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Smallholder Livestock Keepers' Breeding Choices and Its Implication on Poverty Reduction in Developing Countries: Empirical Evidence from Tanzania

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Abstract
The livestock sector in developing countries is characterized by poverty and outdated methods of rearing animals; thus, any initiatives to reverse the situation must focus on improving the breeding types of animals and making the process affordable across the entire livestock keeping societies. Therefore, this study examines determinants of smallholder livestock keepers' breeding choices and their implications on poverty reduction in Tanzania. It employed multinomial logit and probit models to examine breeding choices and their effects on poverty reduction, respectively. Findings showed that the sector is male dominated and largely conducted in rural areas, of which breeding choices are dominated by traditional breeds (56.34%), while improved beef and dairy breeds formed 40.51% and 3.06% of entire livestock, respectively. Moreover, the multinomial logit model results showed that residence, zone, education, and per capita income are significant determinants of livestock breeding choices among smallholder livestock keepers. Probit model results showed that improved beef and dairy breeds significantly reduce poverty compared to traditional breeds. The study recommends developing countries to have clear strategies of improving animal breeds by introducing local breeding improvement programs in all public ranching sites. This should go hand in hand with the improvement of local veterinary centers to reduce animal fatalities and enabling livestock keepers to access medics at lower or subsided costs.

Keywords Livestock · Breeding choices · Poverty · Dairy breeds · Beef breeds · Animal economics · Breeding technology

Introduction

Few studies have been carried out on smallholder livestock keepers' breeding choices, and they do not discuss these smallholder decisions on the breeding choices and their implications for poverty reduction (see Mutenje et al., 2020; Mujibi et al., 2019; Martin-Collado et al., 2018). Thus, the current study adds knowledge on the matter and relevant methodological attributes. However, the available literature has focused on the nexus between livestock keeping and poverty (Engida et al., 2015; Grace et al., 2017; Konga, 2014). While other studies have focused on livestock and food security (International Fund for Agricultural Development (IFAD), 2016), only a few have discussed breeding preferences (Mutenje et al., 2020; Martin-Collado et al., 2018). This paper, therefore, aims to examine the determinants of smallholder livestock keepers' choice (decision) in the breeding type of cattle and its implication for the poverty reduction strategies in Tanzania. Furthermore, the study considers the unique characteristics of each breed in terms of how production is highly associated with household income and wealth.

However, Mujibi et al. (2019) highlight that nearly 40% of the agricultural contribution to gross domestic product (GDP) in African countries is due to livestock activities, which the smallholder keepers dominate. The contribution is higher in individual countries as it ranges between 30 and 80%. Additionally, sub-Saharan African (SSA) countries alone constitute about 450 million smallholder livestock keepers engaged in mixed farming activities. Moreover, the sector accounts for nearly half of the entire livestock production in the continent. However, most of these livestock keepers have remained poor, with many more being in impoverished situations.

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Moreover, annual revenues received from the livestock sector in the East African region have reached US dollars 1 billion as receipts from exports from a total of more than 2 billion cattle (Michael et al., 2018). Nonetheless, the general livestock population in the Southern African Development Community (SADC) is projected to be 529,000,000, with 75% of the livestock population being kept under a smallholder traditional farming system (SADC, 2020).

In 2016, Tanzania accounted for about 1.4% of the global and 11% of the African cattle population (FAO, 2016). Moreover, the Tanzania Livestock Survey of 2016/2017 showed that cattle and goats were the leading animals kept in Tanzania, with 28.401 million and 16.67 million, respectively, while the number of sheep and pigs was 5 million and 2 million, respectively. At these statistics, the recent share of livestock in the GDP has reached 7.4%, with the sector being one of the slowest growing annually at the rate of 2.3% (Michael et al., 2018).

Despite its low contribution to the GDP, Tanzania's livestock is ranked third in Africa, next to only Sudan and Ethiopia (Engida et al., 2015) with the number of cattle increasing yearly as shown in Table 1. Moreover, major constraints associated with the sector include the low production, poor disease resilience, severe hot and dry seasons, and high mortality which is dominant among traditional breeds.

Nonetheless, due to persistent income poverty among smallholder livestock keepers in Tanzania, only less than a third of all family-owned livestock is vaccinated. Additionally, an average of 60% of all animals is reported to have some type of disease with only 6% of rural livestock holders can hire labor, while the rest depends on the family workforce; these facts justify that livestock is highly characterized by poverty in Tanzania (Michael et al., 2018).

To enhance smallholders' livestock keepers' income and food security status, a number of breeding programs were established in Tanzania (TLMP, 2021). Despite these programs by the government to improve the livelihoods of these smallholder livestock keepers, they have been found to choose better breeds based on the households' socioeconomic characteristics. In some other countries, decisions are influenced by the production capacity of the livestock breeds (Kearney & White, 2016).

Studies on non-breeding choices and production show that indigenous or traditional cattle breeds have the lowest milk production (Marshall et al., 2019) as emphasized by the Tanzania Livestock Masterplan findings in Table 2. However, these traditional breeds have often been crossed to produce breeds with varying characteristics (Mujibi et al., 2019). In Tanzania, the main cattle breeds with the largest share in the number of animals kept and beef production are Shorthorn Zebu (80%) and Ankole (14%). In addition, the traditional breeds form 94% of the entire meat produced in the country, while commercialized ranches contribute only 6% (TLMP, 2021).

Table 2 justifies that enhancing the adoption of improved breeds among smallholder livestock keepers in Tanzania will help to increase productivity and income, hence reducing poverty. Improved breeds are characterized with higher productivity, quality products (skin, meat, and milk), and disease resilient.

Table 1 Annual increase in cattle population in Tanzania

Productions zone	2016/2017	2017/2018	2018/2019	2019/2020	2020/21	2021/2022	% change
Traditional system							
Central	13,102,022	14,098,320	14,632,283	15,186,470	15,761,646	16,358,606	20%
Coastal and lake	11,560,207	12,301,694	12,626,411	12,959,700	13,301,786	3,652,901	14%
Highlands	3,773,606	4,095,903	4,288,036	4,489,182	4,699,763	4,920,222	26%
Total	**28,435,835**	**30,495,917**	**31,546,730**	**32,635,351**	**33,763,194**	**34,931,729**	**18%**
Ranching system							
Central	12,330	12,988	13,682	14,413	15,182	15,993	30%
Coastal and lake	19,297	19,525	19,755	19,988	20,224	20,463	6%
Highlands	41,400	46,037	51,193	56,927	63,303	70,393	70%
Total	**73,027**	**78,550**	**84,630**	**91,328**	**98,709**	**106,848**	**46%**
Cattle in feedlots							
Feedlots	78,111	115,878	171,905	255,020	378,323	561,242	619%
Dairy subsector	260,293.01	315,888.3	383,357	465,236	564,603	685,191	163%
Total	**338,404**	**431,765**	**555,261**	**720,255**	**942,924**	**1,246,432**	**268%**

Source: Tanzania Livestock Master Plan (TLMP) (2021)

Table 2 Traditional and improved cattle productivity in Tanzania

Parameter	Traditional cattle breed	Improved cattle breed	Smallholder	Ideal standard
Calving rate	30.00–50.00%	55–73%	40.00–50%	80.00%
Calving interval (months)	18.00–24.00	15.00–21.00	17.00–18.00	12.00
Age at first calving (months)	36.00–48.00	30.00–36.00	43.00–46.00	27.00–30.00
Pre-weaning mortality (%)	25.00–40.00%	4.30%	5.00–6.00%	< 5.00%
Calf mortality (%)	> 25.00%	3.30%	5–6%	< 10.00%
Adult mortality (%)	8.00–10.00%	1.30%	< 1.00%	< 5.00%
Mature weight (kg)	200–300	250–350	-	300–500
Lactation yield	160.0–250.0	2800–3500	1500–2000	2500–3500
Lactation length	200.00	300.00	270.00–300.00	305.00

Source: Tanzania Livestock Master Plan (2021)

Livestock Keeping and Poverty Reduction in Developing Countries

There are around 300 million impoverished people in South Asia and another 100 million throughout Southeast Asia and China who rely on livestock for a living (IFAD, 2016). The world is experiencing an increased demand for livestock products, including meat, milk, and eggs. The sector provides a one-of-a-kind opportunity to alleviate poverty via cattle production and sale. The succession of these prospects depends on the governments' responsiveness in creating a favorable and creative environment that will produce economic surplus and enhance these smallholder livestock keepers' proper access to market information channels.

Additionally, it is critical to emphasize that majorities of the poorest countries rely heavily on livestock. Thus, the livestock industry has grown faster than many other agricultural sectors; if this trend continues, the sector will be the engine of growth for developing countries agriculture sector, as many have projected. Most of the time, cattle are a source of food, manure, work, draught power, income, and export revenues. However, it is critical to note that livestock wealth is far more fairly distributed than land ownership. Accordingly, while considering the objective of inclusive growth, we must keep in mind that, from the standpoints of equality and livelihood, livestock farming must be at the forefront of poverty alleviation programs.

On a related note, Africa is the world's final frontier in the struggle against severe poverty. One in every three Africans (422 million people) now lives below the international poverty threshold. However, they constitute more than 70% of the world's poorest population, with an average of 40% living below the poverty line of US$1.90 per day, and sub-Saharan Africa (including Tanzania) accounts for two-thirds of the world's impoverished population, with the majority working in agriculture (farming and livestock keeping) (SADC, 2020). As a result, because the majority of inhabitants in these countries are employed in the agricultural sector (55–70%), it is by fact that majority of the impoverished population is engaged in agriculture (that is, crop farming and animal keeping) (Galie et al., 2019).

Several initiatives have been devised in Africa to boost agricultural productivity, particularly in the livestock sector, focusing solely on poverty reduction. These measures include implementing social security programs, increasing government spending on agriculture, improving livestock breeding programs to raise production, and improving rural infrastructure to encourage economic inclusion and equity among people in developing nations.

Additionally, most of the livestock development programs in developing countries have focused on animal production capacity without paying extra-attention to the welfare of the smallholder livestock keepers. As a result, these programs have become a new colonial system in these countries. Government authorities encourage pastoralists to produce more without being offered the necessary support to run their day-to-day activities to improve smallholder livestock keepers' welfare. For example, in sub-Saharan African countries, livestock keepers are in frequent conflict with farmers due to the insufficient pastoral land, which directly affects the livestock keepers' production capacity. Thus, conflicts, poor management, animal health, frequent drought (famine), pest and disease management, and low production have made smallholder livestock keepers prone to poverty.

To address such problems, governments in developing countries have launched various technological programs to improve productivity. These programs aimed to enhance the breeding types of livestock that are resilient to hot temperature regions and joint diseases and have high but quality products that are competitive in the regional and global markets. Despite these initiatives, the decision to choose any of these among smallholder livestock keepers in developing countries has not been well documented. Duly, this study examines smallholder livestock keepers' breeding choices and their implications on reducing poverty among pastoral societies.

Theoretical Foundation

The discrete choice model has been used in this paper to apply the random utility theory in modeling livestock keepers' utility-maximizing constraints (Mutenje et al., 2020). The random utility theory states that a decision-maker chooses a batch of alternatives, an alternative that maximize their individual utility (Greene, 2012; Greene & Hensher, 2010). Therefore, considering that individuals value the quality of a commodity differently, it is impossible to determine general utility rather than individual satisfaction feedback. However, these livestock keepers are always rational towards the choice of breeding that gives them the highest utility obtained from utilizing these breeds.

To show this, the current paper has assumed that smallholder livestock keepers' satisfaction depends on the choices made from the available set of choices for breeding types of cattle (j), which later provide a general utility function that

$$U_{ij} = V_{ij} + \varepsilon_{ij}, j = 1, 2, \ldots .j \tag{1}$$

whereas, for a smallholder livestock keeper i, one will be indifferent at U based on the cattle breeding choice j. Therefore, this theory divides utility into a deterministic part (V) and an unobservable part (ε), and smallholder livestock keepers (consumers) are regarded as rational because they will always pick the breeds that provide them with the highest utility.

Analytical Model

To examine determinants of smallholder livestock keepers' breeding choices, this paper uses the multinomial logit model (MNL) as proposed by Maddala and Lahiri (1992) and Gujarati and Porter (2009). The choice of the model is not based on the researcher's curiosity rather the ability of the MNL to use the cumulative distribution function of the logistic distribution, and it has been widely supported in similar studies (Martin-Collado et al., 2018; Murage & Ilatsia, 2011; Mutenje et al., 2020). The multinomial logit model is an extended version of the simple logit model; consider Y is the outcome variable with X regressors:

$$\pi(x) = p(Y = 1|X = x) = 1 - p(Y = 0|X = x) \tag{2}$$

Thus, simple model for logistic regression will be given by the equation:

$$Logit[\pi(x)] = log\left(\frac{\pi(x)}{1-\pi(x)}\right) = \alpha + \beta x \tag{3}$$

whereas the odds will always be given by

$$Odds = \frac{\pi(x)}{1-\pi(x)} \tag{4}$$

Therefore, the logarithm of the odds is called logit, and it is hereby given by

$$Logit[\pi(x)] = log\left(\frac{\pi(x)}{1-\pi(x)}\right) = \log[\exp(\alpha + \beta x)] = \alpha + \beta x \tag{5}$$

When there are multiple breeding choices, the model can be extended as follows:

Let k represent the number of predictors of the binary dependent variable Y that $x_1, x_2, x_3 \ldots \ldots x_k$. Hence, the model for the log of odds is given by

$$logit[P(Y = 1)] = \alpha + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_k x_k \tag{6}$$

With the alternatively direct expression being

$$\pi(x) = \frac{\exp\left(\alpha + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_k x_k\right)}{1 + \exp\left(\alpha + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_k x_k\right)} \tag{7}$$

whereby β_i represents effects explanatory variable x_i on log-odds that $Y = 1$ while controlling other explanatory variables x_k, therefore $\exp(\beta_i)$ becomes a multiplicative effect on the odds of a unit which increases on the explanatory variable x_i when all other variables x_k are constant.

Therefore, when there are n observations, p independent variables, and k categorical responses in the given function, the ideal behind constructing multinomial logit is by making one of the responses as a base outcome of which all other remaining categories will be constructed relatively to it, and all responses are not ordered; hence, any of them can be a base outcome. To simplify these explanations, consider π_j as a multinomial probability of observations falling into j^{th} category with p explanatory variables, $x_1, x_2, x_3 \ldots \ldots x_p$.

Therefore, the multiple logistic regression model is given by

$$log\left[\frac{\pi_j(x_i)}{\pi_k(x_i)}\right] = \alpha_{0i} + \beta_{1j}x_{1i} + \beta_{2j}x_{2i} + \cdots + \beta_{pj}x_{pi} \tag{8}$$

where $j = 1, 2, ..., (k-1), i = 1, 2, ..., n$. However, $\pi^{'}s$ add to unity; and therefore, the equation is reduced to

$$log\left(\pi_j(x_i)\right) = \frac{\exp(\alpha_{0i} + \beta_{1j}x_{1i} + \beta_{2j}x_{2i} + \cdots + \beta_{pj}x_{pi})}{1 + \sum_{j=1}^{k-1}\exp(\alpha_{0i} + \beta_{1j}x_{1i} + \beta_{2j}x_{2i} + \cdots + \beta_{pj}x_{pi})} \tag{9}$$

For $j = 1, 2, \ldots, (k-1)$, the parameters will be estimated by the use of maximum likelihood.

Similarly, in analyzing the effects of breeding choices on poverty reduction in developing countries, the probit model

has been used for estimating important parameters that explain the smallholder livestock keepers' socioeconomic and demographic characteristics.

Consider,

$$\varepsilon_i = N\left(0, \delta^2\right) \tag{10}$$

$$Prob\left(Y_i = 1\right) = F\left(\frac{\beta_0 + \beta_1 X_{1i}}{\delta}\right) \tag{11}$$

where F is a standard normal cumulative density function, therefore when $Y = 1$, and for the calculation on the derivatives (marginal effects):

$$\frac{\partial Prob\left(Y_i = 1\right)}{\partial X_1} = \frac{\partial F(\frac{\beta_0 + \beta_1 X_{1i}}{\delta})}{\partial X_1} = f\left(\frac{\beta_0 + \beta_1 X_{1i}}{\delta}\right)\beta_1 \tag{12}$$

Therefore,

$$y_i = \begin{cases} 0 if y_i^* \leq 0 \\ 1 if y_i^* > 0 \end{cases} \tag{13}$$

where $y_i = 1$ represents smallholder livestock keepers who live below the poverty line, while $y_i = 0$ for those who are living above the poverty threshold of US$ 1.90 per day.

Methods and Data

This paper has applied a non-experimental study design in utilizing the Tanzania Household Budget Survey (THBS) 2017/2018. The 2017/2018 HBS covered 9552 households from 796 primary sampling units (PSUs) drawn from the 2012 Population and Housing Census Frame (NBS, 2022). The THBS is normally undertaken by the Tanzania National Bureau of Statistics (NBS) for collecting demographic and socioeconomic information of residents in Mainland Tanzania. The HBS 2017/2018 was to obtain information on poverty and its associated characteristics. Instead of using the entire population, this study has used a subsample of the livestock keepers to analyze the actual effects and behavior of the studied group. In the current study, poverty has been measured by the use of the expenditure approach which is superior to the income approach because the actual consumption expenditure, which determines the living standard of a consumer unit is not always met wholly out of current income; therefore, the US$ 1.90 poverty line was employed as decision criteria of identifying livestock keepers' poverty statuses (Jolliffe & Prydz, 2016).

Results and Discussion

The results of this paper have been dived into two sections, namely, descriptive and regression results. The descriptive statistics herein explains the general characteristic of the smallholder livestock keepers in Tanzania, while the regression results show a detailed relationship among variables towards the rational breeding choice of the smallholder livestock keepers in Tanzania.

Results in Table 3 explain the socioeconomic characteristics of the smallholder livestock keepers in Tanzania. Results show that the average head of household age across entire smallholder livestock keepers was 48.7 years, while the minimum was 17 years. The minimum age of 17 is typical for head of household among pastoralist societies in Tanzania, especially the Maasai, Mang'ati, and Hadzabe. The oldest age across the entire smallholder livestock keepers' population was 98 years. Moreover, results on Table 3 indicates that the average household size was 5.6 (approximately 6 members) with the lowest household having only one member, while the household with the largest family members was found to have 38 members. These findings inline with the study of Kitole et al. (2022) who used the Tanzania Household Budget Survey data to analyze effects of farmers health on agriculture productivity.

The findings in Table 4 explain the distribution of smallholder livestock keepers in different socioeconomic statuses. Therefore, the majority (85.87%) of smallholder livestock keepers were found to reside in rural areas compared to 14.13% who were living in urban areas. This implies that most of the pastoral activities are carried in rural areas. Livestock is characterized mainly by the patriarchal system as 76.66% of the entire households are male-headed compared to 23.34% that are female-headed. Moreover, the study has shown that majority of the livestock keepers in Tanzania

Table 3 Smallholder livestock keeper household characteristics

Variables	Observation	Mean	Std. deviation	Minimum	Maximum
Head of household age	4671	48.7034	15.5094	17	98
Household size	4671	5.6035	3.1992	1	38
Total household income	4671	1,190,000	2,930,000	733,000.9	181,000,000
Household expenditure	4671	329,872.5	401,226.9	5434.524	6,920,703
Total consumption	4671	302,637.2	287,442.8	2570.42	5,021,778

Income, expenditure, and consumption are in Tanzanian shillings

Table 4 Distribution of smallholder livestock keepers

Variables	Attributes	Frequency	Percentage
Residence	Rural	4011	85.87%
	Urban	660	14.13%
Sex	Male	3581	76.66%
	Female	1090	23.34%
Land ownership	Own land	3461	76.71%
	Don't own land	1051	23.29%
Business ownership	Don't own a business	3686	71.91%
	Own business	985	21.09%
Farming participation	Yes	3967	84.93%
	No	985	15.07%
Choice of cattle breeds	Traditional breeds	2636	56.43%
	Improved beef breed	1892	40.51%
	Improved dairy breed	143	3.06%
Level of schooling	No schooling	2587	55.38%
	Some primary	492	10.53%
	Completed primary	1411	30.21%
	Some secondary	17	0.36%
	Completed secondary	116	2.48%
	More than secondary	48	1.03%
Poverty status	Above poverty line	2221	47.55%
	Below poverty line	2450	52.45%
Zones in Tanzania	Lake Zone	1358	29.07%
	Western zone	438	9.38%
	Central zone	376	8.05%
	East coast zone	400	8.56%
	Southern highland zone	905	19.37%
	Northern highland zone	741	15.86%
	Southern zone	453	9.70%

have not attended any formal education as 55.38% were found to have no any schooling record.

Besides, the findings in Table 4 show that traditional cattle breeds are the dominant breeding category owned by the majority of the smallholder livestock keepers in Tanzania, comprising 56.43% of the entire cattle. In comparison, the improved dairy and beef breeds constitute just 3.06% and 40.51%, respectively. Conversely, by zoning these smallholder livestock keepers in Tanzania, the majority are residing in the Lake Zone (29.07%), southern highlands zone (19.37%), northern highlands zone (15.86%), southern zone (9.70%), western zone (9.38%), east coast zone (8.56%), and central zone (8.05%).

Despite the traditional breed being dominant in Tanzania, its distribution is largely in rural areas compared to urban areas of the country; this is proven by the results provided in Fig. 1. Out of all smallholder livestock keepers in rural areas, 57.09% of their livestock are traditional breeds, while the improved composition is 40.06% for the improved beef breeds and 2.85% for the improved dairy breeds. On the other hand, in urban areas, the differences are small, whereas traditional breeds are just 52.42%, while the improved breeds (dairy and beef) are 47.48%.

Nonetheless, findings in Table 5 show that the traditional breed livestock have been considered as the base outcome that will be used to compare the available breeding choices. Therefore, Table 5 shows that smallholder livestock keepers in urban areas are more fragile in choosing the improved beef and dairy livestock compared to those living in rural areas who have been found to possess a large share of the traditional breeds as shown at Fig. 1. This implies that the majority of the smallholder livestock keepers in urban areas have multiple sources of income; hence, they are more advantageous in owning improved breeds compared to those in rural areas. Besides, Mutenje et al. (2020) as well as Murage and Ilatsia (2011) had similar findings and emphasized that urban livestock keepers prefer keeping improved cattle breeds compared to rural smallholder livestock keepers.

Surprisingly, being a female head of household has been found to significantly influence household decisions of choosing improved dairy and beef breeds. It is contrary

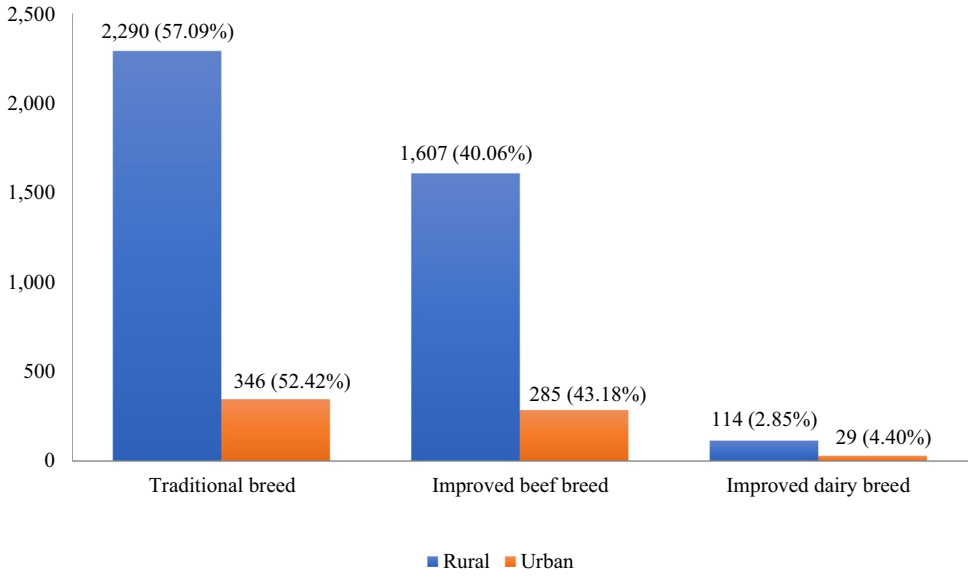

Fig. 1 Dispersion of smallholder livestock keepers' breeding choices across different sectors. **a** Residence

to the situation in most developing countries, whereby the livestock and farming sectors are largely dominated by males (Croce, 2016), and most decisions are typically made by males. Moser (2008) in Lao People's Democratic Republic (Lao PDR) argued that almost 60% decision-making on small livestock like poultry and goats to be kept by households is dominated by males, and females dominate only 40%. Large livestock like buffaloes and cows are dominated by males, whereas 75% of farmers who rear buffaloes and cows said that the decision-making process is determined entirely by the male. These findings are concurrent to Galie et al. (2019). They use the Women Empowerment in Livestock Index (WELI) techniques to analyze gender roles in the livestock sector. In contrast, the results showed that when women are empowered, they can influence the household decision by rearing improved cattle breeds and having a higher income.

Similarly, Table 5 shows that if smallholder livestock keepers can participate in other income-generating activities (e.g., business and farming), their decision to choose improved beef and dairy breeds increases significantly compared to their counterparts. Moreover, these results are corroborated by studies by Mausch et al. (2018) and Swanepoel et al. (2010) who suggest that pastoralists' income diversification is a significant factor in enhancing their decision to choose improved breeds.

The results in Table 5 further show that education plays an important role in enhancing livestock keepers' decisions towards choosing certain breeding types. This is justified by the fact that livestock keepers with just some primary education reduce their decision of choosing improved beef and dairy breed significantly, while those who have completed secondary education and above were found to have a positive and significant relationship. Moreover, due to the high costs of improved breeds, unemployed livestock keepers have been disliking the decision to choose any of these compared to the reference category of traditional breeds.

Regarding the per capita income, findings show that an increase in the smallholder livestock keepers' per capita income increases their preference for improved beef breeds by 23.505% higher than traditional breeds and 31.405% higher for the improved dairy breeds. This justifies the view that, as income increases, the smallholder livestock keepers tend to reduce the stock of their traditional cattle and increase more improved breeds due to the need for higher productivity and more income (Swanepoel et al., 2010). Bayan and Dutta (2017) got similar results and suggested that enhancing income growth among smallholder livestock keepers increases the adoption rate for such societies towards improved breeds. Thus, programs related to the shift from low to high production in the sector should consider these groups' income.

Additionally, the results show that smallholder livestock keepers who are in the southern highlands and northern highlands zones influence their preferences on the possession of the improved dairy breeds compared to those in the Lake Zone. Nonetheless, smallholder livestock keepers being below the poverty line reduce their power to choose to rear the improved dairy cattle breeds significantly compared to smallholder livestock keepers above the poverty line of US$ 1.90 (2011 PPP) per day per capita.

Effects of Improved Cattle Breeding Choices on Poverty Reduction

The results in previous sections have shown that improved cattle breeding choices increase productivity, which has direct effects on the income of the smallholder livestock

Table 5 Multinomial logit results on determinants of smallholder livestock keepers' breeding choice

Variables	Panel I: breed choice Improved beef breed	Panel II: breed choice Improved dairy breed
Urban	0.312**	0.465**
	(0.0192)	(0.1046)
Female	0.0931*	0.509**
	(0.007)	(0.346)
Age	−0.0141	0.00275
	(0.0959)	(0.0113)
Own business	0.268**	0.264**
	(0.0113)	(0.036)
Engage in farming	0.0458**	0.068**
	(0.0009)	(0.002)
Some primary education	−0.073**	−0.0358**
	(0.012)	(0.005)
Completed primary education	0.01101	0.0887
	(0.0932)	(0.328)
Some secondary education	0.01454	0.352
	(0.785)	(10,924)
Completed secondary education	0.0193**	0.0251***
	(0.001)	(0.001)
More than secondary (higher education)	0.323*	0.512**
	(0.0352)	(0.108)
Unemployed	−0.12801**	−0.1150**
	(0.0108)	(0.0365)
Never worked	−0.0901	0.158
	(0.3425)	(0.558)
Married	0.1236	1.231
	(0.4369)	(4,213)
Per capita income	0.23505**	0.31405***
	(0.0043)	(0.00112)
Western zone	−0.0587	−0.128
	(0.715)	(0.591)
Central zone	0.0340	0.361
	(0.126)	(0.527)
East coast zone	0.0303**	0.0648**
	(0.001)	(0.006)
Southern highland zone	0.1601**	0.0996**
	(0.0012)	(0.018)
Northern highland zone	0.0246**	0.0592***
	(0.0001)	(0.003)
Southern zone	0.109**	0.0832**
	(0.025)	(0.002)
Poverty line	−0.3476	−0.6540**
	(0.673)	(0.559)
Observations	4508	4508
Pseudo *R* square	0.3564	0.3564

Standard errors in parentheses

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

keepers. In this section, the extent of poverty reduction due to livestock keepers' decision to choose breeding has been examined and presented in Table 6.

The results in Table 6 show that smallholder livestock keepers being capable of choosing improved beef breeds of cattle helps reduce poverty by 34.04% compared to livestock

Table 6 Effects of livestock breeding choices on poverty reduction

Regressors	Probit coefficient	Marginal effects ($\frac{\partial y}{\partial x}$) Delta method
Residence		
Urban	−0.745***	−0. 3073***
	(0.063)	(0.0179)
Household size	−0.173***	0.110**
	(0.008)	(0.002)
Sex		
Female	0.251***	0.185***
	(0.052)	(0.014)
Age	0.002***	0.015***
	(0.035)	(0.0000)
Breeding choices		
Improved beef breed	−0.367**	−0.3404***
	(0.041)	(0.008)
Improved dairy breed	−0.276***	−0.2661**
	(0.0103)	(0.041)
Employment status		
Self-employed	0.286***	0.522***
	(0.074)	(0.0086)
Paid household worker	−0.085	0.3990**
	(0.419)	(0.135)
Unpaid household worker	0.492***	0.5907***
	(0.106)	(0.0258)
Unemployed	0.437***	0.4728**
	(0.121)	(0.0323)
Retired	0.276	0.45213**
	(0.166)	(0.0520)
Never worked	0.416***	0.5657***
	(0.086)	(0.0162)
Head of household education level		
Some primary education	0.281	0.4729
	(0.468)	(0.6207)
Completed primary education	0.167	0.4765
	(0.549)	(0.5127)
Some secondary education	−0.0494*	0.0991**
	(0.0201)	(0.0129)
Completed secondary education	−0.135***	−0.1754**
	(0.014)	(0.0243)
More than secondary education	−0.4912***	−0.3880***
	(0.2263)	(0.0298)
Land ownership		
Own land	−0.166**	0.3088***
	(0.0501)	(0.0076)
Business ownership		
Own business	−0.368***	−0.4239**
	(0.0452)	(0.01479)
Agricultural participation		
Do farming	−0.16051***	−0.14493**
	(0.0590)	(0.00719)
Constant	0.770***	
	(0.0262)	

Standard errors in parentheses

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

keepers who still keep the traditional cattle breeds. These results are concurrent to the findings by Konga (2014) and Mujibi et al. (2019) who found that an increase in the household decision in choosing to adopt improved animal breeds helps them to increase their agricultural production and income, ultimately reducing pressure on both food insecurity and poverty. On the other hand, Kitole et al. (2022) argued that for agriculture production to have impacts on farmers' welfare, their health should also be in a good state, ceteris paribus.

Likewise, smallholder livestock keepers' choice to rear improved dairy breeds has been found to reduce poverty by 26.61% higher, compared to the traditional breeding choice. Therefore, these results confirm that improved breeding choices (beef and dairy) significantly reduce poverty among pastoral societies in the developing world. Therefore, government initiatives to combat poverty among pastoral societies should consider serious efforts to enhance these pastoral societies to adopt improved livestock breeds that have higher production compared to the traditional breeds as presented in Table 6.

Conclusion

The adoption of improved livestock techniques is necessary for poverty reduction, food security, and nutritional improvement. The livestock sector in Tanzania, like in most developing countries, is characterized by poverty and low productivity; the adoption of improved cattle breeds can potentially leverage pathways to poverty reduction and enhance food security in several ways. Therefore, this paper has broadened the understanding on smallholder preferences on livestock breeding choices and, therefore, provides empirical evidence important on the factors affecting smallholder livestock keepers' choices towards different breeding categories herein used including traditional breeds, improved dairy, and beef breeds.

The findings of this paper suggest that choices of smallholder livestock keepers of the livestock breeding categories significantly depend on the residence, national zoning, income diversification (farming and business ownership), level of education, and per capita income. Therefore, any initiatives or policies necessary for eradicating poverty and improving productivity among these smallholder livestock keepers in Tanzania should consider these factors. Therefore, this paper provides highlights which can help policymakers reshape the existing Livestock Master Plan and the Livestock Sector Development Program in the developing world. They need to include key aspects influencing the decision of Tanzanian smallholder livestock keepers to improve the sector-specific productivity, which will sustain their livelihoods. It can be possible by establishing cheap breeding programs affordable to a large group of smallholder livestock keepers in different areas of the country to improve their productivity and welfare.

The role of women in the sector's transformation cannot be denied nor ignored, as the results have shown that women heads of household are more flexible in choosing improved livestock breeds compared to male heads. It justifies that women are more flexible to change than men. Thus, any empowerment program or intervention aimed at improving or increasing the share of women in the livestock sector will have a positive and significant impact on the sector transformation and hence a positive contribution to the national socioeconomic development.

Lastly, adopting the improved breeds guarantees quality and quantity of products (meat, hides, and milk) which increases income and the livelihoods of the smallholder livestock keepers. Therefore, increasing the availability of improved livestock breeds will directly impact poverty reduction. Furthermore, technological progress has led to an increase in different animal hybrids with more production capacities, despite there being longtime local breeding techniques. Therefore, using more advanced technology will help create the most abundant species that will benefit livestock keepers and the entire sector growth and the economy at large.

Availability of Data and Material Data and all materials will be available upon reasonable request.

Code Availability Codes and all materials will be available upon request.

Declarations

Consent to Participate Not applicable.

Consent for Publication The authors are ready and willing to publish with the journal.

Conflict of Interest The authors declare no competing interests.

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