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Perceptions of pastoral communities on cattle breed improvement: insights from Uganda's community-based breeding scheme

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This study assesses pastoral livestock-keepers' perceptions of breed improvement based on participants in the Community Based Bull Breeding Programme (CBBP) of the Regional Pastoral Livelihood Resilience Project in Uganda (RPLRP). The RPLRP aimed to enhance the production and productivity of local cattle in terms of milk and beef yield, as well as the market value of live animals. This study sought to understand whether the project achieved its breeding objectives, the Community perceptions on the performance and productivity of crossed cattle breeds and the factors influencing community perceptions on breed improvement. To achieve this, the study employed a cross-sectional design, utilizing both descriptive statistics and multiple regression analysis to examine the demographic characteristics of farmers and their perceptions regarding the performance of crossbred offspring as outcomes of the CBBP. The findings indicate that farmers overwhelmingly perceived crossbred offspring as growing faster, producing more milk, and possessing a higher market value than offspring of local breeds of the same age. However, only about a third of the farmers view crossbred offspring as socially dominant, adaptable to local feeds, resistant to pests and diseases, possessing higher mating ability, and adaptable to the local environment compared to local breeds like Zebu. Furthermore, the analysis revealed that factors such as the age of the farmer, education level, cattle-keeping experience, weekly spraying, tethering as the main grazing method, and participation in livestock management training influence their perceptions of crossbred offspring, with some factors being specific to particular perceptions while others are more broadly applicable. This study concludes that the objectives of the breeding programme were largely achieved. From the results, we recommend integrating pasture improvement interventions into CBBPs to enhance the overall performance and productivity of cattle within pastoral systems. Additionally, it is crucial to strengthen government veterinary services by increasing the availability of veterinarians, providing access to free veterinary drugs, and implementing effective market regulation to ensure fair prices for cattle and their products. These measures will not only improve animal health and productivity but also support the long-term sustainability of the livestock sector.

KEYWORDS

perceptions, pastoral, communities, community, breeding

1 Introduction

Pastoralism is a traditional livelihood system characterized by the herding of livestock and the use of natural pastures for grazing (Dong, 2016). In Uganda, pastoralism is crucial to the cultural and economic fabric of rural communities, particularly among ethnic groups such as the Karimojongs, Itesots, and Banyankole (Caravani, 2019). These communities depend heavily on livestock for subsistence, income, and social status. According to Byakagaba et al. (2018), pastoral communities occupy approximately 44% of Uganda's total land area, equating to around 84,000 square kilometres, and account for 4.3% of Uganda's GDP (UBOS, 2020). The predominant local cattle breeds in Uganda's pastoral areas include the Ankole Longhorn and the Small East African Shorthorn Zebu (SEAZ), both adapted to the diverse climatic conditions (Kabi et al., 2016). The SEAZ is particularly prominent in the Teso and Karamoja regions due to its resilience in harsher environments (Mubiru et al., 2023). Known for its smaller size and adaptability, the SEAZ produces between 1.5 to 3 liters of milk daily (Bessong, 2016). The SAEZ however have slower growth rates and low meat yields reaching marketable carcass weight of 60 to 80 Kgs in four years (Greenwood, 2021).

Ouali et al. (2023) reported that the recent years have seen significant changes in forage resources due to climate variability and increased incidences of fire, which have affected the availability of pasture and shrubs necessary for livestock grazing. Additionally, Kabi et al. (2016) noted that the status of water resources in pastoral regions has become precarious, with some areas experiencing reduced water quality and availability, further complicating livestock management. The SEAZ, while resilient, faces competition for resources from wild animals, which leads to conflicts over grazing and water supplies (Daum et al., 2022).As a result, the pastoral communities have continued to face numerous challenges, including high poverty levels, hunger, malnutrition (Ouali et al., 2023).

The most significant way to improve the livelihoods of pastoral communities is by improving the productivity of cattle since its their main source of livelihoods and income (Kabi et al., 2016). According to Wilson (2018), the most viable option for improving the performance and productivity of indigenous cattle at the farm level is breed improvement. Cross breeding highly productive improved breeds such as Sahiwal and local cattle like Zebu can potentially increase the production and productivity of local cattle and thus leverage pathways to improving the welfare and livelihoods of pastoralists (Daum et al., 2022).

In response to challenges in cattle productivity, the Ministry of Agriculture, Animal Industry, and Fisheries (MAAIF) through the Regional Pastoral Livelihood Resilience Project (RPLRP) initiated community-based breeding programmes (CBBPs) to enhance the genetic potential of local breeds (MAAIF, 2020). The initiative aimed to improve the productivity of local breeds, especially Zebu, by introducing superior genetics while protecting local breeds (Ilukor et al., 2022). The RPLRP promoted a participatory, community-driven approach to livestock genetic improvement in pastoral regions.

To enhance cattle productivity, the government distributed 360 Sahiwal bulls, with each district receiving 30 bulls to promote crossbreeding with SEAZ. Sahiwal bulls are recognized for their high beef production and adaptability to tropical and sub-Saharan climates (Kamiti, 2015). They are characterized by their reddish-brown coloration, often with white markings, and males typically darken at the extremities. Sahiwals are robust, tick-resistant, heat-tolerant, and exhibit strong resistance to parasites. They are the highest milk producers among Zebu breeds, averaging about 2,270 kg during lactation (Younis et al., 2024). Additionally, they have well-developed udders and produce fast-growing calves, while their docile nature makes them suitable for slow work, thriving even in harsh conditions (Rehman et al., 2014).

Despite the implementation of the CBBP in Uganda, there is a notable gap in understanding farmers' perceptions of the performance and productivity of crossbred offspring from Sahiwal and SEAZ. Understanding these perceptions is vital for scaling up existing programs and designing future initiatives. Sui and Gao (2023) highlight that perceptions significantly influence farmers' willingness to support the sustainability of breeding programs. Previous studies on CBBPs have primarily focused on program design and implementation (Daum et al., 2022), the actors involved (Ssekibaala et al., 2024), and factors affecting performance (Haile et al., 2019; Haile et al., 2023). Most research has been conducted in Kenya, Ethiopia, and Zambia, leaving a gap in studies specific to Uganda's unique ecological, socioeconomic, and political context. This study aims to fill this gap by assessing community perceptions of breed improvement under the CBBP and the factors influencing these perceptions.

The study was guided by three main research questions; (1) Did the project achieve its breeding objectives? (2) What are the Community perceptions on the performance and productivity of crossed cattle breeds (offsprings from crossing Sahiwal and the local breeds specifically SEAZ)? (3) What factors influence community perceptions on breed improvement? The study employed a mixed-methods approach, combining both quantitative and descriptive research designs with an objective of undertaking both descriptive and inferential statistical analyses to provide a comprehensive assessment of the associations between the characteristics of bull hosts and other external factors that might have affected their perceptions on breed improvement through the CBBP.

2 Materials and methods

2.1 Study area

The Regional Pastoral Livelihood Resilience Project (RPLRP) served as a case study, collecting data from 12 districts across three regions: seven in the Karamoja region (Kaabong, Amudat, Moroto, Nakapiripirit, Kotido, Abim, and Napak), four in the Teso region (Katakwi, Bukedea, Kumi, and Amuria), and one in the Sebei region (Kween). These districts face common challenges such as prolonged droughts, water scarcity, and land degradation due to overgrazing (Auma and Badr, 2022) (Figure 1 here).

Northeastern Uganda is home to approximately 2,253,960 cattle, 2,025,300 goats, and 1,685,500 sheep, with over 80% of the population dependent on pastoralism (UBOS, 2020; Egeru et al., 2014). The study area features distinct savannah rangelands vital for traditional livelihoods and livestock grazing, characterized by perennial grasses and occasional woody plants. Seasonal livestock movement optimizes forage availability and promotes grassland health (Egeru et al., 2014). Topographically, Teso has flat to gently rolling landscapes at altitudes between 1,100 and 1,400 meters, supporting expansive grasslands essential for grazing. In contrast, Karamoja and Sebei have rugged terrains with elevations ranging from 1,200 to over 2,000 meters, where species like *Themeda triandra* and *Cynodon dactylon* thrive in semi-arid conditions (MAAIF, 2021). These topographical and climatic factors influence the productivity of grasslands and the types of livestock supported.

The primary grazing system is free range, governed by communal practices and social institutions such as clan leaders and elders. Seasonal migration allows pastoralists to optimize water and forage availability, maintaining grassland health and preventing overgrazing. While free range grazing is predominant, zero grazing and tethering are also practiced on a smaller scale, driven by increasing land degradation and water scarcity. Traditional ecological knowledge guides these practices, emphasizing biodiversity maintenance within the grasslands (Ouma et al., 2016; Egeru et al., 2022).

2.2 Data collection tools and procedures

The study utilized both primary data and a review of secondary literature. Primary quantitative data were collected through a semi-structured questionnaire administered to bull hosts in the presence of other group members, preferably the executive committee of the farmer group. This approach ensured recall and validation of responses provided by the bull host on behalf of the entire group. In this context, a “bull host” refers to individuals selected to house, maintain, and feed the bull on behalf of 15–20 cattle farmers in their respective groups, as arranged under the RPLRP. These bull hosts were chosen based on their financial capacity to manage the bull, their centrality to other group members for ease of access, and their trustworthiness within the community (Lwiza et al., 2024; Ssekibaala et al., 2024).

The collected data included social demographic information about the bull hosts, such as age, gender, marital status, level of education, and experience in animal husbandry, alongside socioeconomic and institutional data pertaining to farmer group characteristics. Additional questions addressed the enabling environment, such as access to extension services, community breeding scheme actors, and management practices for the bull, including feeding, housing, and veterinary care. The perceived usefulness of the bull and farmer attitudes towards breed

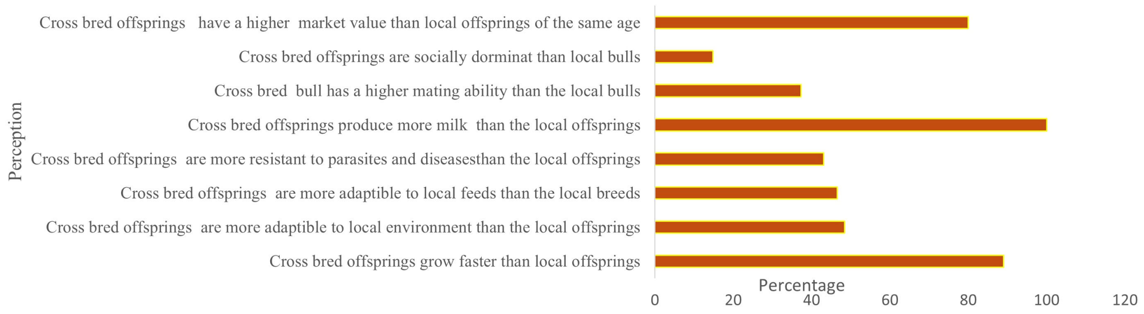

FIGURE 1
Map of Uganda showing the study area.

improvement under the Community-Based Breeding Program (CBBP) were also explored. To develop a comprehensive questionnaire, researchers partnered with Makerere University lecturers to assess community perceptions of crossbred offspring performance.

Seven Master's students from the Teso, Karamoja, and Sebei regions acted as enumerators, trained on paper questionnaires and local language translations (Ateso, Ekaramojong, Kupsabiny) and Computer-Aided Personal Interviewing (CAPI). The questionnaire emphasized clarity and cultural relevance, following Perkins (1991). A pre-test with seven bull hosts in Katakwi district strengthened the tool, and internal consistency was assessed using Cronbach's Alpha (Izah et al., 2023). Data collection occurred through face-to-face interviews from December 2023 to January 2024, with informed consent obtained. Completed questionnaires were validated, and unavailable bull hosts were replaced to minimize bias. Some respondents were contacted by phone for clarification on ambiguous responses. A total of 225 bull hosts participated in the study, comprising 85 from Teso, 33 from Sebei, and 107 from Karamoja.

Secondary data were gathered from existing literature, reports, and databases related to community-based breeding programs, livestock management practices, and demographic statistics of the study regions. This data helped contextualize the primary findings and provided a comprehensive understanding of the environmental and socioeconomic factors influencing bull hosts' perceptions regarding crossbred offspring. Key sources included government reports, academic publications, and relevant studies on livestock production in Uganda.

2.3 Data analysis

Both descriptive and econometric statistics were used to analyse the data. Under descriptive analysis, mean, frequency, percentages, and standard deviations (of responses related to perceptions of breed improvement) were used to characterize bull hosts and the community perceptions in the context of the CBBP. Inferential statistical tests such as T-test and Chi-square test were used to identify statistically significant differences among bull hosts regarding their perceptions on breed improvement (Kiggundu et al., 2021). In addition, we ran a multiple regression analysis to assess the factors influencing the perceptions of farmers on the performance and productivity of cross breeds (offsprings from the CBBP).

The multiple regression model was expressed as:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_n X_n + \varepsilon$$

Where:

Y represents the dependent variable (the community perception)

$X_1, X_2, \ldots, X_n$ are the independent variables (potential influencing factors)

β_0 is the intercept

$\beta_1, \beta_2, \ldots, \beta_n$ are the regression coefficients associated with each independent variable

ε is the error term

The regression coefficients ($\beta_1, \beta_2, \ldots, \beta_n$) indicate the strength and direction of the relationship between the independent variables and the dependent variable (perception). The definition of variables used in the regression analysis is presented in Table 1 (Table 1 here).

3 Results

3.1 Demographic characteristics influencing farmer perceptions of breed improvement

The mean differences in farmer characteristics based on their perceptions of crossbred offspring performance attributes are presented in Table 2. The results indicate that older farmers had significantly lower perceptions ($p < 0.05$) regarding the adaptability of crossbred offspring to local environments and disease resistance compared to younger and middle-aged farmers. In contrast, experienced cattle keepers (>10 years of experience) expressed significantly positive perceptions about milk production from

TABLE 1 Description of variables used in the regression analysis.

Acronym	Variable description	Measurement
X1	Education level of the bull host	Continuous variable measured in number of years of schooling
X2	Age of the respondent	Continuous variable measured in years
X3	Cattle keeping experience	Continuous variable measured in number of years of keeping cattle by the bull host
X4	Keeping improved cattle	Binary variable (1 = Yes, 0 = No)
X5	Membership to breeding associations	Binary variable (1 = Yes, 0 = No)
X6	Bull ownership	Binary variable (1 = Individual, 0 = Group)
X7	If the bull host is literate	Binary variable (1 = Yes, 0 = No)
X8	Livestock production system	Binary variable (1 = Sedentary, 0 = Agro-pastoral)
X9	Main occupation of bull host	Binary variable (1 = Livestock farmer, 0 = Crop farmer)
X10	If the group/individual was involved in the selection of livestock	Binary variable (1 = Yes, 0 = No)
X11	If the respondent sired an offspring from the bull	Binary variable (1 = Yes, 0 = No)
X12	If the respondent has ever received trainings on cattle management.	Binary variable (1 = Yes, 0 = No)
X13	If the respondent received support from local government	Binary variable (1 = Yes, 0 = No)

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TABLE 2 Mean differences in farmer characteristics based on the performance attributes of cross bred offsprings.

Farmer characteristics	Performance attributes of cross bred offsprings							
	Growth rate (n=225) **Yes=200**	Adaptability to local environment (n=225) **Yes=109**	Adaptability to local feeds (n=225) **Yes=105**	Resistance to diseases and parasites (n=225) **Yes =97**	Milk production (n=225) **Yes n=214**	Mating ability of the bull (n=225) **Yes=84**	Social dominance (n=225) **Yes=34**	Market value (n=225) **Yes=180**
Age of the bull host (>56 years)	-2.4294	-2.5176	-1.5107	-3.2771*	-0.2996	-3.2956*	-2.8695*	-1.8176
Number of years of schooling	0.7301	0.6046	0.5857	-0.0445	0.4184	0.8290	0.2628	0.7389
Experience in keeping cattle (>10years)	-0.0825	1.5836	0.5277	0.4379	2.8941*	0.9476	0.2932	1.6786
Marital status (Married)	-0.0064	-0.1134	0.0038	-0.0022	0.0083	0.0258	0.0007	0.0107
Crop farmer	-0.0293	-0.0240	0.0274	-0.0308	-0.1226*	-0.1438*	-0.1003	-0.1828**
Livestock farmer	0.0101	0.0255	0.0190	0.0242	0.0910	0.1264*	0.1384*	0.1703**
Non-farm employee as main occupation	0.0192	-0.0014	-0.0464	0.0065	0.0316	0.0175	0.0381	0.0125
Literacy	0.0058	-0.0236	0.0131	-0.0571	-0.0237	-0.0800	-0.0219	-0.0088
Gender (male)	-0.0089	0.0089	0.0167	0.0325	0.0044	0.0180	0.0245	0.0405
Number of cattle owned	-0.0398	0.0042	0.0167	-0.0122	-0.0095	-0.0314	0.0113	-0.0070
Number of female cattle owned	4.5012	11.1850*	5.11	8.6791*	8.4331*	8.4483*	10.1138*	12.0929*
Local cattle as the only breed of cattle kept	2.2380	8.8649**	3.8558	6.7311*	6.1143*	6.0746*	7.9644**	8.7494**
Zebu as the main cattle breed kept	0.0439	0.0629	0.0714	0.0532	0.1029*	0.0798*	0.0624	0.0727
Belong to a farmer group	-0.0663	-0.0583	-0.0310	-0.0118	0.0441	-0.1403*	-0.0753	0.0535
Ever received training in regards livestock management	0.0086	0.0092	0.0095	0.0103	-0.0072	-0.0071	0.0099	-0.0061

***p value< 0.001, **p value<0.01, *p value<0.0.

crossbred offspring, reflecting their confidence in effective cattle management practices in terms of feeding, housing and veterinary care. Farmers whose primary occupation is livestock farming perceived cross breeds as superior in milk production, mating ability, and market value compared to local breeds. Additionally, farmers who exclusively keep local cattle recognized some advantages of crossbred offspring, particularly in adaptability to local feeds and market value. However, belonging to a farmer group correlated with skepticism about the mating ability of cross breeds, suggesting potential challenges in group dynamics (Table 2 here).

3.2 Community perceptions on the performance of crossbred offsprings from the CBBP

The results presented in Figure 2 offer valuable insights into cattle farmers' perceptions of the performance of crossbred offspring from the CBBP compared to local breeds. The survey revealed a mixed response, with all farmers unanimously agreeing that crossbred animals grew faster and produce more milk than local offspring. Furthermore, a significant majority (80%) believed that crosses had a higher market value than local offspring of the same age. However, perceptions varied on other indicators; less than half of the respondents felt that the crosses were more adaptable to the local environment (48.44%) and were satisfied with their resistance to parasites and diseases (43.11%). About one-third perceived crosses as more adaptable to local feeds (33.6%) and believed that crossbred bulls had greater mating ability than local bulls (37.33%). Finally, just 14.84% of farmers viewed crossbred bulls as more socially dominant and more active in grazing and mating compared to local bulls (Figure 2 here).

3.3 Factors influencing farmer perceptions on the performance of crossbred offsprings

The multiple regression results presented in Table 3 identified several key factors influencing farmers' perceptions of the performance of crossbred offspring from the CBBP program. Perceptions that crossbreds grow faster than local breeds were significantly influenced by the farmer's education ($p<0.01$), the overall number of offspring sired by the bulls, and whether

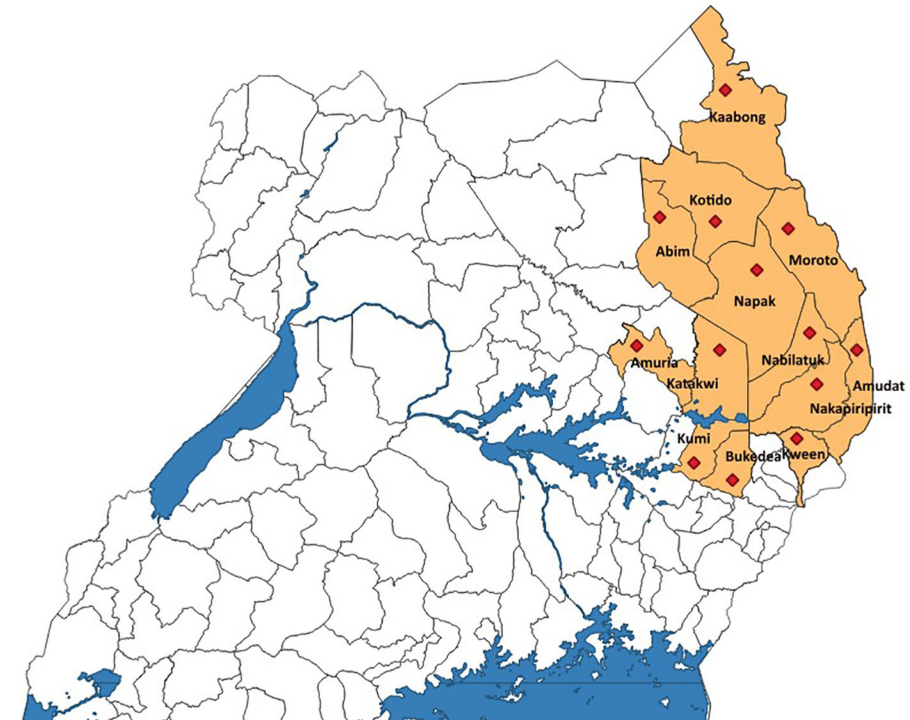

FIGURE 2
Showing community perception about the performance of crossbred offsprings from the CBBP in relation to the local offsprings.

livestock farming was the main occupation of the farmer ($p<0.01$). Additionally, factors such as cattle-keeping experience ($p<0.05$) and receiving the Sahiwal breed contributed to this perception, Veterinary practices, including weekly spraying, annual vaccination, and access to local government veterinary services, all significantly influenced farmer perceptions on the performance of cross breeds ($p<0.01$). Perceptions of crossbreeds' adaptability to the local environment, particularly in relation to pastures, were significantly influenced by several factors. Management training for the bull host ($p<0.05$), the number of offspring sired ($p<0.001$), and the use of tethering grazing ($p<0.01$) all play important roles.

Farmers' perceptions of crossbreeds' resistance to diseases and parasites were positively influenced by several factors, including the number of offspring sired ($p<0.01$), receiving market information, tethering grazing and weekly spraying ($p<0.05$). Additionally, annual vaccination and access to local government veterinary services also influenced farmer perceptions that cross breeds were resistant to diseases at ($p<0.01$). Conversely, these perceptions were negatively affected by higher education levels and receiving the Sahiwal breed ($p<0.01$).

Farmers' perceptions on' milk production by the crossbreds were positively influenced by their age, education, use of tethering as a grazing method ($p<0.01$), their cattle keeping experience, whether livestock farming was their main occupation ($p<0.001$), and whether they had received training on animal care and management ($p<0.05$). Perceptions were also influenced by the number of offspring sired by the crossbred bull ($p<0.05$).

Perceptions of Crossed bulls' mating ability and social dominance were positively associated with farmers' cattle keeping experience, herd size ($p<0.05$), receiving training on animal management and care and livestock farming as the main occupation ($p<0.05$). Additionally, the perceptions on the mating ability of the bull were influenced by the number of offspring sired ($p<0.01$), as well as use of tethering grazing as a grazing method ($p<0.05$). It was also found that free-range grazing negatively ($p<0.01$) affected farmers perceptions that crossbred bulls have a higher mating ability and are socially more dominant that local bulls. Finally, the perceived higher market value of crossbred offspring was positively associated with farmer's age ($p<0.01$), access to market information and training on animal management ($p<0.01$). This perception was further influenced by; livestock farming as main occupation of the farmer, cattle keeping experience of the farmer ($p<0.001$), number of offspring sired, receiving Sahiwal breed and weekly spraying ($p<0.05$) (Table 3 here).

4 Discussion

4.1 Community perception about breed improvement under the CBBP

The finding that 100% of surveyed cattle farmers perceived crossbred offspring as having faster growth rates than local breeds highlight a strong confidence in the benefits of crossbreeding. This unanimous belief is crucial for the adoption of these cattle into herds, as it indicates a collective recognition of their advantages. Faster growth leads to earlier market readiness, improved feed conversion efficiency, and higher overall productivity, which are essential for enhancing livestock productivity and livelihoods (Wanjiru et al., 2021; Njoroge et al., 2023). The confidence in growth rates suggests that farmers are not only aware of the potential economic benefits but are also likely motivated to invest in crossbreeding practices, thereby supporting the integration of these breeds into local farming systems.

Moreover, the perception that crossbred cattle produce more milk than local breeds reinforce the advantages of crossbreeding. Higher milk production capabilities directly contribute to enhanced household income and food security, as noted by Ouma et al. (2018) and Mwanga et al. (2019). This perception is significant because it influences farmers' decisions to adopt crossbreeding, as increased dairy yields can improve household nutrition and income, aligning with the goals of dairy initiatives (Mtimet et al., 2020). The recognition of milk production as a benefit underscores the economic rationale behind crossbreeding, driving further interest in improved breeding practices.

However, the concern that only 33.6% of farmers perceived crossbreeds as adaptable to local feeds reveals a critical barrier to adoption. This skepticism suggests doubts about the ability of crossbreeds to utilize local feed resources effectively. In regions like Teso and Karamoja, where local feeds primarily consist of grasses and legumes, there may be uncertainty regarding whether these resources meet the higher dietary requirements of crossbred cattle (Mubiru et al., 2023; Nyaga and Gicheru, 2023). Addressing these concerns through targeted training on feeding practices is essential, as emphasized by Nyaga and Gicheru (2023) and Mwangi et al. (2021), to enhance farmers' confidence in the compatibility of crossbreeds with local feed.

Furthermore, the finding that only 43.11% of farmers were satisfied with crossbreeds' resistance to parasites and diseases indicates a significant gap in confidence regarding their resilience to local challenges. This dissatisfaction may stem from the effectiveness of veterinary services and disease management practices, which are crucial for smallholder farmers' engagement in community-based breeding programs (Mwangi et al., 2021). It is vital to develop breed improvement programs that enhance disease resistance and educate farmers on prevention methods (Khaula et al., 2022). Without addressing these concerns, farmers may hesitate to adopt crossbreeding, fearing potential health risks.

Mixed perceptions about the mating ability and social dominance of crossbred bulls further complicate the narrative. With only 37.33% of farmers believing in their superior mating capabilities, there may be concerns about the compatibility of crossbred bulls within local social dynamics (Khaula et al., 2022). This uncertainty can hinder the acceptance of crossbreeds, as farmers might prioritize traditional breeds that they believe are better suited to local breeding practices. Despite these challenges, the perception that crossbreeds possess a higher market value compared to local breeds is noteworthy. The majority (80%) of surveyed farmers believe that crossbreeds, particularly those from Sahiwal and Zebu matings, command higher prices. This recognition reflects an understanding of market dynamics and the

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TABLE 3 Marginal effects of factors influencing farmer perceptions of crossbred offspring performance compared to indigenous cattle under the community-based breeding program.

Variable	Cross bred offsprings grow faster than local breeds	Cross bred offsprings are more adaptable to local environment than local breeds	Cross bred offsprings are more adaptive to local feeds than local breeds	Cross bred offsprings are more resistant to diseases and parasites than local breeds	Cross bred offsprings produce more milk than local; breeds	Cross bred bulls have a higher mating ability than local bulls	Cross bred bulls are socially more dominant than local bulls	Cross bred offsprings have a higher market value than locals of the same age
Age of the farmer	0.0083	-0.0022	-0.0019	-0.0987	0.0166**	-0.1143	-0.1275	0.0334**
Education level	0.003**	-0.1605	-0.0066	-1.9277**	0.2346**	0.3105	0.5354	0.1888
Cattle keeping experience	0.0138*	-0.0093	-0.0082	-0.0049	0.3700***	0.8576*	0.1750	0.0098***
Number of cattle owned	0.0053*	0.0010	0.0011	0.0033	0.0042	0.0045*	0.0004	0.0053
Received Market information	0.2047**	0.1143	0.1332	0.0166*	0.0148	0.0139		0.0166**
Received Trainings	0.3753**	0.3242*	0.3105	-0.4418*	0.4810*	0.6352***	0.4692*	0.5018**
Livestock farmer as main occupation	0.2207***	0.0876	-0.0987	-0.1461	0.2558***	0.3469*	-0.1739	0.0346***
Overall offspring sired	0.0201***	0.0198***	0.0196***	0.0166**	0.0148*	0.0139**	0.0142**	0.0099*
Tethering system as the main grazing method	1.1202*	1.1892**	1.1900*	1.0187*	0.8549**	0.8576*	1.0301*	0.6282
Free range as the main grazing method	-0.1474	0.0693	-0.6660	-1.2708**	-0.1474	-0.1092**	-0.0882	0.0033
Received Boran	-0.2995*	0.3400*	-0.3042	0.4551*	-0.0878*	0.2362	0.8764	1.3277
Received Sahiwal	0.4019**	0.0878	-0.8376*	-5.5894**	0.4019**	0.1750	1.4785	0.4387*
Weekly Spraying	0.1332**	0.0856**	-0.0800	0.0431*	0.2020	0.0878	0.8376	5.5894*
Annual Vaccination	0.003**	0.2346**	0.088	0.2003**	0.2346	0.3105	0.5354	0.2346
Veterinary support from local government	1.0844**	0.4787**	2.3667**	1.9277**	0.0955	0.2255	0.3552*	0.2023
Castration of local bulls	0.4019	0.0878	0.8376	5.5894	0.4019	0.0451	0.034***	2.0345

***, ** and * as <0.001, <0.01 and <0.05 significant levels respectively. Source. Computed by researcher.

economic benefits of crossbreeding (Khaula et al., 2022; Mukirane et al., 2024). Farmers' willingness to invest in crossbreeding initiatives demonstrates their awareness of potential financial returns, indicating that aligning perceptions with actual market demand can solidify their confidence in breed improvement.

4.2 Factors affecting community perceptions about breed improvement under the CBBP

The findings indicate a significant positive relationship between a farmer's age and their perceptions of crossbreeds, particularly regarding milk production potential and market value. Older farmers typically possess a wealth of knowledge and experience, shaping their views. As Khaula et al. (2022) suggest, this experience allows them to appreciate the enhanced milk yields associated with crossbreeds. Older farmers are often more patient and have a long-term perspective, enabling them to foresee the benefits of breed improvement for future profitability (Ndambi et al., 2018). Thus, age contributed significantly to positive perceptions of breed improvement, as seasoned farmers are more inclined to value superior performance and market potential (Mukirane et al., 2024).

Educational attainment also significantly influenced perceptions. Farmers with higher education levels are better equipped to recognize the genetic and nutritional advantages of crossbreeds, allowing for a more informed assessment of their potential benefits (Tesfaye et al., 2022). This critical thinking ability fosters a nuanced understanding of the complexities surrounding disease resistance and environmental adaptability, supporting the hypothesis that educational initiatives can positively influence farmers' perceptions and encourage the adoption of crossbreeds (Duguma et al., 2021).

Furthermore, cattle-keeping experience correlated positively with perceptions of crossbreeds. Experienced farmers are more likely to recognize the superior growth rates and milk production capabilities of crossbreeds (Wanjiku et al., 2021; Shumet and Melesse, 2018). This practical knowledge enables them to appreciate advancements in breeding practices, reinforcing the idea that experience is crucial in shaping positive perceptions of breed improvement. The correlation between experience and perceived market value suggests that seasoned farmers understand market dynamics and the premium prices for genetically enhanced cattle (Maina et al., 2022; Njoroge et al., 2023).

The primary occupation of farmers also affected perceptions. Those focused on livestock farming tend to have more positive views on performance characteristics than those primarily engaged in crop farming. This difference can be attributed to the immersive involvement of livestock farmers in cattle management, which enhances their awareness of productive traits (Herrero et al., 2013; Mtimet et al., 2020). Promoting livestock farming as a viable income source is essential to fostering positive perceptions of breed improvement.

Effective livestock management practices are vital for optimizing animal health and productivity. The results show that training significantly shapes farmers' perceptions of crossbreeds, emphasizing the importance of educational initiatives (Ngigi et al., 2017; Kosgey et al., 2021). Trained farmers exhibit a deeper understanding of the genetic and management factors contributing to enhanced productivity, reinforcing the need for comprehensive training programs to bridge knowledge gaps.

Access to market information plays a pivotal role in shaping perceptions, particularly regarding disease and parasite resistance. Farmers receiving market information are more likely to perceive crossbreeds as resistant to common health challenges, as this information often highlights the superior health and productivity profiles of genetically enhanced cattle (Ogutu et al., 2017). Understanding factors influencing demand and the value of different breeds helps farmers recognize the advantages of crossbreeding.

The findings also demonstrate that the number of offspring sired by improved bulls significantly influences perceptions across various performance attributes. Farmers who have more offsprings sired by the improved bulls are more likely to view these cattle as exhibiting superior traits, reinforcing the importance of firsthand experiences in shaping positive perceptions (Biwott et al., 2019). Providing opportunities for exposure to the benefits of improved cattle breeds can accelerate the adoption of innovative livestock technologies (Chinseu, 2018).

Finally, management practices such as tethering allow farmers to closely monitor cattle, enhancing their understanding of behaviour, health, and productivity. This close observation fosters a belief in the adaptability and resilience of crossbreeds, aligning with findings by Okeyo et al. (2020). Conversely, free-range grazing limits monitoring capabilities, leading to skepticism regarding crossbreeds' performance and health resilience (Ndumu et al., 2018; Mukirane et al., 2024). Thus, the grazing system adopted plays a crucial role in shaping farmers' experiences and perceptions, highlighting the need for management practices that facilitate closer engagement with genetically improved breeds.

5 Recommendations

To enhance community perceptions of breed improvement and promote the adoption of crossbreeding practices, the following recommendations are proposed. These are designed to address the factors that affect farmer perceptions on the performance attributes of crossbred offsprings identified in the results and discussion sections.

1. Incorporate pasture management: Integrate pasture management into breeding schemes to address feed compatibility issues. Collaborate with agricultural extension officers to improve local pastures and provide farmers with training on feed supplementation and management.
2. Strengthen government veterinary services: Enhance local veterinary services to address farmers' concerns about the health of crossbreeds. This includes expanding clinics,

training professionals, and implementing disease surveillance systems.
3. Align market value: Ensure that the perceived and actual market value of crossbred cattle and their products are aligned. Monitor market dynamics, communicate pricing trends, and provide training on effective marketing strategies to empower farmers.
4. Promote local breed conservation: Encourage the conservation of local breeds alongside crossbreeds to maintain genetic diversity. Education programs should emphasize the adaptability and resilience of local breeds, while research should focus on enhancing their productivity and disease resistance.

6 Conclusion

The Community-Based Bull Breeding Scheme (CBBP) under the Regional Pastoral Livelihoods Resilience Project (RPLRP) aimed to enhance local cattle production, including milk and beef yield, as well as the market value of live animals. Findings indicate that farmers perceived crossbred offspring as producing more milk, growing faster, and having a higher market value than local breeds, suggesting that the RPLRP has met its objectives. However, it is vital to consider the sustainability of pastoral systems and the conservation of local breeds, which are often more resilient to environmental challenges. Crossbreeds may not adapt well to local feeds and the costs associated with intensive grazing can be prohibitive for resource-constrained pastoral farmers. As breed improvement programs focus on crossing the indigenous cattle, they should be mindful to the conservation of their superior resilience and adaptability that makes them more suitable to the environments of the pastoral communities.

This will boost livestock production without significantly increasing production costs such as veterinary care, supplementary feeding which can pose a challenge for the resource constrained and marginalised pastoral communities.

Data availability statement

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

Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. The participants [OR participants legal guardian/next of kin] provided their written informed consent to participate in this study.

Author contributions

SG: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Validation, Visualization, Writing – original draft, Writing – review & editing. JI: Conceptualization, Data curation, Formal Analysis, Investigation, Methodology, Project administration, Resources, Supervision, Validation, Writing – review & editing. FB: Formal Analysis, Investigation, Methodology, Resources, Supervision, Validation, Visualization, Writing – review & editing.

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Conflict of interest

Author JI was employed by World Bank, Kampala, Uganda.

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

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The author(s) declare that no Generative AI was used in the creation of this manuscript.

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