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Effects of livestock ownership typology on household food security in rural Lesotho

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Abstract This study examines how various livestock ownership typologies affect household food security in rural Lesotho, a developing nation marked with poverty and food insecurity. Despite the significance of livestock to food security, little study has been done in this area. The study divides households into four typologies of livestock ownership, ranging from none to varied animal herds, using data from 2,014 rural households. The study uses analysis of variance (ANOVA) and a mixed effect ordered probit model to examine the connections between these typologies and food security. In comparison to typology I (no livestock ownership), the results show that ownership typologies III (moderate number of small ruminants and poultry) and IV (large number, mixed small and large livestock) have a beneficial impact on household food security. The study advances our understanding of how different livestock species and herd sizes affect food security. It emphasizes the importance of nuanced and context-specific approaches when employing livestock to improve household food security, advising development and intervention programs to take into account the delicate interplay between livestock ownership and food security among the target population. Thus, intervention programs must carefully consider the complex and context-specific relationship between livestock ownership and food security.

Keywords Food security · Herd size · Typology · Livestock · Lesotho · Mixed effect ordered probit model

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Introduction

Livestock production is increasingly being promoted as part of a livelihood diversification strategy because it has been shown to be one of the most effective ways to combat food insecurity, alleviate poverty, increase resilience to food shocks, and serve as crop failure insurance, among other benefits. To achieve food security in developing countries, animal production must increase as the population grows (Abu Hatab et al., 2019). Animal sources provide roughly one-third of the world's protein intake, including livestock source food and other animal products (Popp et al.,

2010). Keeping livestock can also improve child nutrition by empowering women, increasing crop productivity through manure fertilization, and providing milk sources. Livestock is a valuable asset for the rural poor. Apart from being used as a financial asset (a store of wealth), they are also commonly used to build political and social assets through gifting.

A significant aspect of livestock is its ability to balance gender imbalances. Livestock is easier to acquire for women than land: they can own and sell poultry and small ruminants, but cattle are typically reserved for men. Women use the income they earn from selling eggs and milk to purchase grain, health care items, and meals for their families and homes. Owning livestock can improve one's social standing and self-esteem, which are both beneficial to financial success. Furthermore, as Christian et al. (2019) pointed out, the general well-being of children can be improved by promoting agricultural intervention programs such as livestock production. As a result of this increased food security, cattle ownership in rural households is associated with a better food supply, and micronutrients such as iron are critical for combating malnutrition (Ali and Khan, 2013).

Food security is the state in which every person has regular access to an adequate supply of safe and nutritious food, enabling them to maintain good health and an active lifestyle (FAO 2023). The concept consists of four essential aspects: the presence, entry, utilization, and consistency of dietary sources. Thus, food insecurity refers to the insufficient availability and access to food, resulting in individuals not having an adequate supply of food and facing challenges in obtaining their desired food (FAO et al., 2018). Food insecurity is an overarching global issue that poses a threat to every nation on the planet. Livestock, including cattle, sheep, goats, and poultry, make a substantial contribution to the food supply of Lesotho. They offer protein-dense meat, milk, and eggs, which are crucial elements of a well-rounded diet. Increasing the variety of food sources by including livestock helps to provide a varied array of critical nutrients for optimal health (Wodajo et al., 2020). Livestock-derived goods, such as milk and meat, make a substantial contribution to the nutritional value of meals. They supply vital nutrients such as protein, vitamins, and minerals, which enhance the efficient utilization of food and enhance overall nutritional outcomes for individuals and families. Livestock act as a safeguard against food insecurity in times of crises or shocks, such as droughts or crop failures. They serve as a type of insurance, enabling households to depend on livestock as a means of sustenance or revenue during periods of limited access to alternative food sources.

Recent empirical studies on livestock ownership in rural Sub-Saharan Africa have consistently revealed its potential to improve food security. According to Adesogan et al. (2020), livestock production improves household food security by providing easy access to high-quality protein foods and other nutrients such as vitamins, minerals, and fats. Andriamparany et al. (2021) observed that households in Madagascar that keep livestock are more resilient to food insecurity than those that do not. According to a similar study conducted in rural Mauritania by Ba (2020), livestock farming households have a 23.6% higher probability of being food secure than non-livestock farming households for all types of livestock. Households with large livestock (cattle) and small ruminants (sheep and goats) have a 16 to 22% better chance of avoiding severe food insecurity than households without cattle, sheep, or goats.

Despite the many studies on livestock ownership and food security, one issue that has been highlighted is the measurement of livestock ownership. Per the literature, assessments on the influence of livestock ownership on food security either use a binary (yes/no) measure, a count (the number of livestock owned), or a Tropical Livestock Unit (TLU) (Nkegbe et al., 2017; Hoddinott et al., 2015; Headey & Hirvonen, 2016; Azzarri et al., 2015; Mosites et al., 2016; Tefera & Tefera, 2014). The binary measure implies that all types of animals have the same influence on food security regardless of their quantity, whereas the count model assumes that all kinds of animals have the same effect on food security regardless of their number (Dumas et al., 2018). This study contends that the use of binary and/or count number of livestock may not hold true because the kind and quantity of animals owned by a household may influence the amount of income made or saved, time and labor required, and social value. Moreover, the use of TLU grossly overvalues some animals while

undervaluing others. Thus, categorizing livestock into typologies is a better way to assess how households use their livestock.

In response to the gap in measuring livestock ownership in the existing literature, the study makes two significant contributions to the body of knowledge. First, the study had conceptualized four livestock typologies by combining household TLU with total livestock count. Typology 1 consists of no livestock owned. Typology II has a few number of animals, a mix of poultry and small livestock species, mostly small ruminants and few large species. Typology III has a moderate to large number of animals, a mix of small and large livestock species, mostly large ruminants. Finally, typology IV has a large number of animals, a mix of small and large livestock species, mostly large ruminants. According to Dumas et al. (2018), this measure is a better proxy for how people use their livestock. Second, using a multi-level fixed effects ordered probit regression model, the study assesses the nexus between livestock ownership typologies and food security status. The multilevel fixed effects ordered probit regression has the ability to contain both random and fixed effect variables as well as the food security response variable, which is categorical and ordered as: food security, moderate food insecurity and severe food insecurity; using the food insecurity experience scale (FIES) as a food security indicator. Using a large data set from rural farming households in a small and developing economy like Lesotho, the study highlights a deeper understanding of the complexities in livestock ownership and its link to household food security. These insights are critical for rural development intervention programs and policies.

Livestock sector and food security

Livestock sector in Sub-Saharan Africa

Human diets largely consist of foods derived from animals, and smallholder livestock farmers in developing nations continue to be the primary providers of the local demand for these foods (Molina-Flores et al., 2020). The demand for meat will increase twofold worldwide, leading to an increase in the requirement for animal feed (Ritchie et al., 2017). In 2018, Africa possessed a substantial proportion of the world's livestock, including 2 billion chickens, 438 million goats, 384 million sheep, 356 million cattle, 40.5 million pigs, 31 million camels, and 38 million equines (Panel, 2020). By 2050, the demand for chicken in Sub-Saharan Africa is projected to increase by 214%, while the demand for pork is expected to rise by 161%, and the demand for mutton/goat is predicted to grow by 52% (Erdaw, 2023). Although the livestock sector in Africa has significant potential, it is unable to satisfy the increasing demands of a growing population (Bjornlund et al., 2020). The poor development of the livestock sector in Africa has been attributed to a number of problems, including inadequate policy, poor technology utilisation, climate change, and insufficient investment (FAO, 2017; Ali et al., 2021).

The livestock industry in Lesotho plays a crucial role in its socio-economic structure, making a considerable contribution to people's livelihoods and ensuring food security. For many years, the main contributor to Lesotho's livestock production to GDP has been the sales of wool and mohair (Mokhethi et al., 2015). The principal livestock species in the country are cattle, sheep, and goats, which serve various requirements. Sheep and goats play a vital role in sustaining the livelihoods of rural communities in Lesotho. Lesotho has a significant presence of small-scale farmers engaged in Angora goat farming, which has led to the country's second position in global mohair production. The production of Angora goats in Lesotho takes place in distinct agro-ecological zones, including plains, foothills, highlands, and the Senqu river basin. Cattle, highly esteemed for their versatile functions, play a vital part in the rural communities of Lesotho. Cattle are utilized as a means of providing mechanical force for agricultural tasks, supplying milk for domestic consumption, and presenting avenues for generating revenue through commerce and traditional events. Lesotho's number of agricultural holdings keeping cattle was predicted to be 125,718, which is the highest among the dominant livestock (cattle, pigs, goats sheep and chicken), as reported by the Kingdom of Lesotho Bureau of Statistics (2021). Similarly, in 2020, there were approximately 94,399 households engaged in sheep rearing, 64,944 households engaged in goat rearing, and 45,232 households engaged in pig rearing (Kingdom of Lesotho Bureau of Statistics 2021). Sheep and goats play a crucial role in Lesotho's livestock industry, as they are well-suited to the country's difficult terrains and climatic circumstances.

Cattle play a crucial role in rural homes, providing meat, milk, skins, and wool. Nevertheless, cattle productivity is adversely affected by various issues, including restricted availability of grazing pasture, water scarcity, disease outbreaks, and the impacts of climate change. The collective endeavors spearheaded by governmental efforts, non-governmental organizations (NGOs), and international agencies are focused on enhancing livestock management techniques, bolstering disease control measures, and facilitating improved access to veterinary services. The primary livestock industry challenge confronting Lesotho is the issue of overgrazing, exacerbated by excessive livestock numbers, leading to soil degradation. This problem can be addressed by reducing the livestock population in the country, a process known as destocking (Mofolo & Rethabile, 2021). Emmanuel (2022) suggests that destocking can be accomplished by replacing cattle, sheep, and goats with pigs, poultry, rabbits, and other enclosed animals that do not rely on range resources.

The contribution of livestock to food security

Food insecurity is widespread in many Sub-Saharan African countries, including Lesotho. The Sub-Saharan Africa region has seen exacerbated food insecurity due to a combination of factors including droughts, floods, unsustainable farming techniques, the COVID-19 epidemic, high food costs, and the Russia-Ukraine war, which has significantly impacted food availability (FAO, 2023). The data published by FAO in 2023 reveals that the incidence of undernourishment among individuals in Africa continues to increase. Lesotho is currently facing challenges related to insufficient access to food and malnutrition. Furthermore, recent global events have had a detrimental impact on the country's food security situation, according to the swift evaluation report conducted by Lesotho Vulnerability Assessment Committee (LVAC) in 2018 (LVAC 2018). A study revealed that 14% of the population in Lesotho faces food insecurity (FAO, 2023). The occurrence of droughts and floods, insufficient agricultural techniques, high food prices, and global economic downturns have worsened food insecurity in the Southern Africa Developing Community (SADC) region, including Lesotho (Mokati et al., 2022).

The correlation between the typology of livestock ownership and the state of food security in Lesotho is complex and has multiple aspects. A household's or a community's level of food security is greatly influenced by the kinds and numbers of livestock they own. Multiple researchers in the field of livestock studies have found that livestock production and management significantly contribute to the food security of many communities worldwide. The study conducted by Adams et al. (2021) revealed that numerous rural populations saw livestock as both a method of saving and a long-term investment. In Lesotho, sheep and goats are the preferred livestock for long-term investment due to their small size. Moreover, farmers in Lesotho engage in livestock rearing, especially cattle primarily for the purpose of prestige and cultural customs, such as paying bride price, supplying liquid milk for household members, and ploughing (Rantšo & Makhobotloane, 2020). In the next paragraph, we discuss a conceptual model of the mechanism through which livestock typology impact household food security status.

Raising livestock has become increasingly popular as a way of increasing access to animal products, income generation and improving household food security. Figure 1 present the key ways livestock ownership can improve rural household food security status, which is the key hypothesis of this study. Livestock production has the potential to improve household dietary quality through animal source products (e.g., milk, meat, eggs).

Using livestock faeces and urine to fertilize the soil or as manure and using animals (e.g., donkeys) as draft power reduce crop production cost and increase crop yield. This may translate into a high supply of food products in the household to increase the frequency and diversity of food consumption. This may improve the quality of household dietary habits. In addition, livestock and its products may generate cash income for the purchase of other food products to boost dietary quality. As suggested by Njuki and Sanginga (2013), keeping livestock also improves household food security by selling animals and their products, and acts as 'living savings account' as a store of capital and consumption smoother.

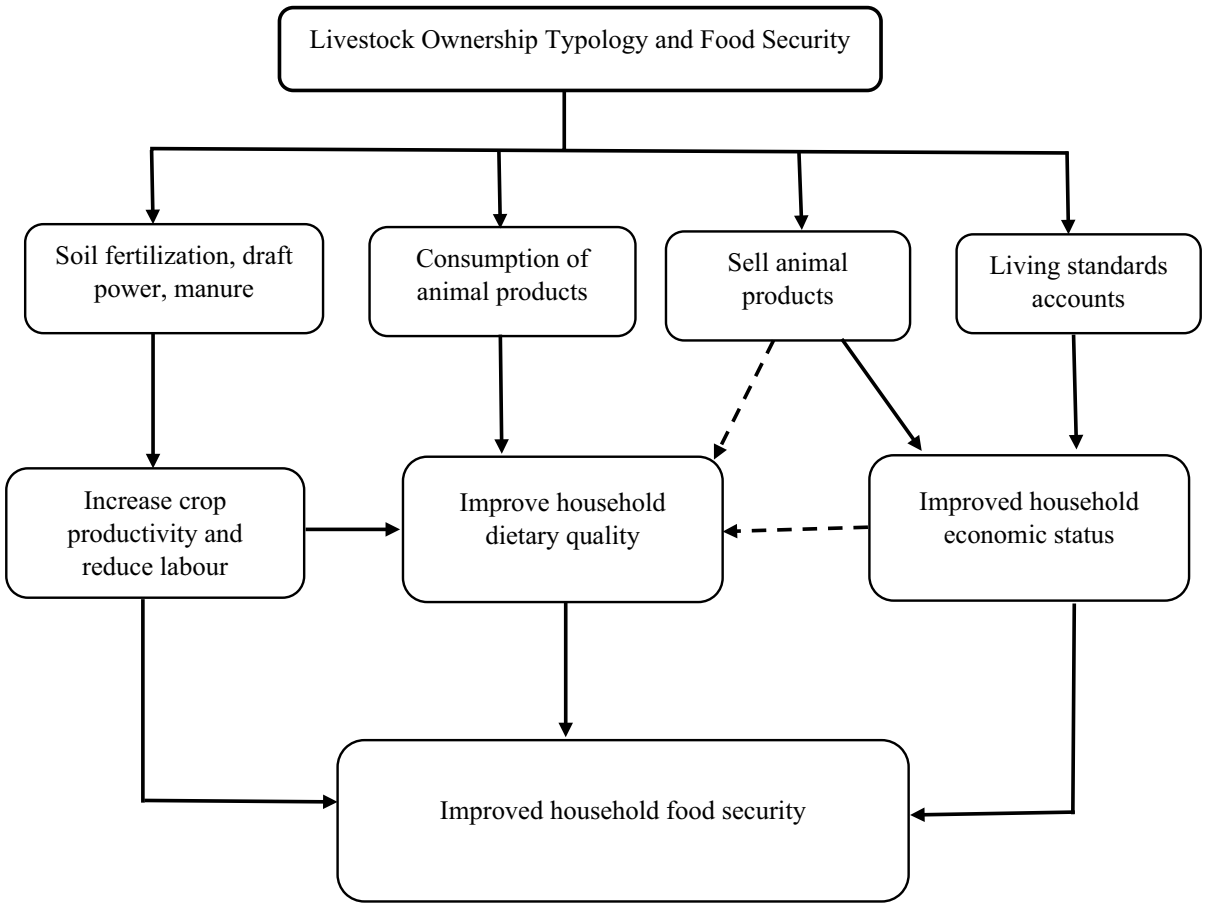

Fig. 1 Conceptual framework showing primary pathways linking livestock ownership to household food security. The block solid lines show strong linkages, and the dash line indicates moderate or weak linkages

Research methods

The study area and the context of the study

Lesotho is a small developing country with a population of 2,160,995 and land surface area of 30,355km2 (11,720 sq. miles), and totally encircled by South Africa. Additionally, it is the only autonomous state entirely above an altitude of 1,000 m (3,281 feet) in the world. At 1,400 m, it features the world's highest and lowest points (4,593 feet). Approximately 80% of the country is above 1,800 m (5,906 feet). Lesotho has 12 percent arable land and a moderate climate. However, due to its uneven and spatially variable rainfall, it is only minimally suitable for agricultural production (Moeletsi & Walker, 2013). The country's annual rainfall ranges from 500 mm in the Senqu River valley to 1,200 mm in a few isolated locations along its eastern and northern boundaries. Lesotho is divided into 10 districts: Thaba-Tseka, Maseru, Leriba, Quithing, Mafeteng, Mokhotlong, Qacha's Nek, Berea, Butha-Buthe, and Mohale's Hoek (Lesotho Vulnerability Assessment Committee (LVAC), 2018). Figure 2 depicts the map of Lesotho showing the ten districts.

The data set for this study came from a household survey conducted from a larger project dubbed "Sustainable Poverty reduction through Income, Nutrition, and access to Government Services (SPRING)". The primary objective of Lesotho's National Strategic Development Plan 2012–2017 and the National Policy on Social Development was to guarantee comprehensive social protection for every individual residing in the country

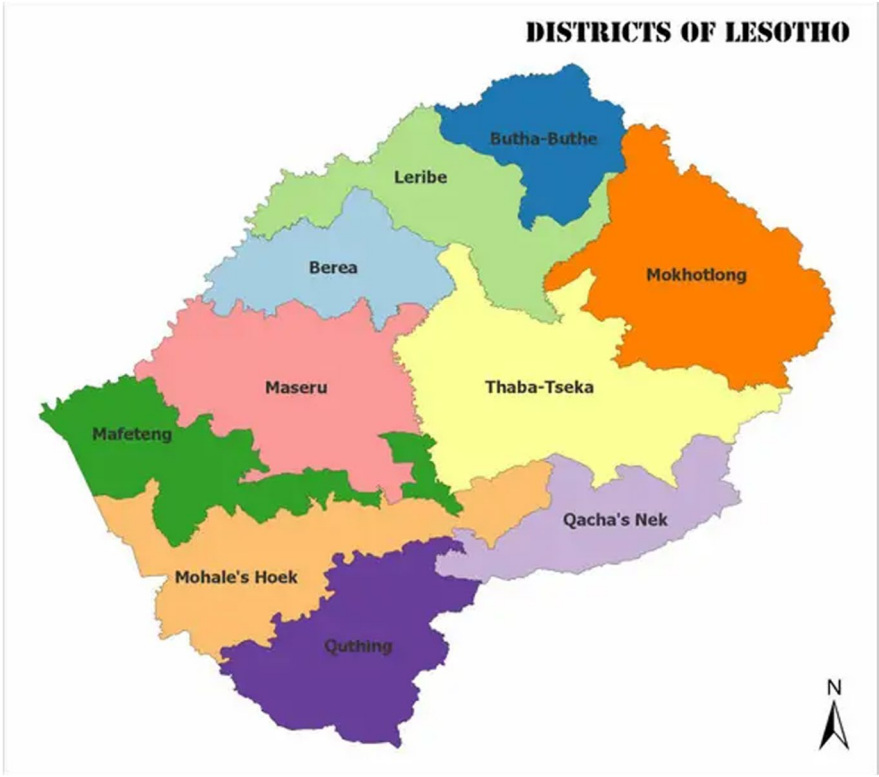

Fig. 2 A map of Lesotho showing the 10 districts

(Government of Lesotho, 2015). Hence, numerous development collaborators, such as the European Union and FAO, have supported the government in addressing vulnerability, impoverishment, and social marginalization. The Child Grants Program (CGP) was a relief program that provides monetary aid to economically disadvantaged and susceptible households.

In July 2013, FAO-Lesotho launched a pilot initiative called "Linking Food Security to Social Protection Program (LFSSP)." The objective of the program was to enhance the food security status of economically disadvantaged and susceptible households by offering vegetable seeds and homestead gardening instruction to eligible individuals under the CGP. The selection of these particular families was chosen with the intention of optimizing the efficacy of both program in enhancing the food security of their beneficiaries. The impact assessment conducted by FAO on the LFSSP demonstrated that the integrated program had positive outcomes on homestead gardening and agricultural production (Daidone et al., 2017). In light of these favorable results, the United Nations Children's Fund, the Ministry of Social Development, and the Catholic Relief Services joined forces in 2015 to establish a more extensive livelihood program called the Sustainable Poverty Reduction via Government Service Support (SPRS) (SPRINGS). The SPRING project aims to enhance CGP cash transfers by focusing primarily on promoting domestic gardening.

Sampling and data collection techniques

As stated earlier, the study relied on the household survey conducted by the SPRING's project. The units of interest were poor and vulnerable farming households that are engaged in crop cultivation and animal rearing. The districts, community councils, and households were chosen using a multistage sample design. The survey was conducted in six districts: Butha-Buthe, Maseru, Mafeteng, Leribe and Berea located in northern Lesotho and Mohale's Hoek in the South western Lesotho. The CGP project predefined these districts, taking into account their prominence in agricultural production. In the second phase, the community councils were selected by a process of random sampling, with representation from each district. From Berea and Mafeteng, six community

councils were chosen each. From Butha-Buthe, Leribe, Maseru, and Mohale's Hoek, three, four, five, and two community councils were selected, respectively. Fourth, households were randomly selected from each community and information was collected through face-to-face interviews. The data was collected between November 2017 and January 2018. The geographical distribution of the household sample are 570, 392, 355 and 284 across Maseru, Leribe, Berea and Mafteng districts, respectively. The remaining two districts: Butha-Buthe and Mohale's Hoek had sample size of 284 and 122, respectively. In total, 2014 households were sampled across the six districts.

The survey captured detailed quantitative data on demographic, household agricultural farming practices including the cultivation of crops and rearing of animals, household expenditure and income, household assets, and others.

Measurement of variables

Livestock typology In this subsection, the diversity of the livestock farming system was explored through typological analysis. This was applied in Lopez-Ridaura et al. (2018), Dumas et al (2018), and de Glanville et al. (2020), among others. According to Tittonell (2014), typologies of a farming system can be derived from farm assets or resources (structural typology) or livelihood pursuits (functional typology) or even both. The study's typological analysis was of the livestock system's structural features. Following Dumas et al. (2018), two standard measures were used to create the typology. The first variable was the number of animals possessed, measured as

Table 1 Description of the livestock ownership typologies

	Typology I (n = 898)	*Typology II (n = 163)*	*Typology III (n = 653)*	*Typology IV (n = 300)*
Description	No livestock of any kind	Few animals, mixed poultry and small ruminants (e.g., 2 chicken, 2 goats, 1 pig, 2 sheep)	Moderate no. of animals Mostly small animals with few large livestock (e.g., 7 chicken, 4 goats, 4 sheep, 3 pigs 1 donkey, 1 horse)	Many animals, mixed large and small livestock (e.g.,195 chicken, 12 sheep, 11 goats, 3 cattle, 7 pigs, 3 donkey, 3 horses)
Mean TLU (range)		0.163 (0.01–0.40)	0.676 (0.03–1.60)	2.548 (0.7–18.9)
Own livestock (%)		100%	100%	100%
Mean of no. livestock (range)		1.497 (1–2)	4.089 (1–50)	9.937 (3–300)
Own chicken (%)		23.9%	26.6%	0.7%
No. of chicken, mean (range)		1.590 (1–2)	9.501 (3–50)	195.000 (90–300)
Own goat (%)		18.4%	6.1%	18.0%
No. of goats, mean (range)		1.500 (1–2)	4.101 (3–6)	16.037 (7–40)
Own sheep (%)		22.1%	11.5%	18.7%
No. of sheep, mean (range)		1.639 (1–2)	4.147 (3–6)	15.161 (7–54)
Own pigs (%)		35.6%	0.8%	2.3%
No. of Pigs, mean (range)		1.345 (1–2)	3.000 (3–3)	7.429 (5–12)
Own donkey (%)		0.0%	23.1%	8.0%
No. of Donkey mean (range)		0.000	1.397 (1–2)	3.501 (3–10)
Own horse (%)		0.0%	6.4%	1.7%
No. of horse, mean (range)		0.000	1.333 (1–2)	3.800 (3–7)
Own cattle (%)		0.0%	25.4%	50.7%
No. of cattle, mean (range)		0.000	0.398 (0–2)	2.403 (3–27)

Authors' estimation from the survey data

total livestock units (TLU). This was weighted at 1.0 for horses, 0.70 for cattle and donkeys, 0.20 for pigs, 0.10 for sheep and goats, and 0.01 for chickens. The household TLU was then combined with the types and numbers of livestock owned by households to assign them into four livestock ownership typologies. A crosstabulation of the two variables yielded four livestock ownership typologies (Table 1). The study also included the number of horses, sheep, goats, cattle, pigs, donkeys, chickens, and total livestock owned, as well as binary measure of any livestock owned: any pigs, goats, sheep, chickens, donkeys, cattle and horses.

Household food security Despite the difficulties in measuring food security, as shown by numerous research (e.g., Cafiero et al., 2018, Chegere & Stage, 2020, Gwada et al., 2020, Chegere & Kauky, 2022, Danso-Abbeam et al., 2023), employing an accurate method of assessing food security among households is an essential first step in successfully addressing it. This study used the Food Insecurity Experience Scale (FIES), an experiential evaluation of food access. FIES assesses how severely a person cannot access the food needed to lead a full, dignified, and healthy life. According to Sustainable Development Goal 2 (SDG 2), by 2030, countries must "end hunger," "achieve food security while improving nutrition," and "advance sustainable agriculture" (FAO et al., 2018). The FIES was chosen for the study's focus because it is most in line with these objectives compared to other indicators of food security. These indicators include the Household Food Insecurity Access Scale, Food Consumption Score, Household Coping Strategies Index and Cost of Calories, among others.

Information for the FIES indicator was gathered using the Food Insecurity Experience Scale Survey Module (FIES-SM). The FIES-SM, which was developed based on responses to an 8-item survey, evaluates behaviors and conditions related to a person's inability to access food because of a lack of resources or economic hardship (Sassi & Sassi, 2018). The target group can be divided into three categories, depending on the "Yes/No" responses to the FIES-SM questions: mild, moderate, or severe food insecurity. According to FIES-SM, a yes response receives a value of one (1), while a no response receives a value of zero (0). The total number of affirmative responses is thus 8, whereas the total number of no responses is 0. For households with a score of 0, food insecurity is not a concern (Chegere & Stage, 2020). The FIES indicator evaluates two levels of food insecurity. Scores of 0–3, 4–6, and 7–8, are used to indicate levels of food security to mild food insecurity, moderate food insecurity, and severe food insecurity, respectively. On the other hand, the mildly food insecure category is seen as food secure by FAO et al. (2018) and Gwada et al. (2020). In other words, the study follows the FAO et al. (2018) and Gwada et al. (2020) categorization of food security, moderate food insecurity, and severe food insecurity.

Empirical formulation of the mixed effect ordered probit model

Mixed effects ordered probit regression (meoprobit) is ordered probit regression containing both fixed effects and random effects. The *meoprobit* allows for many levels of random effects. However, this study considered the two-level model, where a series of M independent clusters, and conditional on a set of fixed effects x_{ij}, a set of cut points K, and a set of random effects μ_j, the cumulative probability of the response being in a category higher than K can be specified as:

$$\Pr(Y_{ij} > K|\kappa, x_{ij}, k, \mu_j) = \Phi(x_{ij}\beta + \mu_j - K_\kappa) \tag{1}$$

where $j = 1, ..., M$ clusters, μ_j are independent and identically distributed $N(0, \sigma^2)$, and κ is a set of cut points $\kappa_1, \kappa_{2,}..., K_{k-1}$, where K is the number of possible outcomes; and $\Phi(\cdot)$ is the standard normal cumulative distribution function. From the above, we can derive the probability of observing outcome K for response Y_{ij} as:

$$\begin{aligned}\Pr(Y_{ij} = K|\kappa, \mu_j) &= \Pr(K_{k-1} < x_{ij}\beta + z_{ij}\mu_j + \varepsilon_{ij} \le K_k) \\ &= \Pr(K_{k-1} - x_{ij}\beta - z_{ij}\mu_j < \varepsilon_{ij} \le K_k - x_{ij}\beta - z_{ij}\mu_j) \\ &= \Phi(K_k - x_{ij}\beta - z_{ij}\beta\mu_j) - \Phi(K_{k-1} - x_{ij}\beta - z_{ij}\beta\mu_j)\end{aligned} \tag{2}$$

where K_0 is taken as $-\infty$, and K_k is taken as $+\infty$. Here x_{ij} does not contain a constant term, because its effect is absorbed into the cutpoints. We may also express this model in terms of a latent linear response, where observed ordinal responses Y_{ij} are generated from the latent continuous responses, such that:

$$Y_{ij}^{*} = x_{ij}\beta + z_{ij}\mu_j + \varepsilon_{ij} \quad (3)$$

$$Y_{ij}^{*} = \begin{cases} 1 \;\; if\; Y_{ij}^{*} \le K_1 \\ 2 \;\; if\; K_1 < Y_{ij}^{*} \le K_2 \\ . \\ K \;\; if\; K_{k-1} < Y_{ij}^{*} \end{cases} \quad (4)$$

The error term ε_{ij} is distributed as standard normal with mean zero and variance one (1) and are independent of μ_j.

Results and discussion

Descriptive statistics

In this section, we discuss four important associations: i) the various typologies and their constituents, ii) the association between livestock kinds and food security status; iii) the association between livestock typologies and household characteristics; and iv) the relationship between independent variables and food security categories.

Livestock ownership typologies

Table 1 describes the constituents of livestock ownership typologies. Table 1 indicates that about 44.59% of the farming households do not keep livestock and were all categorized as livestock ownership typology I. Out of the 55.41% of households that own livestock, 8.10% were categorized as typology II, while 32.42% and 14.89% were classified as typology III and IV, respectively. Moreover, ownership of pigs appeared to be the most dominant with about 35.6% of the households having at least one pig (typology II). In Lesotho, pig farming is predominantly carried out by small-scale farmers, typically as an additional source of income in conjunction with other livestock endeavors or crop cultivation. According to Knoema (2020), pig farming has had consistent growth from 1972 to 2021, with the pig population reaching 29,178 in 2021. Governmental entities, NGOs, and international organizations have intervened to improve pig farming in Lesotho. These efforts have the objective of enhancing pig management practices, facilitating improved access to veterinary services, implementing disease control measures, and providing training and support to small-scale pig farmers. Chicken is the next most significant livestock kept by rural farming communities in Lesotho. This is with a mean of about 10 chickens per household and a range of 3—50 chickens. These households are classified as Typology III.

Poultry farming on a small scale is widespread in rural and peri-urban regions of Lesotho, making a substantial contribution to people's incomes and ensuring food security. Chickens are commonly raised for domestic consumption, offering a consistent supply of protein through eggs and occasional meat. Some households practice semi-intensive system of keeping chicken. In contrast, a smaller number of households engage in commercial large-scale poultry farming.

Typology IV households have an average of 195 chickens, 16 goats, 15 sheep, 7 pigs, 3 donkeys, 4 horses, and 2 cattle. Sheep and goats in Lesotho are raised using different methods, which represent the many ways that rural communities care for and use these animals. A prevalent typology consists of expansive grazing systems in which sheep and goats have unrestricted movement, also known as communal grazing grounds or natural pastures. Some households incorporate sheep and goats into an agricultural system that combines both crop cultivation and livestock rearing. These systems integrate animal husbandry with food production, enabling a mutually beneficial utilization of resources. Semi-intensive systems are implemented in peri-urban areas or in locations where there is ample land available. The typology of cattle in Lesotho reflects a wide range of animal rearing methods that have been adjusted to suit the country's challenging terrains and the needs of its inhabitants. Cattle play a crucial role in the socio-economic structure, serving as working animals, providers of milk, meat, and revenue for rural people. The prevailing classification entails conventional extensive grazing systems, wherein cattle freely roam communal grazing lands. Guided by indigenous herders or shepherds, these cattle forage on organic meadows and serve as crucial components of cultural traditions and rural sustenance. About 25% of cattle-keeping households are classified as typology III, while 51% are classified as typology IV. Aside from the wide variety of livestock ownership, the average livestock holdings were also satisfactory. This was done with

Table 2 Association between livestock kinds and food security

Variable	*FS*	*MFI*	*SFI*	*Total*	*F-statistic*	*P-value*
Panel A (binary = %)						
Any livestock kind	67.38	58.3	46.69	55.51	32.32	0.000[a]
Chicken	15.34	22.33	20.42	19.23	3.00	0.005[a]
Milk cow	1.85	2.59	2.32	2.24	0.22	0.801
Other cattle	26.98	24.91	26.68	26.29	0.21	0.808
Sheep	16.93	14.23	13.69	13.68	0.91	0.401
Goat	10.85	9.71	12.29	11.09	0.63	0.531
Pigs	6.87	6.15	6.03	6.35	0.14	0.873
Donkeys	15.61	16.51	15.08	15.65	0.14	0.871
Horse	5.56	3.56	3.48	4.20	1.30	0.273
Panel B: Typologies						
Typology I	32.79	41.69	53.41	44.59	32.17	0.000[a]
Typology II	7.31	8.49	8.34	8.09	0.33	0.721
Typology III	36.54	35.66	28.06	32.42	7.49	0.006[a]
Typology IV	23.35	14.15	10.18	14.89	24.57	0.000[a]
Panel C: Number of livestock own						
Chicken	10.29	8.93	10.14	9.79	0.08	0.925
Milk cow	1.29	2.38	2.20	2.00	1.44	0.258
Other cattle	3.94	2.92	2.64	3.18	7.84	0.005[a]
Sheep	9.44	7.21	5.03	7.30	4.64	0.011[b]
Goat	12.00	6.17	7.51	8.67	4.57	0.012[b]
Pigs	2.04	2.21	1.92	2.04	0.11	0.897
Donkeys	1.78	1.65	1.63	1.69	0.39	0.681
Horse	1.68	1.82	1.33	1.59	0.78	0.466
Total livestock	4.10	2.85	2.26	2.93	7.76	0.000[a]
TLU	0.92	0.59	0.44	0.61	32.49	0.000[a]

FS, MFI and SFI denote food security, moderate food insecurity and severe food insecurity, respectively. [a,] *and* [b] *denote significant levels at 1 and 5%, respectively*

Authors' estimation from the survey data

TLUs of 0.163, 0.676, and 2.548 in typologies II, III, and IV, respectively. This equates to approximately 16 chickens in typology II, 68 chickens in typology III, and 255 chickens in typology IV.

Association between livestock kinds and food security categories

Table 2 shows an ANOVA test of the relationship between different kinds of livestock ownership and food security as measured by FIES. The table is divided into three sections. Panel A is a binary measure of ownership of any kind of livestock as well as ownership of specific livestock kind. Panel B assesses the relationship between the four typologies and household food insecurity. Panel C examines the relationship between the number of livestock kinds owned and household food security status.

Overall, 55.5% of farm households had livestock of some kind, with 67.38, 58.31, and 46.69% falling into the food security (FS), moderate food insecurity (MFI), and severe food insecurity (SFI) categories, respectively. Thus, the population of food secure households that own livestock of any kind differs significantly from the population of moderately and severely food insecure households ($p < 0.01$). Cattle (milk cows and other cattle) are the most commonly owned livestock kind, followed by chicken.

Furthermore, sheep and donkeys were owned by approximately 17% and 16% of food secure households, respectively. In contrast, goats and pigs were owned by only 11 and 6% of the total sampled population. Aside from chicken, there is no significant difference in livestock ownership among farming households in the three food security categories. For livestock typologies (panel B), a significant proportion of food secure households (36.54%) are found

in typology III, while 35.66 and 28.06% of moderate and severe food insecure households are found in the same typology, with statistically significant differences between them.

Typology II has the fewest farming households, with 7.31, 8.49, and 8.34% of households being food secure, moderately food insecure, and severely food insecure, respectively. Possessing even modest amounts of animals, such as chickens, sheep, and goats, can have a substantial effect on the ability of a household to secure food by providing vital elements like protein through eggs, meat, or milk. This directly enhances the nutritional value of the household's diet. Households also generate extra revenue by selling excess food through small-scale animal husbandry. This cash can be used to acquire food items that may be deficient in the household diet, hence enhancing dietary variety. Moreover, having a moderate-to-large quantities of livestock like sheep, goats, and cattle can be used as collateral in emergency situations. This allows households to obtain credit for food or other essentials during difficult times. Thus, owning livestock serve as a safeguard during times of economic downturns or crop failure, when households are at a higher risk of experiencing food insecurity.

In panel C, goat has the highest average of 12 owned by food secure households, followed by chicken, which has an average of 10 owned by food secure and moderately food insecure households. Furthermore, there is a significant relationship between TLU and the food security categories. This implies that there is a positive relationship between food security and livestock ownership, with a statistically significant difference between food security categories. In general, these findings are consistent with those of Tefera and Tefera (2014) and Beyene and Muche (2010), who found that livestock production plays an important role in combating food insecurity among rural households.

Association between livestock ownership typologies and households' characteristics

Table 3 shows an independent test of the relationship between livestock ownership typologies and farm household demographics. The test revealed that 44.6% of farm households in typology I are male, 23.5% are married, and 88.7% have formal education. The proportion of males and marital status differed statistically significantly across the four typologies. Furthermore, for typology I, the average dependency ratio was 0.63, for typology II, it was 0.64, for typology III, it was 0.57 and for typology four, it was 0.54. The ANOVA test revealed a significant relationship between the typology of livestock ownership and the number of dependents on the household head. Again, farm households' assets such as agricultural

Table 3 Association between Household characteristics and livestock ownership typologies

Variable	*Typology I*	*Typology II*	*Typology III*	*Typology IV*	*Total*	*F-statistic*	*P-value*
Gender	0.446	0.491	0.525	0.533	0.489	4.112	0.0065[a]
Age	0.512	0.527	0.459	0.407	0.481	4.281	0.005[a]
Marital status	0.235	0.264	0.303	0.317	0.272	6.7266	0.081[c]
Educational status	0.887	0.902	0.856	0.873	0.876	1.508	0.211
Dependency ratio	0.627	0.638	0.568	0.537	0.597	3.763	0.010[b]
Farm size	0.835	0.966	1.022	1.170	1.002	4.564	0.004[a]
Non-farm business	0.541	0.736	0.701	0.766	0.645	0.941	0.422
Own Mobile phone	0.784	0.917	0.833	0.883	0.826	9.501	0.000[a]
Own TV/Radio	0.447	0.546	0.531	0.642	0.511	12.29	0.000[a]
Remittances	1,460.139	1,637.882	1,690.932	1,497.69	1,554.954	0.751	0.525
Access to national grid	0.277	0.313	0.216	0.281	0.261	3.660	0.012[b]
Financial literacy	70.168	76.981	72.103	74.517	71.995	0.270	0.848

[a, b] and [c] denote significant levels at 1, 5 and 10%, respectively

Authors' estimation from the survey data

land under cultivation, mobile phones, radios, and televisions were found to have a significant relationship with livestock ownership typology. According to the results, as farm household farm size increases, they move from lower to higher typology.

This is understandable because an increase in the number of productive assets, such as agricultural land, will result in higher crop output and lower animal sales by farm households. Increased crop output may result in higher farm income, allowing households to properly manage livestock in terms of meeting their feed, water, and health needs, and may even allow them to expand their livestock herd size. As a result, they progress from a lower typology to an upper typology. Farming households received approximately R1,554.95 in remittances on average across the four typologies, with no statistically significant differences between the typologies.

Association between food security and household characteristics

An ANOVA test of the association between demographic characteristics of farm households and food security as measured by FIES is shown in Table 4. The findings revealed a similar proportion of male household heads across the three food security categories. However, the proportion of married households varies significantly across the three food security categories. Despite the fact that a significant proportion of household heads have received formal education, there is no significant difference between the three food security categories. Households with high educational attainment appear to be in a more favourable position to be food secure. This makes sense because people with higher education are expected to have a better understanding of food security. They are also expected to have decent and well-paying jobs, and to have access to and adopt modern agricultural technologies, which will increase their income generation ability and, by extension, food security.

Furthermore, the average farm size for food secure households was 1.08 ha, 1.04 ha for moderate food insecure households, and 0.88 ha for severe food insecure households. There is a significant difference between the three food security categories. This indicates a positive relationship between farm size and food security, implying that household food security increases as farm size increases. Furthermore, approximately 88.4, 85.5, and 77.3% of food secure, moderate food insecure, and severe food insecure households, respectively, own a mobile phone. Similarly, approximately 65.4, 51.7, and 42.1% of food secure, moderate food insecure, and severe food insecure households have a radio and/or television. The significant difference in asset ownership across the three food security categories indicated that farm households' food security improved as the number of assets owned

Table 4 Association between households' characteristics and food security status

Variable	*FS*	*MFI*	*SFI*	*Total*	*F-statistic*	*P-value*
Gender	48.131	50.748	48.210	48.862	0.521	0.596
Age	0.446	0.513	0.483	0.481	2.522	0.081[c]
Marital status	0.316	0.264	0.249	0.272	3.993	0.018[b]
Educational status	0.886	0.881	0.868	0.876	0.611	0.548
Dependency ratio	0.578	0.622	0.591	0.595	1.233	0.291
Farm size	1.080	1.042	0.881	1.000	4.161	0.016[b]
Non-farm business	0.103	0.051	0.048	0.065	9.814	0.000[a]
Own Mobile phone	0.884	0.855	0.773	0.826	17.190	0.000[a]
Own TV/Radio	0.654	0.517	0.421	0.421	39.293	0.000[a]
Remittances	1,894.361	1,592.590	1,327.040	1,554.951	5.718	0.003[a]
Access to national grid	0.316	0.232	0.244	0.261	6.206	0.002[a]
Financial literacy	65.280	70.021	77.212	71.991	2.360	0.095[c]

FS, MFI and SFI denote food security, moderate food insecurity and severe food insecurity, respectively. [a, b] *and* [c] *denote significant levels at 1, 5 and 10%, respectively*

Authors' estimation from survey data

increased. The findings also revealed that only 26.1% of households have access to the national grid. However, the proportion of food secure households with access to the national grid is significantly higher than the proportion of food insecure households with access to the national grid.

Contribution of livestock ownership typology to farm household food security

Table 5 discusses the relationship between livestock ownership typologies and household food security status. It also discusses other factors that influence household food security status, using quantitative analysis. According to the results of the multi-level mixed effects ordered probit model, livestock typology II has no significant relationship with household food security. This is not surprising given that rural households typically keep these few animals solely for consumption on special occasions, such as Christmas and Ramadan. These are seasonal events that occur once a year. As a result, because households in this category rarely slaughter animals for home consumption, household members do not benefit significantly from frequent animal product consumption. Furthermore, households in this category (for example, having two chickens and a sheep) are more likely to sell their animals to cover other non-food expenses such as educational expenses and other uncertainties (Dumas et al., 2016) or even wait for the flock to mature before reaping the benefits of their initial investment.

Farm households in livestock ownership typology III, on the other hand, were found to be more likely to be food secure and moderately food insecure, but less likely to be severely food insecure than their counterparts in typology I. Furthermore, farm households in the livestock typology IV category are less likely to experience severe food insecurity but more likely to experience food security than households in the typology I category (no livestock ownership). Although keeping livestock for consumption was not common in the study areas, having more livestock (e.g., small ruminants and poultry) gives the household some flexibility to consume animal products (particularly eggs and poultry meat) on a regular basis or sell animals to buy other food products such as fish or even meat from butcheries without drastically altering the flock. This can improve dietary diversity and nutritional intake of households, especially in areas where alternative sources of animal protein are scarce. Owning a large number of livestock also allows households to diversify their income sources.

These observations align with the findings of Beyene and Muche (2010), who asserted that the primary motive for raising small ruminants was to produce monetary income for households by selling live animals to fulfil urgent financial commitments. This improves resilience, reduces vulnerability, and acts as risk mitigation for farmers during times of food insecurity and crop failure (Ampaire, 2011). Furthermore, large livestock, such as donkeys, can boost productivity by acting as draught power in farm operations. The incorporation of livestock such as cattle and donkeys into mixed farming systems also contributes to soil fertility through the use of their feces as manure and their use for plowing and transportation to improve crop productivity and crop production diversification, thereby increasing farm incomes and, as a result, food security. In their study, Etalema and Abera (2018) observed that in the highland and mid-altitude agroecologies of Ethiopia, sheep and goats were predominantly sold to produce revenue for specific goals, such as purchasing farm supplies.

In terms of other factors, being married increased the likelihood of food security. However, it decreased the likelihood of a farm households suffering from moderate to severe food insecurity. This is understandable given married households' ability to pool resources and share responsibilities. Household members can share responsibilities for food production and resource management, as well as pooling resources to generate higher and more diverse sources of income. The division of labour among household members, as well as multiple and diverse income sources, will improve household food security even further.

Likewise, a single additional person in the dependency ratio raises the probability of a household having enough food and facing mild food insecurity, while reducing the chances of severe food insecurity. Although many empirical studies (e.g., Aidoo et al., 2013; Taylor, 2017) found a negative relationship between household food security status and dependency ratio, having more members relying on the household head can be advantageous because these members can contribute to the household labor force.

Table 5 Effects of Livestock typologies on household food security

Variables	*Coefficient*	*Marginal Effects*		
	FIES	*FS*	*MFI*	*SFI*
Livestock ownership typologies vs Typology I				
1. Livestock typology II	-0.0834 (-0.1031)	0.0243 (-0.0304)	0.007 (-0.0081)	-0.0312 (-0.0385)
2. Livestock typology III	-0.274 (-0.0629)[a]	0.0846 (0.0199)[a]	-0.0176 (0.0058)[a]	-0.102 (-0.0234)[a]
3. Livestock typology IV	-0.461 (-0.083)[a]	0.1490 (-0.0286)[a]	0.0199 (-0.0077)[a]	-0.1689 (-0.0298)[a]
Gender	0.0191(-0.0543)	-0.0058 (-0.0168)	-0.0012 (-0.0031)	0.007 (-0.0198)
Age	-0.0697 (-0.0625)	0.0215 (-0.0192)	0.0039 (-0.0037)	-0.0254 (-0.0228)
Marital status	0.0555 (-0.0216)[b]	0.0171 (-0.0067)[a]	-0.0031 (0.0015)[b]	-0.0202 (-0.0078)[a]
Educational status	-0.0619 (-0.0956)	0.0191 (-0.0295)	0.0035 (-0.0055)	-0.0226 (-0.0349)
Dependency ratio	-0.237 (-0.077)[a]	0.0732 (-0.0238)[a]	0.0134 (-0.0055)[b]	-0.0866 (-0.0279)[a]
Farm Size	-0.226 (0.0414)[a]	0.0698 (-0.0127)[a]	0.0128 (-0.0041)[a]	-0.0826 (-0.0149)[a]
Nonfarm business	-0.315 (-0.108)[a]	0.0973 (0.033)[a]	0.0178 (-0.0076)[b]	-0.115 (-0.0394)[a]
Owned phone	-0.221(-0.0789)[a]	0.0682 (-0.0244)[a]	0.0125 (-0.0054)[b]	-0.0807 (-0.0286)[a]
Owned TV Radio	-0.343 (-0.058)[a]	0.1058 (-0.0181)[a]	0 0.0194 (-0.0058)[a]	-0.1252 (-0.0207)[a]
Amount transfer received	-2.77e-05 (-1.02E-05)[a]	0.000 (0.0000)	0.000 (0.000)	-0.000 (0.0000)
Electricity access	-0.0745 (-0.0662)	0.023 (0.0205)	0.0042 (0.0039)	-0.0272 (0.0241)
Financial literacy	0.0005 (-0.0003)[c]	-0.0001 (0.0000)	0.0000 (0.0000)	0.0002 (0.0002)
cut1	-1.374 (-0.219)[a]			
cut2	-0.615 (-0.218)[a]			
var (cons [district])	0.024 (-0.0172)			
LR test vs oprobit [Chi2 = 17.91]	Prob > Ch2 = 0.000			
Observations	1,924			
Number of groups	6			

Livestock typology I (no livestock ownership) was used as base category. [a, b] *and* [c] *denote significant levels at 1, 5 and 10%, respectively*

Authors' estimation from the survey data

Similarly, households with substantial cultivated lands are more likely to be in the food security and moderate food insecurity categories. However, being in the severe food insecurity category is less likely. Larger farm sizes typically result in higher crop yields, which contribute significantly to farm income and, as a result, improve household food security. Furthermore, larger agricultural lands allow households to diversify crop cultivation and practice crop rotation in order to increase farm productivity and resilience to climate variability and change. These observations are supported by the results of previous studies conducted by Christian et al. (2019) and Herrera et al. (2021), which suggest that in the setting of subsistence agriculture, the extent of cultivated land has significant consequences for household food security. The analysis also revealed that households that engage in non-farm economic activities are more likely to experience food security and moderate food insecurity. Non-farm work, on the other hand, has a higher likelihood of reducing severe food insecurity among farming households. This could be because working off-farm generates extra income in addition to farm income, increasing household income diversity and food security. This is consistent with studies conducted by Danso-Abbeam et al. (2023), Assefa and Beyene (2023) and Worku (2023). Furthermore, information-related assets such as mobile phones, television, or radio reduce the likelihood of households experiencing severe food insecurity while increasing the likelihood of food security status among farming households. Radio and television inform households, including shows about farming methods and technology. Owners of these assets have better access to information on increasing farm productivity and diversifying income sources,

which improves food security. In a related study, Savari et al. (2020) highlighted that television was one of the primary channels for the improvement of food security in a related study examining the role of educational channels in raising food security status among women in Iran.

Conclusion and recommendation

Livestock production has the potential to improve food security and reduce poverty in developing economies such as Lesotho. In this study, rural households in Lesotho were classified into four distinct livestock ownership typologies. These are as follows: i) no livestock (typology I); ii) few livestock, mixed poultry and small ruminants (typology II); iii) moderate number of livestock, mostly small ruminants with a few large livestock (typology III); and iv) large quantity of livestock, mostly small and large ruminants (typology IV). ANOVA was used to explore the connection between household characteristics and livestock ownership typologies. In addition, it explored the relationship between livestock ownership typology and household food security status. The study concluded that typology III and IV households typically have larger farm sizes. In addition, a higher proportion of these households own assets such as mobile phones, radios, and televisions. According to the ANOVA analysis, while a larger proportion (53.41%) of households who do not own livestock (typology I) experience severe food insecurity, 36.54 and 35.66% of households in typology III experience food security and moderate food insecurity, respectively.

Furthermore, the mixed effect ordered probit model revealed that, while being in typology II has no significant effects on household food security status when compared to having no livestock (typology I), having a moderate number of poultry, small ruminants, and few large animals (typology III) has the potential to increase household food security and upgrade the food security status of those currently experiencing moderate food insecurity. Similarly, households in the typology IV category are more likely to improve their food security than those who do not own livestock. The study's approach to livestock typology measurement, unlike the binary or count measure of livestock ownership, and its differential effects on different stages of food security have significant policy implications for rural households in Lesotho and Sub-Saharan Africa in general. Development and intervention programs must carefully consider the complex and context-specific relationship between livestock ownership and food security, including how livestock are used by the target population, when using livestock as a means of improving food security. Policymakers and other community development stakeholders may consider developing a livestock typology system that considers livestock characteristics, such as kind, type, herd size, and use. This system can be used to identify the various roles livestock play in various aspects of livelihood. After this, targeted policies and interventions can be developed to support each typology.

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