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EDITED BY
Carol Kerven,
University College London,
United Kingdom

*CORRESPONDENCE
Florence Lwiza,
florence.lwiza@mak.ac.ug

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Institutional and economic analysis of community-based breeding programs in pastoral and agro-pastoral areas of Uganda

Florence Lwiza[1]*, John Ilukor[1,2], Paul Aseete[1], Fredrick Bagamba[1], Sadat Walusimbi[3], Pushna Kunda Ng'andwe[2], Joseph Oryokot[2], Barbara Kasura Magezi Ndamira[2] and Rachel K. Sebudde[2]

[1]Department of Agribusiness and Natural Resources Economics, Makerere University, Kampala, Uganda, [2]World Bank, Kampala, Uganda, [3]Department of Agricultural Production, College of Agricultural and Environmental Sciences, Makerere University, Kampala, Uganda

The study examines community-based breeding schemes as a cost-effective method for enhancing the productivity of indigenous livestock breeds. While such projects offer benefits, their success varies in different locations. Drawing data from Uganda's Teso and Karamoja regions, the research reveals that investing in such projects yields positive outcomes for farmer groups. However, challenges such as limited access to veterinary services, high maintenance costs, and the failure of the exotic breeds to adapt to extreme temperatures and drought conditions hinder project success and continuity. The study emphasises the importance of collective resource mobilisation, effective group governance, and farmer involvement in breed selection to address these issues. It also recommends promoting income-generating activities within the groups, strengthening leadership structures, and fostering member commitment to collective efforts. These measures aim to enhance the effectiveness and sustainability of community-based breeding programs.

KEYWORDS

community, breeding, livestock, pastoral, economics, institutions

Introduction

Livestock farming constitutes an important source of animal protein for the nutrition of the Ugandan population and contributes 16% to the agricultural Gross Domestic Product (GDP) of Uganda and 4% to the overall GDP (MAAIF, 2020). Livestock production contributes to households' welfare, economic status, and culture in the pastoral regions. Common livestock there includes indigenous breeds of cattle, goats and poultry. Indigenous breeds of cattle and goats are more resilient to harsh weather and tick-borne diseases and have a high calf survival rate estimated at 90% (Kugonza et al.,

2012). However, the main challenge in the commercial rearing of indigenous breeds of goats and cattle in the pastoral areas of Uganda is their low productivity (Kabi et al., 2015). For example, the milk production level for the Ankole indigenous cattle is low, averaging 508 L per year as compared to crossbred cattle averaging 1834 L per year (Kugonza et al., 2012; Behnke and Nakirya 2012). Peloschek (2009) also reported that calves' mean weight at birth is 18.5 and 26.5 kg for indigenous and crossbred cattle, respectively. Ngongolo and Mmbaga (2022) examined the performance of goats in Tanzania, and they showed that milk production per day was an average of 0.8 L and 0.3 L for the cross-bread and indigenous goats, respectively. The factors that affect the productivity of livestock in pastoral communities include limited access to adequate and nutritious pastures, limited access to water, diseases, and low-yielding breeds (Mugisha et al., 2014).

One strategy for improving the productivity and resilience of indigenous goats and cattle is crossbreeding. Crossbreeding occurs when the exotic breeds of livestock mate with the indigenous breeds to enhance the offspring's traits (Mugisha et al., 2014). In Uganda, the common method for crossbreeding is through centralised breeding schemes. Under the centralised schemes, state institutions manage nucleus-breeding units, and these are responsible for the distribution of germplasm through either natural service or artificial insemination (Gebre et al., 2022). However, the use of services offered under the centralised breeding scheme by the farmers is limited because of the high cost of accessing these services and their limited availability, especially in rural areas (Ouédraogo et al., 2021). The centralised breeding systems seldom consider farmer's preferences, needs and resources when selecting traits and breeds of livestock (Haile et al., 2019). This is because although the farmers are the beneficiaries of the investments, they are usually not involved in the design of the breeding programs, leading to the promotion of breed types that do not meet the breeding objectives and interests of the farmers (Kosgey et al., 2006; Haile et al., 2019). In developing countries, the required infrastructure for applying artificial insemination is largely unavailable (Mwanga et al., 2019). An alternative to the use of centralised crossbreeding schemes is community-based breeding. Community-based breeding programs (CBBPs) target groups of livestock farmers in the same geographical location and with a common interest in improving the genetic resources for their livestock (Haile et al., 2018). The farmer groups, therefore, are both owners and managers of the breeding livestock. The advantages of CBBPs are that they require lower investment in infrastructure and involve farmers in the selection of breeds to be promoted (Haile et al., 2023).

Communal breeding programs were introduced in the Teso and Karamoja sub-regions of Uganda, through the Regional Pastoralist Livelihoods Resilience Project (RPLRP). To reduce the vulnerability of pastoral communities to frequent and prolonged droughts, Uganda's Ministry of Agriculture Animal Industries and Fisheries (MAAIF) implemented the Regional Pastoralist Livelihoods Resilience Project (RPLRP) project. CBBPs were one of the projects promoted by the RPLRP from 2018 to 2021 to increase the productivity of indigenous breeds of cattle and goats for pastoral communities of northeastern Uganda. The assumption was that with increased productivity, the pastoralist communities can sustain their livelihoods even when environmental conditions are less favourable. This study was conducted at the end of the project cycle to draw lessons that will be used to inform the design of related programs, for example, the Climate Smart Agricultural Transformation Project being developed by the MAAIF. The farmer groups received Sahiwal exotic bulls or Boer and Gala exotic bucks for crossbreeding. Similar projects for breed improvement have been implemented by community-based organisations in the different pastoral areas of Uganda and other developing countries of Sub-Saharan Africa. However, many of these have been implemented as pilot projects, within specific geographical locations, and are seldom up-scaled (Mueller et al., 2015). This is partly a result of the limited empirical analyses of the viability of the investment and the factors that affect the successful implementation of the projects. Scholtz and Theunissen (2010) recommended the promotion of breed improvement by using germplasm from superior indigenous breeds but with a limited analysis of the financial feasibility of the strategy. The success of breeding projects depends on the economic feasibility of the investment, availability of support services such as extension and veterinary services, communal grazing lands and water sources, and markets (Leroy et al., 2016; Kuraz Abebe, 2022). The access to support services depends on the capacity and number of institutions that provide the services. However, the empirical analyses of the institutional factors and constraints to up-scaling communal breeding projects are limited. This research, therefore, was conducted with the objectives of; (i) mapping the key institutions and actors involved in the management of community breeding programs: (ii) analysing the socioeconomic factors affecting the sustainability of the breeding stock; (iii) analysing the costs and benefits of investment in community-based breed improvement programs for indigenous goats and cattle. This study contributes to the existing literature by analysing the peculiarities of community-based breeding projects and conducting a comparative assessment of the net benefits of investment in both goats and cattle breed improvement. The findings therefore enrich the limited, yet expanding literature on the economics of community-based breeding, providing valuable insights for the formulation of breeding policies and community-based breeding initiatives.

Materials and methods

Study area

In Northeastern Uganda, the study surveyed the sub-regions of Teso and Karamoja. The data were collected from 11 purposively selected districts where the Regional Pastoralist Livelihoods Resilience Project that promoted community breeding was implemented. These districts included Kaabong, Amudat, Moroto, Nakapiripirit, Kotido, Abim, and Napak in the

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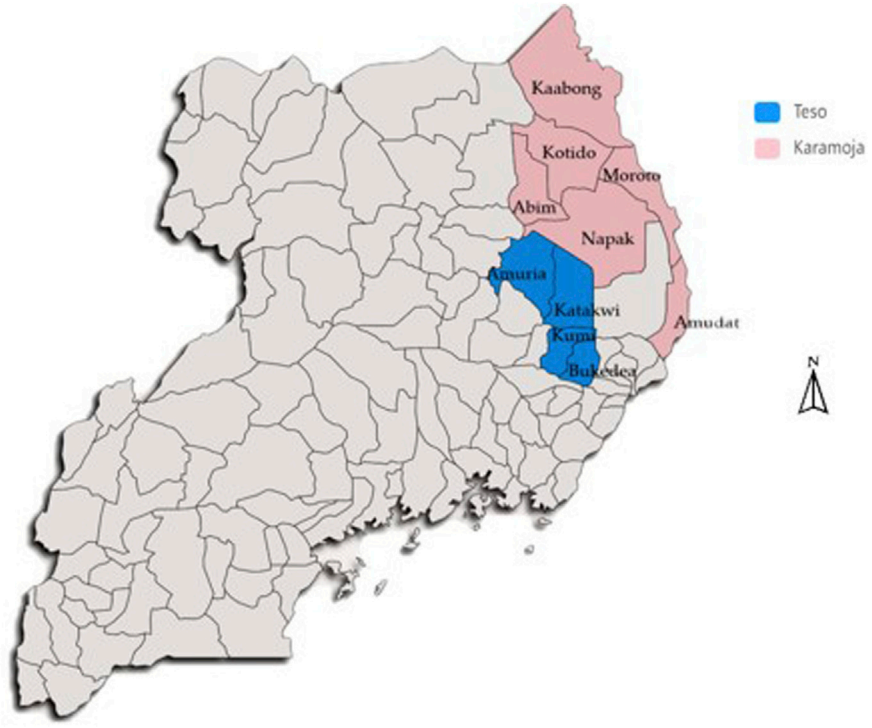

FIGURE 1
Study districts in the Teso and Karamoja regions of Uganda.

Karamoja region; Katakwi, Bukedea, Kumi and Amuria in the Teso sub-region, as shown in Figure 1. Northeastern Uganda has about 2,253,960 cattle (20% of Uganda's cattle), 2,025,300 goats (16% of Uganda's goats), 1,685,500 sheep (50% of Uganda's sheep) and 14% camels (UBOS, 2020). In this region, more than 80% of the population is dependent on pastoralism and agro-pastoralism (Egeru et al., 2014). The pastoral system is characterised by grassland vegetation, whereby seasonal migration in search of water and pasture is common, whereas the agro-pastoral system is a crop-based sedentary production system where both crop production and livestock production are done. Northeastern Uganda experiences one wet season in a year that runs from March to August, whereas the dry season lasts an average of 6 months from September to February (Lwasa et al., 2019). However, there is variability in the weather patterns, with increasingly longer dry seasons of up to 8 months. The main ethnic groups include the Karamojong, Itesots, Jie, and Sebei, and these practice communal grazing that is governed through social institutions such as clan leaders, elders, kraal leaders and herders.

Data collection and analysis

The study data was collected through a cross-sectional survey of farmer groups that received exotic breeds of cattle and goats for breed improvement. The districts where the data was collected were those where the RPLRP was implemented and these were purposively selected. From each district, 5 villages were randomly selected and from each village, a list of groups that received the breeding stock was used to identify the groups to sample. Therefore, 81 groups for cattle breed improvement projects were sampled, and these represented 24.65% of the groups that received the breeding bulls, whereas for the goat breed improvement projects, 74 groups were sampled and these represented 41.5% of the groups that received the breeding goats. Despite the limited sample size and scope of the study, the results remain valid and can be generalised to pastoral communities with similar socioeconomic conditions. The data collected included the characteristics of the groups, group governance and challenges, quantities of inputs, outputs and market prices for inputs and outputs for the investments.

Given the low literacy levels, the groups had no written records of their group activities and finances. The data was therefore collected based on a recall of events by the respondents. The challenge with recall methods is that they can lead to inaccurate or incomplete data, leading to measurement errors. However, recall bias was minimised by collecting data through group interviews with a minimum of 2 group members. Through the group interviews, participants could remind each other of details and events, and challenge or

TABLE 1 Description of variables.

Acronym	Variable description	Measurement
X_1	Presence of markets	Binary variable
X_2	Type of livestock	Binary variable, (1 = Cattle, 2 = Goats)
X_3	If the group charges for breeding services	Binary variable (1 = Yes, 0 = No)
X_4	Membership to pastoralist associations	Binary variable (1 = Yes, 0 = No)
X_5	Membership to breeding associations	Binary variable (1 = Yes, 0 = No)
X_6	If there are Agricultural NGOs in the community	Binary variable (1 = Yes, 0 = No)
X_7	If the group can access veterinary services	Binary variable (1 = Yes, 0 = No)
X_8	Distance to all-weather roads	Continuous variable measured in Kilometres
X_9	If there were conflicts in the group	Binary variable (1 = Yes, 0 = No)
X_{10}	If the group was involved in the selection of livestock	Binary variable (1 = Yes, 0 = No)
X_{11}	Number of women in the group	Continuous variable measured in whole numbers
X_{12}	Hours per day spent caring for livestock	Continuous variable measured in hours
X_{13}	Region where the groups are located	Binary variable (1 = Karamoja, 0 = Teso)

corroborate each other's responses, leading to more reliable data and complete data.

To identify the key actors and their level of importance in the management of the breeding projects, the respondents were tasked to rate the actors on a 3-point Likert scale where 1 = not important, 2 = fairly important, and 3 = important. We used a 3-point Likert scale to make it easier for the respondents, most of whom were elderly and illiterate, to understand the survey questions and response options. The three distinct response options reduce the cognitive burden for the respondents, and the ambiguity of responses (Aybek and Toraman, 2022). We used a weighted average mean to estimate the relative importance of the actors. The weighted average mean is a method that is to determine the relative importance of factors that have differing weights as shown in Eq. 1, where W is the weighted average mean, X_i are the data values to be averaged, w_i are weights applied to the X values and n are the number of terms to be averaged.

$$W = \frac{\sum_{i=1}^{n} w_i X_i}{\sum_{i=1}^{n} w_i}$$

To analyse the institutional and socioeconomic factors that affect the sustainability of breeding livestock, we used regression analyses. According to Martyniuk (2021); Gamborg and Sandøe (2005), sustainability in livestock breeding is the continuous availability of breeding animals and their germinal products to meet the needs of a broad range of stakeholders that include the breeders, producers, consumers while respecting animal welfare and sustainable agriculture. For this research, the sustainability of the breeding livestock was measured as a binary variable, based on the availability of the breeding stock and/or their offspring by the time the survey was conducted.

The rural livelihood framework posits that the human, social, physical, natural, and financial resources affect institutions and livelihood outcomes. Therefore, the selection of the factors affecting the survival of breeding stock was based on the key capitals of the livelihood framework, as shown in Table 1. Given that the key institution involved in the management of breeding livestock was the group of farmers, the unit of analysis was the farmer's group.

The model was based on the assumption that the survival of the breeding stock is not random. Rather, it is determined by the livestock type and breed, the location, access to livestock support services, group-specific characteristics and management factors. The techniques and strategies employed by the farmers' group to manage their breeding stock, such as feeding, healthcare, and shelter, directly influence the survival of the stock. These management practices are affected by the group's knowledge, resources, and collective decision-making processes, which are internal factors. The groups decide to whether to undertake the routine management activities, creating a possibility of endogeneity resulting from self-selection. We used access to training and extension services as a proxy for the management. Training equips group members with the knowledge that they need for proper management of the breeding stock and also influences the decision to undertake routine management activities. However, access to training influences the survival of the breeding stock, and the survival of the breeding stock may influence the group's access to training, creating a challenge of simultaneity.

Given that the dependent variable (survival of the breeding stock) and the endogenous regressor (access to training and extension services) are both binary variables, the use of the ordinary probit model would lead to biased and inconsistent estimates. We therefore used a bivariate probit model that controls for selection bias and simultaneity. By modelling the joint distribution of the two binary outcomes, the bivariate model yields more efficient and consistent parameter estimates.

The survival of the breeding stock (Y_1) took on 2 values; 1 if the group that received the breeding stock has at least one surviving parent stock or the offspring and 0 if there was none. Access to training and extension services (Y_2) was measured as 1 if the group had received training on the management of breeding stock and 0 otherwise.

$$Pr((Y_1 = 1)(Y_2 = 1)) = ln(P1 - P) = \alpha_0 + \alpha_1 X_{j1} + \alpha_2 X_{j2} + \cdots\cdots \alpha_n X_{jn} + \quad (1)$$

The description of the independent variables is shown in Table 1.

To analyse the economic viability of investments in communal breeding, cost-benefit analyses were conducted by quantifying the monetary value of the breeding stock, inputs, and also the value of the outputs and benefits to groups. A common measure to use in valuing inputs and outputs is that of market prices. However, some inputs and outputs that households use, such as family and group labour, are non-market goods and cannot be valued based on market prices. Therefore, we attached a monetary value to the non-marketed inputs and outputs by using their shadow prices, as was done by Shadow prices for the inputs are obtained based on the rate that a farmer would pay if they had procured them from the market. For example, where the group members used their own labour or family labour, the value was estimated based on the rate per day for labour procured from the market. The outputs were also valued based on the equivalent price on the market.

We analysed the benefits and costs of keeping breeding stock by estimating the Net Present Value (NPV) The NPV is a measure used to decide if a project is worth investing in by comparing the value of future earnings to the present-day cost of the investment (Ng'ang'a et al., 2020). It is obtained from the difference between the monetary value of all the benefits and costs for investments, adjusted for changes in the value of money over time, as shown in Eq. 2.

$$NPV = \sum_{t=1}^{n} \frac{B_t - C_t}{(1+i)^t} \quad (2)$$

Where *Bt* is the benefit each year, *Ct* is the costs each year, *i* is the discount rate, and *t* is the lifespan of the investment. The discount rate reflects the expected rate of return from investing capital. For this study, we used a discount rate of 5% and this was based on the rate that the commercial banks in Uganda give for capital invested as savings. Given that the savings rates vary over time and can affect the value of the investments, tested the robustness of our results by using discount rates at 3% and 6%.

The major costs incurred in the investment of community breeding include costs of acquiring the livestock, veterinary services, and maintenance of records, supplies, and feed. The costs for accessing veterinary services include the costs of vaccination and treatment of diseases that may occur during the growth of livestock. Given that the bulk of the feed is obtained from grazing, the breeding livestock were also given purchased feed supplements. The costs therefore include the initial expenditure on the breeding flock and the annual expenditures on supplementary feeding, veterinary drugs, and services, the imputed cost of family labour and the cost of supplies such as name tags, measuring tapes, and record books. The analysis examined the benefits and costs of a representative group resulting from the investment in breeding cattle or goats. The benefits measured included the value of the offspring, taking into consideration the variation in the flock size over the lifetime of the parent stock. The method used to value the outputs was adapted from Haile et al. (2018) and it was obtained as shown in Eq. 3, where V is the value of outputs, V_S is the value of livestock at the beginning of the year, V_B is the value of new births, V_D is the value of livestock lost through death or theft.

$$V = V_S + V_B - V_D \quad (3)$$

The key assumptions were that:

(i) The survival rate of the opening was 33.33% for the goats and 57.10% for the bulls and these values were obtained from the study findings. (ii) The maturity period is 2 years for the bulls and 1 year for the goats. (iii) The offspring from the use of improved breeds have a superior genetic composition and therefore fetch higher market prices as compared to the pure indigenous livestock. (iv) The market value of each generation of the offspring reduces by 20% since their traits are less superior as compared to the parent stock. (v) The rate of return for both the bulls and bucks was estimated at 5%.

Results

Key actors involved in the management of community-based breeding programs

We identified the key actors through stakeholder mapping. Stakeholders are persons with significant

influence over a program or those who are significantly impacted by it. The relative importance of the actors was analysed using the weighted average mean score of the Likert scale ratings and these are summarised in Figure 2, where the larger the mean score, the higher the importance of the actor. The stakeholders that were identified included the following.

We identified the key actors through stakeholder mapping. Stakeholders are persons with significant influence over a program or those who are significantly impacted by it. The relative importance of the actors involved in the implementation of the breeding projects was analysed using the weighted average mean score of the Likert scale ratings, whereby the larger the mean score, the higher the importance of the actor. The results show a consistent pattern in the ratings for the actors for both the bull and buck breeding projects. However, the ratings for the actors involved in bull breeding were consistently higher than the ratings for the actors involved in the buck breeding projects.

Hosts are seen as the most crucial actors in cattle breeding, with the highest rating of 50. In buck breeding, while still important, their role is perceived to be less critical, reflected by the rating of 16.5. The Sub-county and Para Veterinary Officers are important, in cattle breeding, given their high ratings estimated at 38 and 35, respectively. For the groups that had the breeding bucks, their importance, while still significant, is comparatively lower (16.3 and 11.3), possibly indicating different health management practices or needs between the two types of livestock. Group Members and District Veterinary Officers play moderate roles in cattle management (ratings of 18 for both), indicating their involvement in supporting and overseeing livestock activities. In goat management, their roles are perceived as less critical, with ratings of 6.8 and 4.2, respectively. However, the community leaders, group executives and veterinary input traders were rated the lowest, with ratings less than 10.

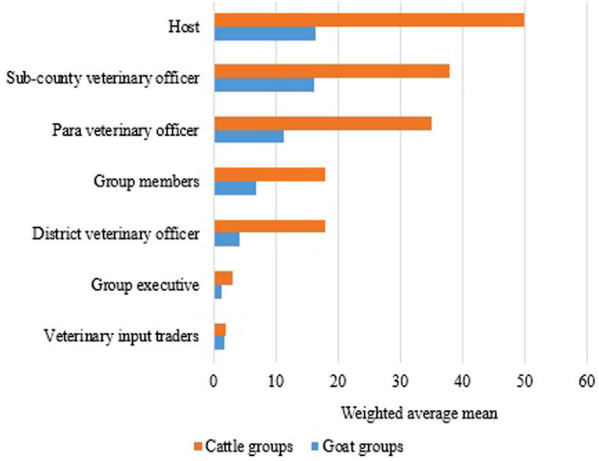

FIGURE 2
Relative importance of the key actors for the CBPP.

Challenges faced by the groups in sustaining the breeding livestock

Despite the important role played by the farmer groups, they face several challenges in the implementation of community breeding projects. The findings showed that groups with the breeding bulls and breeding bucks faced similar challenges, as shown in Figure 3. The major challenge in the management of breeding stock was their vulnerability to tick-borne diseases, as stated by 35% of the groups that received breeding bulls and bucks. Thefts resulting from cattle rustling and criminal networks within the villages are prevalent in the study area. The results showed that 29% of the groups that received breeding bulls and 58% of the groups that received breeding bucks lost their stock to theft. The proportion of groups that stated prolonged drought as a key challenge was 15% for both the groups that received breeding bulls and those that received breeding bucks. Despite the availability of communal grazing lands and water sources, the availability of the pasture is seasonal, and therefore farmers cannot access them during extremely dry weather. The proportion of groups that stated prolonged drought as a key challenge was 15% for both the groups that received breeding bulls and those that received breeding bucks. Despite the availability of communal grazing lands and water sources, the availability of the pasture is seasonal, and therefore farmers cannot access them during extremely dry weather. The least challenges were limited savings, no clear roles for members, non-functional management committees, and multiple levels of decision-making, all of which were reported by less than 10% of the groups.

Socio-economic characteristics for groups with communal breeding goats

The exotic breeds of bulls and bucks were distributed to groups of farmers, and these were responsible for their routine management. The main stated objectives for breed improvement for both the goats and the cattle were to increase weight gain and the rate of growth for the offspring. Other stated objectives included increasing the milk yield and increasing the resilience to harsh weather and diseases. The veterinary officers selected the groups that received the goat breeding stock based on their interest in breed improvement, capacity and experience in livestock production. The findings in Table 2 showed that 66 groups received the breeding bucks, whereby

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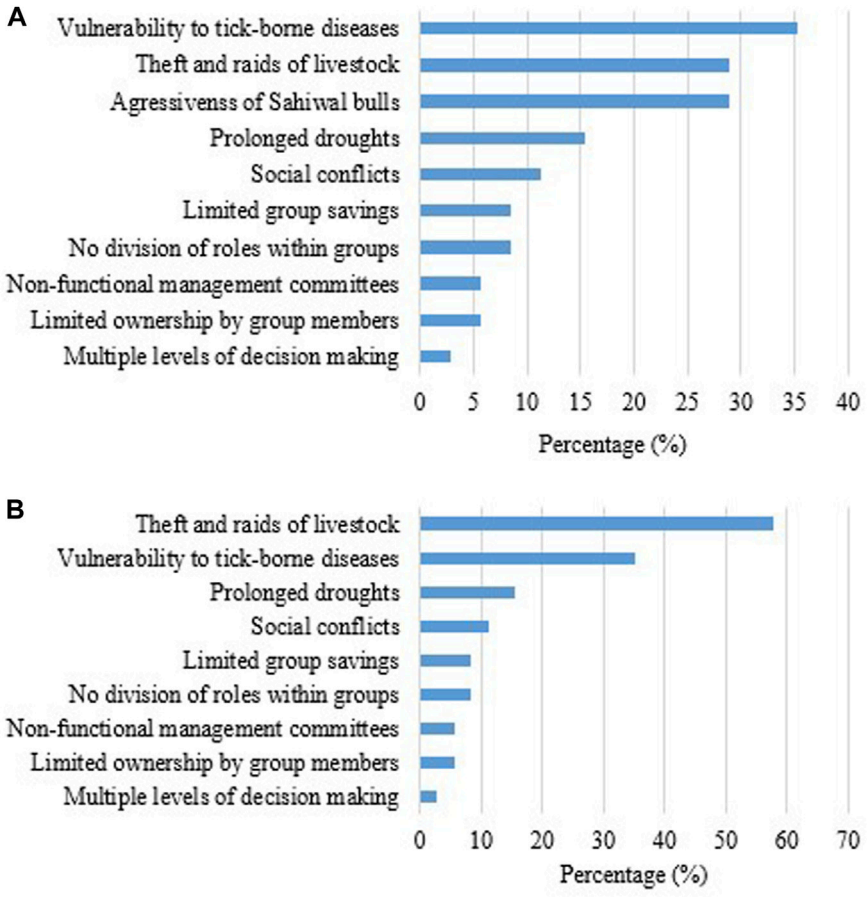

FIGURE 3
Challenges faced by the farmer groups. Graph **(A)** shows the challenges faced by groups with the breeding bulls, whereas graph **(B)** shows the challenges faced by groups with breeding bucks.

42.42% received the Boer breed, whereas 57.58% received the Gala breed. At the start of the project. Most of the groups (71.2%) were consulted regarding the type of breed to receive. Karamoja region had a higher number of groups sampled with the breeding bucks as compared to the Teso region. Therefore, of the 66 groups surveyed, 46 were from Karamoja and 20 from the Teso region. The percentage of the breeding bucks that were alive by the time the survey was conducted was 34.85% for the whole sample, and 34.78% and 35% for the Karamoja and Teso regions, respectively. In the Karamoja region, only 7% of the groups that lost bucks could replace them and, 16.67% in the Teso region. The groups that replaced the lost bucks used indigenous breeds as replacement stock.

On average, 9 offspring had been sired by the breeding bucks, with a significantly higher number of offspring in the Teso region as compared to the Karamoja region. The average number of offspring was 7 for the Karamoja region and 15 for the Teso region. However, the results show that the survival rate of the offspring was higher in the Karamoja region as compared to the Teso region and the difference was statistically significant at 1% level. The survival rate for the offspring was estimated at 59.45% for the whole sample and for the Karamoja and Teso regions, it was estimated at 49.2% and 2.77% respectively. The results further show that the groups kept the breeding bucks for an average of 2.82 years. For the Karamoja and Teso regions, the groups kept the bucks for an average of 2.67 and 3.15 years, respectively. However, keeping the bucks for more than 2 years creates the risk of inbreeding. The groups held onto the breeding stock for more than 2 years because they lacked replacement sources.

On average, the groups spent 3.72 h per day taking care of the breeding bucks. This included feeding, cleaning, and collection of water. There was no statistical difference in the number of hours used to take care of the breeding bucks between the Teso and Karamoja sub-regions. Also, the average distance to the main roads was 16.75 km, with the Karamoja region having a significantly higher distance of 23.07 km compared to the Teso region with 2.23 km. The distance to the main road

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TABLE 2 Descriptive statistics for groups with communal breeding bucks.

	All (n = 66)	Karamoja (n = 46)	Teso (n = 20)	t-statistic
Proportion of groups that participated in breed selection	71.21	65.21	85.00	2.66
Proportion of groups that received Boer goats	42.42	41.30	45.00	0.08
Proportion of groups that received Gala goats	57.58	58.70	55.00	
Mean years that breeding bucks are kept	2.82	2.67	3.15	−0.92
Mean survival rate of parent stock (%)	34.85	34.78	35.00	0.99***
Mean number of offspring sired per buck	9	7	15	−2.79***
Mean hours spent on routine activities per day	3.72	3.91	3.275	1.061
Mean survival rate of offspring	59.45	49.20	82.77	−3.26***
Mean annual operational costs (USD)	32.21	33.76	28.66	0.39
Mean distance to an all-weather road (Kilometres)	16.75	23.07	2.23	1.19
Proportion of groups with access to veterinary inputs	21.21	28.26	5.00	4.51**
Proportion of groups with access to veterinary officers	24.24	28.26	15.00	1.33
Proportion of groups with access to para-veterinary officers	66.67	82.61	30.00	17.36***
Proportion of groups with access to extension services	30.30	32.61	25.00	0.38
Proportion of groups charging a fee for service	12.12	17.39	0.00	3.96**
Proportion of groups willing to charge a fee	25.76	17.39	45.00	3.63*
Proportion of groups with access to training	62.12	65.22	55.00	0.62
Proportion of groups supported by Agricultural NGOs	60.61	87.78	5.00	37.16***
Proportion of groups with membership to a pastoralist association	40.91	43.48	35.00	4.74
Proportion of groups that have experienced internal conflicts	9.09	8.70	10.00	0.05

***, **, * Significant at 1%, 5%, 10% respectively.

shows the remoteness of the locations and could also impact the ability to access inputs, extension and veterinary services.

Water and pasture are essential for the sustenance of the livestock. However, the findings showed that 28.79% of the sample accessed communal dams for watering the goats, and 30.30% had access to communal grazing lands within their communities. Most of the farmers travel long distances to access water and pasture. The assessment of the support services available shows that only 34.29% of the farmer groups accessed veterinary officers whereas 44.29% accessed extension services. Veterinary services are essential in treating livestock and administering routine vaccinations, whereas extension services are useful in delivering knowledge to farmers about good management practices. However, the groups that had higher access to para-veterinary officers were estimated at 47.14% for the sample, 66.67% and 29.73% for the Karamoja and Teso regions, respectively.

Pastoralist associations are important avenues for advocacy and lobbying for services, sourcing for replacement breeding stock, and sharing information related to livestock production and marketing. However, only 25.71% of the sample were members of pastoralist associations in the area. The number of groups that were members of breeding associations was significantly higher for the Karamoja region compared to the Teso region and the results were significant at a 5% level. This difference is attributed to the availability of institutions and extension workers that can initiate the formation of the associations. The results further showed that 50% of the groups had agricultural Nongovernmental organisations in their localities, from which they could access services related to livestock management. The Karamoja region has a higher proportion of Agricultural NGOs present in the study areas compared to the Teso region with only 13.51% and the results were statistically significant at a 1% level.

Financial resources are important for the sustenance of the groups. However, only 4.29% of the groups mobilised financial resources within the group by charging a fee for breeding services. As a way of raising funds for the groups, 48.57% of the sample stated they were willing to charge a small fee for using the breeding stock to service the goats in the community.

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TABLE 3 Descriptive statistics for groups with communal breeding bulls.

Characteristics	All (n = 70)	Karamoja (n = 33)	Teso (n = 37)	t-statistic
Proportion of groups supported by agricultural NGOs in the community	50.00	90.91	13.51	41.79***
Mean number of offspring sired per bull	5	1	8	−4.51***
Mean number of off-spring survived per bull	4	1	7	−4.95***
Mean number of years spent keeping the breeding bulls	3.47	2.81	4.05	−1.74*
Mean hours spent on routine activities per day	3.50	4.24	3.00	1.89*
Survival rate of parent stock	83.54	66.42	91.27	−2.39**
Mean annual operational costs (USD)	55.31	60.42	50.77	0.59
Distance to all-weather road (Kilometres)	18.89	40.04	1.94	2.28**
Proportion of groups with breeding bulls alive	25.71	9.09	40.54	9.03***
Proportion of groups with access to veterinary inputs	31.43	51.52	13.51	11.69***
Proportion of groups with access to veterinary officers	34.29	48.48	21.62	5.59**
Proportion of groups with access to para-veterinary officers	47.14	66.67	29.73	9.55***
Proportion of groups with access to communal grazing lands	41.43	27.27	54.05	5.16**
Proportion of groups with access to extension services	44.29	54.55	35.14	2.66
Proportion of groups charging a fee for service	4.29	6.06	2.70	0.48
Proportion of groups willing to charge a fee	48.57	42.42	54.05	0.72
Proportion of groups with access to training	75.71	60.61	89.19	7.75***
Proportion of groups that participated in breed selection	85.71	81.82	89.19	0.77
Proportion of group with membership to a pastoralist association	27.14	39.39	16.22	4.74**
Proportion of groups that have experienced internal conflicts	17.14	18.18	16.22	0.05

***, **, * Significant at 1%, 5%, 10% respectively.

Socio-economic characteristics for groups with communal breeding bulls

The findings shown in Table 3 show that the number of groups that received the Sahiwal breeding bulls was 70 for both the Teso and Karamoja regions. In the Karamoja sub-region, 33 groups were sampled, whereas in the Teso sub-region, 37 were sampled. The findings however show that the percentage of bulls that were still alive by the time the survey was conducted was 25.71% for the whole sample and 9.09% and 40.54% for the Karamoja and Teso regions, respectively. The loss of the breeding bulls was attributed to the infestation with tick-borne diseases, cattle thefts, limited pasture and water and their inability to withstand extreme temperatures in the study area. The average number of offspring sired by the Sahiwal bulls was an average of 5 for the whole sample, whereas the Karamoja and Teso regions had an average number of 1 and 8, respectively. The difference in the mean number of offspring was statistically significant at a 1% level. However, the mean number of offspring that survived was 1 and 6 for the Karamoja and Teso regions, respectively, and this difference was statistically significant 1% level. The survival rate of the calves was estimated at 60.42% and 91% for the Karamoja and Teso regions, respectively. The calves are more resilient to extreme weather conditions and tick-borne diseases as compared to the parent stock because they are crossbreeds. The findings further showed that the groups kept their breeding bulls for an average of 3.47 years for the sample and 2.81 and 4.05 years for the Karamoja and Teso regions, respectively. The difference in the number of years that the groups kept the Sahiwal bulls was significantly different at a 10% level for the two regions. However, keeping the bulls for more than 2 years also created the risk of inbreeding. The groups stated that they were not aware of a source that they could use to replace the bulls or to exchange them to avoid inbreeding.

On average, the number of hours used to take care of the breeding bulls was 3.5 h per day and this was used to collect water and pasture for the bulls and the routine husbandry practices such as cleaning. The bulls consumed an average of 20 L of water per day and this was collected from dams and wells that were distant from the households. The bulls were sedentary and unable to walk for long distances to access water sources.

Considering the services that were accessible in the community, the findings showed that only 18.57% of the groups with the Sahiwal bulls had a water dam present in their parishes, and only 41.43% had communal grazing lands within their parishes. Byakagaba et al. (2018) show that access to communal grazing lands in pastoral areas is reducing because of the privatisation of the lands.

The findings show that 34.29% of the groups could access services from the sub-county veterinary officers and 47.14% access the services from the para-veterinary officers. However, the percentage of groups that accessed the services was higher for the Karamoja region and the difference was statistically different at 5% for the veterinary officers and 1% for the para-veterinary offices.

The percentage of groups that charged a fee to access the Sahiwal Bull services was low, estimated at only 4.29% for the whole sample. For the Karamoja and Teso regions, this was estimated at 6.06% and 2.70% respectively. However, the percentage of groups that were willing to charge a fee was higher, estimated at 48.57% for the whole sample and 42.42% and 54.05% for the Karamoja and Teso regions, respectively. Mobilisation of financial resources within the groups contributes to meeting the veterinary expenses. However, given the high poverty levels in the region, farmers' ability to raise resources remains low.

Only 27.14% of the groups were members of pastoralist associations, with the Karamoja region having a significantly higher percentage of 39.39% as compared to the Teso sub-region with 16.22%. This could be attributed to the higher number of agricultural organisations in the Karamoja region who mobilise the pastoralists to form groups to increase access to services and for lobbying. The Karamoja region had over 90% of the groups having access to the services of agricultural NGOs as compared to the Teso region with only 13.51% and this difference was statistically significant at a 1% level. Likewise, the proportion of groups with access to extension services was higher for the Karamoja region, where 54.55% of the groups had access and 35.14% for the Teso region.

Factors affecting the survival of breeding stock

The results for the factors affecting the survival of breeding stock are presented in Table 4. The results for the whole sample show that access to para-veterinary officers, group membership to pastoralist associations, group participation in the selection of livestock type, and the location of the groups had a significant effect on the survival of breeding stock. Groups that had access to para-veterinary officers were 0.1463 (p-value = 0.026) times more likely to sustain the breeding stock as compared to those that did not. In addition, groups that received support services from the resident agricultural non-governmental organisations had a higher likelihood of sustaining the breeding stock by 0.1543 (p-value = 0.054) and the results were significant at the 10% level. Groups located in the Teso region are also 0.3418 times more likely to sustain breeding stock as compared to those in the Karamoja region and the results were significant at the 1% level. The groups that were members to pastoralist associations were 0.0886 times more likely to sustain breeding stock as compared to those that were not and these results were significant at 10% level.

In the Karamoja region, the groups that had access to agricultural non-governmental organisations were 0.9770 times more likely to sustain the breeding stock as compared to those that did not, and the results were significant at the 1% level. The groups that participated in the selection of livestock for breeding were 0.1982 (p-value = 0.003) times more likely to sustain the breeding stock as compared to those that did not participate. However, an increase in the cost of managing the bulls also reduced the likelihood of sustaining the breeding bulls by 0.0009. In addition, groups that had the breeding bulls were 0.1992 times less likely to sustain the breeding stock compared to those that had the bucks.

For the Teso region, access to para-veterinary officers and an increase in the cost of managing the breeding stock increased the likelihood of sustaining the breeding stock by 0.2197 (p-value = 0.039) and 0.0019 (p-value = 0.023) respectively. Conversely, the groups that charged a fee for the use of the bull or buck service were 1.0530 times less likely to sustain the breeding stock as compared to those that did not charge a fee.

The analysis of the results for the groups that had breeding bucks shows that the groups that had access to agricultural organisations were 0.2577 (p-value = 0.028) times more likely to sustain the breeding stock as compared to those that did not have access. In addition, groups that were charging a fee for the service of the bucks were 0.2485 times more likely to sustain the breeding bucks (p-value = 0.017). Group consultation of the type of livestock for breeding has a positive and significant effect on the survival of the breeding stock and the result was significant at the 1% level with 0.2819 compared to those that did not participate. On the other hand, an increase in the cost of sustaining the breeding bucks reduces the likelihood of the survival of the breeding stock by 0.0011 (p-value = 0.049). The results further showed that groups that received the Gala breed of bucks were 0.2197 times less likely to sustain the breeding buck and the results were significant at 1% level.

The results for the groups that received the Sahiwal bulls show that membership in a pastoralist association increased the likelihood of the survival of the breeding stock by 0.3431 (p-value = 0.005). In addition, groups in the Teso region were 0.4665 times more likely to sustain the breeding bulls compared to those in the Teso region. However, groups that charged a fee for bull service and those that experienced conflict were less likely

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TABLE 4 Marginal effects for the factors affecting the survival of breeding livestock.

		By region		By livestock type	
	All livestock (n = 136)	Karamoja (n = 79)	Teso (n = 57)	Sahiwal bulls (n = 70)	Bucks (n = 66)
Access to veterinary inputs	−0.0518	0.0160	−0.0906	0.0282	−0.094
	(0.0658)	(0.0639)	(0.1435)	(0.0959)	(0.0973)
Access to para-veterinary officers	0.1462	−0.0280	0.2197	0.0877	−0.0114
	(0.0658)**	(0.0829)	(0.1198)*	(0.0887)	(0.0829)
Access to veterinary officers	0.0044	0.0055	0.1272	−0.0772	0.0847
	(0.0653)	(0.0680)	(0.1040)	(0.0934)	(0.0862)
Presence of Agricultural NGO in community	0.1540	0.9770	0.0027	0.0611	0.2577
	(0.0798)*	(0.1928)***	(0.0933)	(0.1151)	(0.1261)**
If group charges for services	0.0142	0.0269	−1.0530	−1.1163	0.2485
	(0.1135)	(0.1017)	(0.3227)***	(0.2203)***	(0.1040)**
Number of women in group	−0.0009	−0.0038	−0.0052	−0.0049	0.0021
	(0.0032)	(0.0038)	(0.0047)	(0.0042)	(0.0037)
Time spent on routine activities per day	−0.0101	−0.0025	0.0018	−0.0174	0.0116
	(0.0111)	(0.0148)	(0.0155)	(0.0144)	(0.0165)
Location (base = Karamoja region)	0.3418			0.4665	0.1587
	(0.0699)***			(0.1236)***	(0.1172)
Membership to a pastoralist association	0.0886	0.0980	0.0721	0.3431	0.0305
	(0.0747)*	(0.0733)	(0.1330)	(0.1212)**	(0.0891)
Group participation in breed selection	0.0919	0.1983	−0.0816	−0.1044	0.2819
	(0.0791)	(0.0663)***	(0.1286)	(0.1025)	(0.0801)***
If group experienced internal conflicts	−0.0777	−0.0562	−0.0491	−0.1757	−0.1010
	(0.0815)	(0.0916)	(0.1171)	(0.0925)*	(0.1052)
Operational costs (USD)	−0.0001	−0.0009	−0.0019	0.0003	−0.0011
	(0.0005)	(0.0005)*	(0.0008)**	(0.0006)	(0.0006)**
Distance to main road (Kilometres)	0.00003	0.00004	0.0156	−0.00001	−0.00002
	(0.0002)	(0.0001)	(0.0121)	(0.0001)	(0.0003)
Sahiwal bull (base = buck)	−0.0894	−0.1992	0.0811		
	(0.0571	(0.0591)***	(0.1026)		
Boer breed (base = Gala)					−0.2197
					(0.0699)***
Sample (n)	136	79	57	70	66
Wald chi2	27.01	15.31	80.87	223.94	28.11
Probability	0.0579	0.4292	0.000	0.000	0.0436
Log pseudo likelihood	−155.0739	−81.4299	−59.7222	−59.2887	−73.3769

***, **, * Significant at 1%, 5%,10% respectively.

to sustain the breeding bulls by 1.1627 (p-value = 0.000) and 0.1757 (p-value = 0.058).

Economic analysis of investments in community-based breed improvement

The economic feasibility of the investment in communal breeding programs is based on a cost-benefit analysis using the Net Present Value (NPV). We compared the financial benefits and costs of a baseline scenario with purely indigenous breeds, and this was compared to a scenario where the indigenous breeds are crossed with exotic breeds under community-based breeding projects. The benefits measured include the value of the livestock, taking into consideration the variation in the flock size over time. The results of the analysis for presented in Table 5 and the details are presented in the Supplementary Material.

The discounted and undiscounted net benefits of investment in cattle breeding are positive, implying that the investments are economically feasible. However, the net benefits of investment in the exotic bulls were 2 times higher than the indigenous breeds. Also, the initial cost of purchasing the Sahiwal bull is recovered within 1 year. The differences in the net benefits for breeding using the indigenous and exotic breeds resulted from the differences in the prices for the parent stock and offspring. The findings show that the indigenous breeding had lower initial investment costs but also a lower value of outputs. The use of exotic breeds for breed improvement involves higher initial investment costs but with higher productivity and value of outputs. The benefit-cost ratios were all greater than one, but higher for exotic breeds as compared to the indigenous breeds.

The findings show that when indigenous goat breeds are used, the payback period is 4 years. The net benefits for the first 2 years are negative and become positive in the third year, but the initial investment is recovered in the fourth year. However, with the exotic breeds, the net benefits are positive in the first year and the initial investment is recoverable in the third year. Even though the initial investment in exotic goats is higher than that with cattle, the net benefits are higher for the cattle breed improvement project compared to the goat breed improvement. The payback period for the cattle is 2 years and 4 years for the goats and cattle projects, respectively.

The NPV analysis provides insight into the financial viability of investing in breed improvement. However, the NPV value can be affected by several risk factors. We conducted a sensitivity analysis to analyse how changes in discount rates affect the NPV value. The discount rates show the opportunity cost of capital, and they directly affect the present value of the benefits and costs of the investment. The findings show that the investments in breed improvement remain viable with positive net benefits by the end of the investment period for both the indigenous and exotic breeds and for the cattle and goat improvement projects. Nevertheless, the farmer groups need to put in place strategies to manage possible risks and to optimise operational efficiency.

Discussion

Institutional arrangements

The study mapped the key actors and their level of importance in the implementation of the breeding projects. The findings showed the main actors that supported the breeding groups were the group members, the veterinary officers, and veterinary input dealers. Veterinary officers supported the groups right from the design of the CBBPs to their implementation. However, the veterinary officers had a very low level of influence regarding the decision-making and implementation of the community-based breeding projects. Also, there was limited interaction between the farmer groups and community leaders, yet they were influential in scaling up the projects.

The actors evaluated include hosts, sub-country veterinary officers, para-veterinary officers (para-vets), district veterinary officers, group members, group chairpersons, community leaders, group executive committees, and veterinary input traders. The key observation from the findings was that there is a clear distinction emerging between the ratings for actors involved in the bucks and bulls breeding projects, with the actors involved in the management of bulls consistently receiving higher ratings across all actors. This pattern suggests a higher level of involvement associated with bulls compared to bucks. The ratings for Hosts, Sub-country Veterinary Officers, and Para-vets stand out, underscoring their pivotal roles in the breeding projects.

Host

Hosts are seen as the most crucial actors in managing or influencing the outcomes associated with the breeding projects, with the highest rating of 50. In goat management, while still important, their role is perceived to be less critical, reflected by a lower rating of 16.5. The host, who is a member of a pastoralist group, is responsible for routine management activities such as grazing and watering and provides shelter to the breeding stock. He or she also contributes to the financial resources and is involved in decision-making within the group. The groups selected the hosts based on their reputation within the communities, their willingness to shelter the livestock and the prior experience that they have in looking after livestock.

Veterinary officers

The veterinary officers were ranked highly since they provide essential health services for the livestock. They include the sub-county veterinary officers, para-veterinary officers and the District Veterinary Officers (DVOs). The sub-county

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TABLE 5 Summary of benefits and costs for indigenous and crossbred goats and cattle.

Baseline scenario: Benefits and costs with indigenous cattle breeds in USD equivalent							
	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Total benefits	0	1,039	1,039	3,636	3,636	8,312	17,662
Total costs	338	331	331	994	994	2,186	5,173
Undiscounted net benefits	(338)	708	708	2,643	2,643	6,126	12,490
Discounted net benefits (5%)	(338)	674	642	2,283	2,174	4,800	10,236
Undiscounted Benefit-cost ratio	3.4						
Payback period	1						
Benefits and costs for cattle crossbreeding under CBPPs in USD equivalent							
	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Total benefits	0	2,494	2,494	7,481	7,481	14,662	34,610
Total costs	3,117	331	331	994	994	2,186	7,952
Undiscounted net benefits	(3,117)	2,162	2,162	6,487	6,487	12,476	26,658
Discounted net benefits (5%)	805	2059	1961	5,604	5,337	9,775	25,542
Undiscounted Benefit-cost ratio	6.14						
Payback period	2						
Baseline scenario: Benefits and costs with indigenous goat breeds in USD equivalent							
	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Total benefits	0	142	569	1,849	5,688	17,207	25,455
Total costs	240	312	662	1,714	4,870	14,338	22,136
Undiscounted net benefits	(240)	(169)	(94)	134	818	2,869	3,319
Discounted net benefits (5%)	(240)	(161)	(85)	116	673	2,361	2,663
Undiscounted Benefit-cost ratio	1.1.5						
Payback period	4						
Benefits and costs for goat crossbreeding under CBPPs in USD equivalent							
	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Total benefits	0	1,365	4,642	12,505	31,378	48,363	98,252
Total costs	0	1,365	4,642	12,505	31,378	48,363	98,252
Undiscounted net benefits	2,870	551	1,170	3,029	8,604	25,330	41,553
Discounted net benefits (5%)	−2,870	776	3,149	8,186	18,736	18,047	46,024
Undiscounted Benefit-cost ratio	2.36						
Payback period	3						

veterinary officers provide advisory livestock health services and train farmers on proper animal husbandry practices, and these were rated highly at 16.3 and 38 for the groups that kept breeding bucks and bulls, respectively. The Para-veterinary officers are trained animal health technicians who provide basic healthcare services such as prescriptions, deworming, vaccination, and treatment of common diseases. They work under the supervision of a veterinary officer. Health complications that cannot be handled by the para-veterinary officers are managed by the sub-county or district veterinary officers. Para-veterinary

officers had a score of 11.3 and 35 for groups that kept the breeding bucks and bulls respectively. The district veterinary officers do regular checkups to identify and treat complicated livestock diseases and these were rated at 4.2 and 18 for groups that had the breeding bucks and bulls respectively. The high ratings for the veterinary officers indicate their substantial involvement, suggesting that their roles are indispensable for achieving positive outcomes.

Group members

The importance of group members was rated low for the groups with the breeding bucks, but moderate for the groups with breeding bulls. Group members support the management of the livestock by collecting water for the breeding stock and contributing financial resources to support the treatment, deworming and tick control. The group members had a mean score of 18 and 6.8 for the groups with bulls and bucks, respectively. However, the group members noted that the commitment to the group obligations was not consistent. The group members also reported occasional conflict arising from unfair division of responsibilities, free riding and misuse of finances that led to some members exiting the groups.

Executive committee

The executive committees comprise the leadership of the group and they plan and make decisions to improve the welfare of the group. The committees lobby for resources at the village, and parish levels and are also a link to communicate with the sub-county officers. The executive committee had a low mean score of 3 and 1.3 for the groups with the breeding bulls and bucks, respectively. This is because several groups had leaders who were not fulfilling their duties as expected by the group members. The duties included holding meetings to report the progress of group activities and planning and mobilising resources for group activities.

Veterinary input traders

Veterinary input dealers increase accessibility to inputs used in routine management, treatment of diseases and control of vectors among the livestock. Despite the importance of the veterinary input dealers, they were not easily accessible by the groups. The shops were mostly in urban locations that were distant from the farmer groups and therefore their services were not commonly used. Therefore, the veterinary input dealers were ranked with the lowest average mean score of 2 and 1.7 for the groups with breeding bulls and bucks, respectively.

The analysis of the weighted average mean of actor ratings reveals critical insights into the involvement of various actors. Hosts, sub-country veterinary officers, and para-vets emerge as the most influential actors, underscoring their crucial roles in achieving positive outcomes for communal breeding projects. Conversely, veterinary input traders and group executives exhibit minimal impact, suggesting a peripheral role. These findings have important implications for resource allocation and highlight the importance of focusing efforts on the key actors driving the success of the breeding projects.

Challenges faced in the management of breeding stock

Vulnerability of breeding stock and offspring to tick-borne diseases

The results provide a clear depiction of the various challenges affecting breeding projects, with theft and raids of livestock, vulnerability to tick-borne diseases, and prolonged droughts being the most significant issues. Tick-borne diseases directly affect the health and productivity of livestock. In the Teso and Karamoja regions, the major tick-borne diseases include East-coast fever, Heart-water, Babesiosis and Anaplasmosis, all of which result in lower productivity and can lead to the death of the livestock (Muhanguzi et al., 2014). The Sahiwal bulls were more susceptible to tick-borne diseases as compared to the indigenous Zebu and Ankole cattle as shown by Roessler et al. (2010). The Boer and Gala goats were also more susceptible as compared to the indigenous goat breeds, yet farmers lack access to affordable financial capital required for tick control and treatment of the tick-borne diseases in cases of infection. Tick-borne diseases cause high mortality rates for both the breeding stock and offspring. This leads to the loss of valuable breeding animals, particularly those with desirable genetic traits, undermining long-term sustainability. The high frequency of tick-borne diseases underscores the need for enhanced veterinary services, regular health checks, and effective disease control measures. Improving the management of tick-borne diseases is crucial for maintaining the overall health of the breeding stock.

Thefts of breeding stock

The second key challenge is the theft of livestock. Thefts resulting from cattle rustling and criminal networks within the villages are prevalent in the study area. The results showed that 29% of the groups that received breeding bulls and 58% of the groups that received breeding bucks lost their stock to theft. This suggests that security measures and preventive strategies are either lacking or ineffective. The theft led to the loss of breeding stock, reducing the genetic pool available for breed improvement, and hindering efforts to enhance the quality of the herd in the communities. In communities where thefts were prevalent, some farmer groups sold off their breeding stock to reduce the risk of losses. The farmer groups could not obtain replacement stock because of the high cost of their purchase and they were also not accessible within the communities.

Prolonged droughts

Extreme weather events such as high temperatures and droughts were highlighted as a significant challenge. Prolonged droughts affect the availability of water, limiting the regrowth of pastures, and drying up of the surface water sources. Water scarcity leads to dehydration, stress, and higher susceptibility to diseases, reducing the health and reproductive efficiency of breeding stock, and undermining the long-term continuity of breeding efforts. The frequency of drought conditions underscored the need for sustainable livestock management strategies to mitigate the adverse effects of drought conditions.

Social conflicts

Social conflicts arise from disagreements amongst group members regarding resource contributions and use, and division of labour for the management of the breeding stock. Social conflicts reduce the effectiveness of communal and group efforts to address challenges that affect the sustenance of breeding stock. The major conflicts resulted from unfairness in the access to the breeding livestock, the sharing of benefits and contribution to the maintenance of the livestock. Social conflicts resulted in members' discontent, limited cooperation from members, and some members exiting the groups. However, the conflicts are mostly resolved based on the group's constitution. Group constitutions state the rules that guide the group activities, procedures for conflict resolutions and any sanctions for the violation of the rules.

Limited savings

To meet the costs of management of the breeding livestock, the groups engaged in collective savings within the group. However, the savings are too low to cater for the expenses of the management of the breeding bulls and bucks, such as disease management, tick control and purchase of feed supplements. The limited preventative care and medical interventions lead to higher mortality rates, and lower reproductive performance, undermining the sustainability of breeding efforts. Inadequate nutrition also results in malnutrition and reduced fertility among breeding animals and offspring. Also, members who could not contribute to the groups' savings were excluded, and sometimes, this resulted in conflicts. Therefore, the design phase of the breeding projects should pay attention to ensuring that the poor are not excluded from receiving the services by prioritising savings and resource mobilisation for the groups. One strategy to increase group finances is to manage the collected finances transparently. This requires establishing regular meetings and communication from the group leadership, as well as having clear rules and guidelines for the use of group finances and penalties for non-compliance. Having written guidelines helps to ensure that the group members understand them and can refer to them when making financial decisions. Given the high poverty level, engaging in alternative business activities such as crafts and poultry keeping can generate revenue to meet the immediate needs of the groups without the need to sell cattle and goats. However, the design of the enterprises should be based on the existing resources and markets. For the groups to engage in alternative economic activities, they should learn new skills. The organisations promoting communal breeding can therefore partner with existing community-based organisations that offer informal vocational and financial management training.

No clear roles for members

Group members made efforts to support the host in mobilising resources for the management of the breeding livestock, feeding, cleaning and collecting water. However, 8% of the groups stated that the roles of the leadership and the group members were not stipulated since many of the groups did not have a constitution in place. The members of the groups had different understandings of what their roles and contributions should be to the group. Ambiguous roles can lead to miscommunication, misunderstandings, and conflicts among community members. Disagreements over responsibilities, decision-making authority, and resource allocation can disrupt cooperation and collaboration essential for sustainable communal breeding practices.

Non-functional management committees

Whereas all the groups had management committees in place, 6% of the sampled groups had committees that were not functional. Functional committees are required to aid in decision-making regarding the management of the breeding stock. The reasons stated for the non-functionality were the lack of motivation and facilitation for the group leaders to maintain communication with the group members. Also, some groups had committee members who were not fully aware of what their roles in the groups were. Without functional management committees, there was limited planning, *ad hoc* decision-making, and accountability regarding the use of breeding stock. Non-functional committees also lead to inefficient allocation of resources, and limited ability to invest in critical areas such as animal health and nutrition that are important for sustenance of the breeding stock.

Multiple levels of decision-making

One challenge that was mentioned by the group leaders was the lack of coordination and unclear reporting lines during the implementation of the projects. The groups work with different actors within the community, including community leaders, group leaders, local government, and non-governmental organisations, all of which occasionally support the groups through training, vaccination and occasional provision of inputs. However, the group leaders did not know which line of authority to report to and how often to report the progress of the project because the communication from the different

actors was limited. When decisions made at one level, do not align with decisions made at another level, this can lead to inconsistencies and conflicts. Multiple decision-making levels also led to coordination challenges, and conflicting priorities, that hindered the timely implementation of planned activities.

Kuraz Abebe (2022) reports that the lack of coordination and synergies between institutions limits the progress of communal breeding projects and results in the duplication of activities and support of pastoral communities. With no coordination office in place, communication and periodic engagements to enable the different actors to share their experiences remains limited. Promoters of communal breeding projects should therefore engage the local government's agricultural and veterinary officers in planning, implementation and supervision of the projects. These actors should be kept updated on the intervention progress so that they can foster ownership by the national and district-level stakeholders, enable the district leadership to address issues of policy concern and mobilise resources for scaling up.

Limited ownership by group members

To ensure the breeding programs' continuity, building capacities and ownership is essential (Wurzinger et al., 2021). However, the results showed that 6% of the groups had limited cooperation by members in group activities that included savings and collection of water and pasture. Limited ownership led to low levels of engagement and involvement of group members in decision-making processes, and collective responsibilities related to feeding and health monitoring of the breeding stock. This neglect led to reduced productivity and reproduction ability for the breeding stock.

Aggressiveness of the Sahiwal bulls

For the groups that received the breeding bulls, 29% reported the aggressiveness of the Sahiwal bulls as being a key constraint to their management. Aggressive behaviour posed safety risks to both the livestock and the handlers involved in the management of breeding stock. The aggressiveness leads to injuries, accidents, and stress among livestock, compromising their welfare and their longevity for breeding. Fear, stress, inadequate feeding, and changes in the hormonal state contribute to the aggressiveness of the bulls (Orihuela, 2021).

Factors affecting the sustainability of breeding stock

The results show that access to para-veterinary officers significantly increases the likelihood of survival of breeding stock. Para-veterinary officers provide essential services such as vaccinations, disease treatment, and preventive care, which are crucial for maintaining the health and productivity of breeding animals. Their expertise in diagnosing and managing livestock health issues helps prevent outbreaks of diseases and reduces mortality rates. Regular visits from these professionals ensure that breeding stock receives the necessary care and interventions promptly, ultimately enhancing their overall survival rates. However, the para-vets have limited resources to fulfil their mandate. The remuneration for the para-vets was not structured into the local government system and therefore they did not receive any payment and facilitation for transport but relied on contributions from group members. The design of CBBPs should consider adequate capacity building and remuneration of the para-vets given their significance in sustaining the breeding stock.

Membership in a breeding association also increases the survival of breeding stock. Breeding associations offer members access to improved breeding practices, shared resources, and collective knowledge. These associations provide training on best practices in animal husbandry, access to quality breeding materials, and opportunities for genetic improvements through organized breeding programs. Members benefit from the association's support network, including technical advice, and superior breeding stock. This collective approach ensures better management of breeding animals, higher genetic quality, and enhanced survival rates due to improved overall care.

Participation in the selection of livestock type by groups increases the survival of breeding stock. This process allows for the selection of breeds best suited to the local environment and management conditions. Consultation of the groups also helps to consider the diverse needs, perceptions and preferences of the farmers and therefore promote the appropriate technology. (Mutenje et al., 2020; Wurzinger et al., 2021). Participation can also lead to commitment, cooperation and participation in the projects. Groups involved in the selection process can choose breeds with higher resilience to local diseases, better adaptability to the climate, and optimal productivity under available resources. This participatory approach ensures that the selected breeds are more likely to thrive in the given conditions, thereby improving their survival rates. Informed selection based on collective knowledge and preferences also promotes better care and management practices tailored to the specific needs of the chosen livestock type. The diversity of farmers' objectives and needs is important in determining the choice of livestock types and breed choices for promotion (Mutenje et al., 2020; Girma et al., 2023).

The location of the group significantly affects the survival of breeding stock, with groups in Teso more likely to sustain breeding livestock compared to those in the Karamoja region. This could be because of the differences in climate whereby the Teso region has a moderate climate with bimodal rainfall patterns, while the Karamoja region has a semi-arid climate with unpredictable rainfall patterns. The vegetation in Karamoja is predominantly thorny bushes and grasses, whereas in the Teso region, it is woodland and forested areas. Karamoja region is in a

semi-arid region with temperatures reaching up to 40°C, whereas the Teso region temperatures range between 26°C and 34°C. The average rainfall in the Karamoja region ranges between 400 and 700 mm, whereas, in the Teso region, it is 900 and 1,200 mm. Teso region also benefits from better access to water, grazing land, and agricultural extension services, which are crucial for maintaining healthy breeding stock. Teso may have more established support networks, agricultural policies, and economic stability, facilitating better livestock management practices. In contrast, Karamoja often faces challenges such as harsher climatic conditions, limited access to resources, and frequent conflicts, all of which hinder the ability to sustain breeding livestock effectively.

Access to services from agricultural community-based organizations (NGOs) increases the survival of breeding stock by providing critical support in areas such as veterinary care, training, and resource provision. NGOs often introduce innovative practices, supply inputs like vaccines and feed, and offer educational programs to improve livestock management. They may also facilitate access to markets and financial services, enhancing the economic viability of livestock breeding. This comprehensive support helps farmers maintain healthier and more productive breeding stock, reducing mortality rates and improving overall survival through enhanced management practices and resource availability.

An increase in management costs decreases the survival of breeding stock by straining the financial resources available for essential care and maintenance. Higher costs for feed, veterinary services and other inputs can lead to cutbacks in critical areas, compromising the health and wellbeing of the animals (Mutenje et al., 2020). With limited resources, farmers reduce expenditures on preventive measures, such as vaccinations and quality feed, leading to higher susceptibility to diseases and malnutrition. The financial burden can also limit the ability to invest in infrastructure improvements, further exacerbating the challenges of maintaining a healthy and viable breeding stock. The maintenance of breeding livestock requires investments in labour, medical care, and feeding that are not affordable by many small-scale farmers (Haile et al., 2019). Even though investment in breeding livestock has the potential to generate revenue through charges for the use of the semen, sustaining the investment requires that the economic benefits outweigh the costs of investment. The initial capital investment in the production and maintenance of breeding livestock is high and the costs cannot be recovered within the first year (Kassie et al., 2009). Mutenje et al. (2020) estimate the time between investments into raising a breeding bull to the realisation of the benefits for low-input livestock production systems as being three to 4 years. If the opportunity cost of the capital is high, then the length of time to maturity can be a disincentive for investment and sustenance of breeding stock. The cost of investment and maintaining the breeding livestock, can, however, be reduced through the promotion of effective institutional arrangements and management frameworks that create incentives for collective participation (Uddin et al., 2010; Mutenje et al., 2020). Collective ownership of the breeding livestock is characterised by shared responsibilities and finances between the beneficiaries, making it affordable to access the services of small-scale farmers. Kaumbata et al. (2021) recommend that investments in breeding programs should be commercialised and financially rewarding to cover the costs of maintaining the livestock.

The results showed that groups that charge a fee for breeding services have a higher likelihood of sustaining breeding bucks. The collected fees can be reinvested into improving the care and management of the livestock, including purchasing quality feed, accessing veterinary services, and improving breeding facilities. Financial contributions from members create a sense of ownership and accountability, leading to better management practices and increased commitment to the wellbeing of the livestock. With sufficient resources to address health and nutritional needs, the survival rates of breeding stock are likely to improve significantly. However, the effect of commercialization of breeding services was negative for groups with breeding bulls, and this may be because of the high cost of maintaining them. Goats typically require less intensive resources than cattle, so even modest fees can significantly improve the quality of care and resources available, leading to better survival rates.

The results for the groups with breeding bucks show that groups with Galla goat breeds are more likely to sustain breeding bucks compared to those with Boer breeds. Galla goats have superior adaptability to harsh environments and disease resistance. They are suited to arid and semi-arid regions, where they can thrive on minimal resources and withstand challenging climatic conditions. Their hardiness and lower maintenance requirements make them a more viable option for sustaining breeding bucks in regions with limited resources. In contrast, Boer goats, while highly productive, often require intensive management, and better-quality feed, making them less sustainable in resource-constrained settings. The findings show the importance of sufficient pretesting of the exotic breeds for suitability and adaptability before promoting them. This helps to scale out breeds that can adapt and increase the survival rates of the offspring.

Conflict among group members reduces the likelihood of sustaining breeding stock by undermining the cohesion and cooperation necessary for effective livestock management. Internal disputes can lead to a breakdown in communication and trust, resulting in poor coordination and decision-making regarding breeding practices, resource allocation, and animal care. This discord may cause neglect of essential tasks such as regular health checks, vaccinations, and feeding, as members may be unwilling or unable to work together effectively. Additionally, conflicts divert resources away from livestock management to address interpersonal issues, further compromising the wellbeing

of the animals. The overall disharmony within the group disrupts the structured and collaborative approach needed to sustain healthy and productive breeding stock, leading to increased mortality and decreased productivity and, in some cases, to the death of livestock.

Economic analysis

The analysis of the benefits and costs of investment in communal breeding projects was done for up to 5 years, which also corresponds to the useful life of the breeding stock. The results show that there were benefits to investment in breed improvement, although the net benefits were negative for the first year. Negative benefits are attributed to the high upfront investment costs that include the construction of housing, and purchase of the breeding stock. From the first year, the net benefits became positive. The increase in the net benefits is attributed to the changes in the flock sizes and the flock value since the offspring obtained from crossbreeding had a higher market value as compared to the parent indigenous breeds. The results showed that there are economic benefits to investments in communal breeding of indigenous goats and cattle. Similar results were obtained by Jembere et al. (2019); Ngongolo and Mmbaga (2022) who analysed the profitability of crossbreeding goats and Sahiwal bulls, respectively. Ilatsia et al. (2011) also showed that there are economic gains from the pure breeding of indigenous Zebu dams and crossbreeding the Zebu cows with Sahiwal bulls. Livestock production is easily affected by risks and uncertainties. Uncertainties include disease outbreaks, thefts and accidents that may disrupt production. The likely uncertainties were considered by incorporating the possibility of livestock losses when valuing the benefits. Also, the results of the sensitivity analysis show the net benefits remain positive when there are changes in the discount rates. The results imply that the stability of the CBBPs is not significantly affected by changes in discount rates, indicating lower risk and opportunity costs associated with the investment.

Conclusion

The findings show that the sustainability of community breeding initiatives has the potential to lead to positive net benefits for pastoral communities. The sustainability of the community breeding initiatives depends on the ability of the farmer groups and the ability of the local government to maintain an oversight role. Therefore, the key recommendations for sustaining communal breeding projects include the following;

i. Enhance group participation: Since the farmer groups are the key actors in the management of breeding programs, the condition for the success of community breeding of livestock is dependent on having functional farmer groups, and the availability of resources such as feed, water, labour, and finances for maintaining the livestock. Established groups should engage in collective action that eases access to inputs, and decision-making in the management of the flock. Members' participation in groups is determined by the level of benefits they attain through their membership. It is, therefore, crucial for the groups to focus on fulfilling members' needs and expectations related to the group activities. Farmers should also be actively involved in the selection of their preferred livestock types and breeds. Where breeds are promoted, they should be the types that easily adapt to the climatic conditions and are manageable by the farmers.
ii. Strengthen group governance. Community breeding projects should facilitate farmers to develop management frameworks that create incentives for collective participation and shared responsibilities and finances amongst group members. The groups should have clear rules governing their activities and enforce sanctions for their violation. Collective action should also be promoted beyond the group level by formulating breeding networks or associations. Breeder networks or associations can be avenues for sharing information, accessing training, lobbying, increasing access to replacement stock and the collective purchase of inputs.
iii. Creating and strengthening of breeder associations: Breeder associations are an avenue through which the pastoralists can access training and advisory services, and identify the sources for replacement stock through networking.
iv. Local government support: For the programs to be sustainable, there needs to be a long-term commitment by the local governments, as these play an oversight role and are responsible for maintaining supporting infrastructure such as communal wells, grazing lands water, pasture and veterinary infrastructure to support investments in commercial goat breeding. The local government should also recruit and support the extension staff and veterinary doctors to increase outreach to the farmers. For the local government to maintain oversight of the breeding projects, there needs to be a clear structure that describes the roles of the actors, and the reporting mechanisms.
v. Increase resource mobilisation: Sustaining the investments in breed improvement requires that the economic benefits outweigh the costs of investment. The benefits of breed improvement can be increased by operating breeding as a business and encouraging saving initiatives within the groups. For example, charging a fee for the services contributes to the savings and investment by the group that enables them to meet the costs of production and management costs and also to access replacement stock. However, the costs should not be too high to limit resource-poor farmers from accessing the services. Therefore, the government and development partners

should invest in the development of business models that can be adapted for profitable breeding.

vi. Increase access to support services: The livestock groups should be able to acquire important services to support livestock production, such as access to water, drought-resistant pastures, and veterinary services.

We acknowledge that, while our results provide valuable insights into the specific context studied, caution should be exercised when generalising to other settings. The study was conducted in pastoral regions with extreme drought conditions, which may not fully represent the diversity of pastoral practices and conditions found in broader regional or global contexts. Future research with a larger and more diverse sample across varied geographic locations is recommended to validate and extend our conclusions.

Data availability statement

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

Ethics statement

This study involved the collection of survey data on livestock management practices from farmers. However, an ethical review was not obtained. The survey was designed to collect non-sensitive information about livestock management practices and did not involve any personal or identifying information. Participants were informed about the purpose of the research and provided their consent to participate. The study adhered to ethical standards of voluntary participation, informed consent, confidentiality, and data protection. Informed consent was obtained from all subjects involved in the study.

Author contributions

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication. Conceptualization, FL, JI, PA, and SW; methodology, FL; software, FL; validation, PN'a, JO, BK, and RS; formal analysis, FL; investigation, FL; resources, FB; data analysis, PA; original draft preparation, FL and JI; review and editing, JI; visualization, FL; supervision, PN'a, JO, BK, and RS; project administration, PN'a, JO, BK, and RS; funding acquisition, RS.

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Conflict of interest

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

Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontierspartnerships.org/articles/10.3389/past.2024.12950/full#supplementary-material

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