 29–35.

Buckley, J. A. (2015). Food safety regulation and small processing: a case study of interactions between processors and inspectors. *Food Policy* 51, 74–82. doi:10.1016/j.foodpol.2014.12.009

Bunei, E. K., Barclay, E., and Kotey, B. (2023). Understanding factors leading to farmer non-compliance with agri-food safety regulations in Kenya: a quantitative analysis. *Int. J. Rural Criminol.* 8 (1), 59–81. doi:10.18061/ijrc.v8i1.9564

Castillo, G. M. L., Engler, A., and Wollni, M. (2021). Planned behavior and social capital: understanding farmers' behavior toward pressurized irrigation technologies. *Agric. Water Manag.* 243, 106524. doi:10.1016/j.agwat.2020.106524

Charlebois, S., and Summan, A. (2014). Abattoirs, meat processing and managerial challenges. *Int. J. Rural Manag.* 10 (1), 1–20. doi:10.1177/0973005214526504

Creamer, M., and Horback, K. (2024). Consistent individual differences in behavior among beef cattle in handling contexts and social-feed preference testing. *Appl. Animal Behav. Sci.* 276, 106315. doi:10.1016/j.applanim.2024.106315

Crumpler, K., Gagliardi, G., Otieno, Z., Dino Radin, M., Berrahmouni, N., Federici, S., et al. (2022). *Regional analysis of the nationally determined contributions in sub-Saharan Africa: gaps and opportunities in the agriculture and land use sectors*, 94. Food and Agriculture Org.

Delgado-Demera, M. H., Vasquez-Gamboa, L., Zambrano-Alcivar, E. R., Zambrano-Gavilanes, M. P., Vera-Loor, L. E., López-Rauschemberg, M. K., et al. (2024). Impact of the educational level of the owners on the implementation of good livestock practices on selected farms. *J. Animal Behav. Biometeorology* 12 (4), 2024027. doi:10.31893/jabb.2024027

Donkoh, S. A., Azumah, S. B., and Awuni, J. A. (2019). Adoption of improved agricultural technologies among rice farmers in Ghana: A multivariate probit approach. *Ghana J. Dev. Stud.* 16 (1), 46–67. doi:10.4314/gjds.v16i1.3

Falowo, A. B., and Akimoladun, O. F. (2019a). Veterinary drug residues in meat and meat products: occurrence, detection and implications. *Intech* i (Issue tourism, 13). doi:10.5772/57353

Grace, D. (2015). Food safety in low and middle income countries. *Int. J. Environ. Res. public health* 12 (9), 10490–10507. doi:10.3390/ijerph120910490

Greene, W. H. (2002). *Econometric analysis fifth edition book*. New York, USA: Macmillan.

Hayden, M. T., Mattimoe, R., and Jack, L. (2021). Sensemaking and the influencing factors on farmer decision-making. *J. Rural Stud.* 84, 31–44. doi:10.1016/j.jrurstud.2021.03.007

Herzfeld, T., and Jongeneel, R. (2012). Why do farmers behave as they do? Understanding compliance with rural, agricultural, and food attribute standards. *Land Use Policy* 29 (1), 250–260. doi:10.1016/j.landusepol.2011.06.014

Hodges, A. W., Court, C. D., Rahmani, M., and Stair, C. A. (2019). *Economic contributions of beef and dairy cattle and allied industries in Florida in 2017*, 71.

Hove-Sibanda, P., Awino, Z. B., and Agyemang, E. (2025). "Sustainable food supply chains and agricultural logistics in Africa," in *Eco-logistics and sustainable supply chain innovations* (IGI Global Scientific Publishing), 267–320.

Igbinenikaro, E., and Adewusi, A. O. (2024). Financial law: Policy frameworks for regulating fintech innovations: Ensuring consumer protection while fostering innovation. *Finance and Account. Res. J.* 6 (4), 515–530. doi:10.51594/farj.v6i4.991

Ilukor, J., Joyce, A., and Okiror, S. P. (2022). The impacts of COVID-19 on cattle traders and their response in agro-pastoral and pastoral regions in Uganda: a case of karamoja and Teso cattle traders. *Pastoralism* 12 (1), 18. doi:10.1186/s13570-022-00230-y

Izah, S. C., Sylva, L., and Hait, M. (2023). Cronbach's Alpha: a cornerstone in ensuring reliability and validity in environmental health assessment. *ES Energy and Environ.* 23, 1057. doi:10.30919/esee1057

Jeffer, S. B., Kassem, I. I., Kharroubi, S. A., and Abebe, G. K. (2021). Analysis of food safety management systems in the beef meat processing and distribution chain in Uganda. *Foods* 10 (10), 2244. doi:10.3390/foods10102244

Kassie, M., Teklewold, H., Jaleta, M., Marenya, P., and Erenstein, O. (2015). Understanding the adoption of a portfolio of sustainable intensification practices in eastern and southern Africa. *Land Use Policy* 42, 400–411. doi:10.1016/j.landusepol.2014.08.016

Khan, F. U., Nouman, M., Negrut, L., Abban, J., Cismas, L. M., and Siddiqi, M. F. (2024). Constraints to agricultural finance in underdeveloped and developing countries: A systematic literature review. *Int. J. Agric. Sustain.* 22 (1), 2329388. doi:10.1080/14735903.2024.2329388

Kyayesimira, J., Bunny, L. J., and Andama, M. (2020). Microbial quality of beef and hygiene practices in small and medium slaughterhouses and butcheries in Uganda.

Mack, G., Ritzel, C., Ammann, J., and El Benni, N. (2024). Improving the understanding of farmers' non-compliance with agricultural policy regulations. *J. Rural Stud.* 106, 103190. doi:10.1016/j.jrurstud.2023.103190

Michalk, D. L., Kemp, D. R., Badgery, W. B., Wu, J., Zhang, Y., and Thomassin, P. J. (2019). Sustainability and future food security—a global perspective for livestock production. *Land Degrad. and Dev.* 30 (5), 561–573. doi:10.1002/ldr.3217

Nanfuka, S., Mfitumukiza, D., and Egeru, A. (2020). Characterisation of ecosystem-based adaptations to drought in the central cattle corridor of Uganda. *Afr. J. Range and Forage Sci.* 37 (4), 257–267. doi:10.2989/10220119.2020.1748713

Ncayiyana, P. P. (2017). *The ethics of antibiotics use in animal farming Master's thesis*. Johannesburg (South Africa): University of the Witwatersrand.

Ngenoh, E., Kurgat, B. K., Bett, H. K., Kebede, S. W., and Bokelmann, W. (2019). Determinants of the competitiveness of smallholder african indigenous vegetable farmers in high-value agro-food chains in Kenya: a multivariate probit regression analysis. *Agric. Food Econ.* 7, 2–17. doi:10.1186/s40100-019-0122-z

Nicholas, J. G. (1991). Quantitative analysis of trace elements in carbonates using laser ablation inductively coupled plasma mass spectrometry. *J. Anal. At. Spectrom.* 6 (6), 445–449.

Njoga, E. O., Onunkwo, J. I., Okoli, C. E., Ugwuoke, W. I., Nwanta, J. A., and Chah, K. F. (2018). Assessment of antimicrobial drug administration and antimicrobial residues in food animals in Enugu State, Nigeria. *Trop. Animal Health Prod.* 50 (4), 897–902. doi:10.1007/s11250-018-1515-9

Nyokabi, N. S., Berg, S., Mihret, A., Almaw, G., Worku, G. G., Lindahl, J. F., et al. (2023). Adoption of biosecurity practices in smallholder dairy farms in Ethiopia. *Transbound. Emerg. Dis.* 2023 (1), 1–12. doi:10.1155/2023/2277409

Paulo, L. S., Lenters, V. C., Chillo, P., Wanjohi, M., Piedade, G. J., Mende, D. R., et al. (2025). Dietary patterns in Tanzania's transitioning rural and urban areas. *J. Health, Popul. Nutr.* 44 (1), 71. doi:10.1186/s41043-025-00774-w

Perkins, W. T., Fuge, R., and Pearce, N. J. G. (1991). Quantitative analysis of trace elements in carbonates using laser ablation inductively coupled plasma mass spectrometry. *J. Anal. Atomic Spectrom.* 6 (6), 445–449. doi:10.1039/ja9910600445

Pretty, J. (2003). Social capital and the collective management of resources. *Science* 302 (5652), 1912–1914. doi:10.1126/science.1090847

Randolph, T. F., Schelling, E., Grace, D., Nicholson, C. F., Leroy, J. L., Cole, D. C., et al. (2007). Invited review: role of livestock in human nutrition and health for poverty reduction in developing countries. *J. Animal Sci.* 85 (11), 2788–2800. doi:10.2527/jas.2007-0467

Sánchez-Zamora, P., Gallardo-Cobos, R., and Ceña-Delgado, F. (2014). Rural areas face the economic crisis: analyzing the determinants of successful territorial dynamics. *J. Rural Stud.* 35, 11–25. doi:10.1016/j.jrurstud.2014.03.007

Shah, J., and Alharthi, M. (2024). Factors affecting farmers' choice to adopt risk management strategies: the application of multivariate and multinomial probit models. *J. Integr. Agric.* 23 (12), 4250–4262. doi:10.1016/j.jia.2024.10.004

Tefera Mekasha, Y., Nigussie, S., Ashagre, W., Getahun Feleke, M., Wondie, A., Mulaw, A., et al. (2024). Evaluating the knowledge, practice, and regulatory situation of veterinary experts regarding counterfeit veterinary medications in the selected districts of Central Gondar zone, Ethiopia. *Veterinary Med. Res. Rep.* Vol. 15, 91–108. doi:10.2147/vmrr.s450560

Teklewold, H., Kassie, M., Shiferaw, B., and Köhlin, G. (2013). Cropping system diversification, conservation tillage and modern seed adoption in Ethiopia: impacts on household income, agrochemical use and demand for labor. *Ecol. Econ.* 93, 85–93. doi:10.1016/j.ecolecon.2013.05.002

UBOS (2016). *Uganda demographic and health survey 2016*. Kampala, Uganda: Ministry of Health Knowledge Management Portal.

UNBS (2016). *Requirements-Design and operation of abattoirs and slaughterhouses*. Kampala, Uganda: UGANDA STANDARD — Requirements.

Wang, X., and Cheng, Z. (2020). Cross-sectional studies: Strengths, weaknesses, and recommendations. *Chest* 158 (1), S65–S71. doi:10.1016/j.chest.2020.03.012

Yirga, C., Atnafe, Y., and Awhassan, A. (2015). A multivariate analysis of factors affecting adoption of improved varieties of multiple crops: A case study from Ethiopian highlands. *Ethiop. J. Agric. Sci.* 25 (2), 29–45.