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Farmer-Identified Solutions for Small Ruminant Production Challenges in Ethiopia, Tanzania, and Uganda: Insights from 54 Studies

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ABSTRACT

Sheep and goats constitute a vital asset for smallholder farmers throughout East Africa; however, numerous obstacles still hinder small ruminant productivity. This review sought to pinpoint the main limitations in small ruminant farming and propose feasible and sustainable approaches to address them. Out of 54 qualifying studies, the majority originated from Ethiopia (n = 44), with only six from Tanzania and four from Uganda. In Ethiopia and Tanzania, disease was the most prevalent constraint (n = 28 and n = 3, respectively), while in Uganda, limited access to veterinary care was the primary challenge (n = 4). Other frequently reported issues across all three countries included scarcity of quality breeding animals, lack of livestock records, and the absence of structured marketing systems. Among the diseases, ectoparasites, gastrointestinal infections, orf, and sheep/goat pox were most commonly associated with production losses. Farmers in several studies suggested solutions such as better access to veterinary inputs and drugs, improved record maintenance, and easier acquisition of quality breeding stock. Community-driven participatory plans were also emphasized to enhance awareness of animal health management, pasture use, and husbandry practices. The review underscored significant knowledge deficiencies, the demand for additional research—particularly in Tanzania and Uganda—and the necessity of integrated approaches to address interrelated production barriers.

Keywords: Ethiopia, Tanzania, Ugandam small ruminants, Challenges, Interventions, Goats

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Introduction

Ensuring sustainable food production poses a growing global concern as populations continue to rise. Population expansion and the increasing demand for animal-source foods in developing regions such as East Africa have led to greater consumption of meat and dairy products [1, 2]. Therefore, sustainable livestock systems play an essential role in securing both food supplies and environmental stability [3–7].

Sheep and goats are among the most significant assets for East African smallholders. They contribute to household nutrition, generate income through the sale of meat, milk, wool, hides, and manure, and carry strong cultural importance [8, 9]. These animals are also well suited to harsh climates and reproduce efficiently due to their short gestation cycles [10, 11]. In 2017, Ethiopia was estimated to have approximately 30.7 million sheep and 30.2 million goats [11]; Tanzania in 2016 had about 5 million sheep and 16.7 million goats [12]; and Uganda in 2018 held roughly 3.4 million sheep and 12.3 million goats [13]. The number of households dependent on livestock for their survival continues to rise [3–5].

Nevertheless, several barriers persist in small ruminant production—such as restricted availability of veterinary products and care [10, 12, 14], poor grazing conditions due to bush invasion and urban sprawl [15–17], increasing drought episodes [18], insufficient disease management [19–21], and weak market accessibility [22]. Furthermore, the livestock sector often receives inadequate funding and recognition. Consequently, many resource-limited herders remain in poverty, lacking essential interventions that could promote their development [23, 24]. Most existing publications are confined to specific diseases or nations, broadly discuss production constraints, or analyze isolated control and development initiatives.

This systematic review therefore aimed to assess challenges affecting small ruminant farming within the East African nations engaged in the African Livestock Productivity and Health Advancement (ALPHA) initiative—Ethiopia, Tanzania, and Uganda. Established in 2017 and co-financed by the Bill & Melinda Gates Foundation (BMGF) and Zoetis Inc., the ALPHA Initiative seeks to enhance livestock productivity across sub-Saharan Africa [14]. The authors also aimed to summarize prior interventions and outline feasible practical recommendations. It is expected that identifying these challenges and opportunities will help guide targeted, sustainable actions that can improve the small ruminant sector across East Africa.

Materials and Methods

This review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework [25]. Three databases—Web of Science, PubMed, and Embase—were searched on 9 October 2019 for publications from 1990 to 2019. One researcher conducted the search, data extraction, and synthesis, with co-authors providing feedback as necessary. The search terms applied across all databases were: ((small ruminant OR goat OR sheep) AND (Tanzania OR Ethiopia OR Uganda) AND (product * OR econom *)).

Figure 1 illustrates the selection procedure, including duplicate removal and exclusion after title/abstract screening followed by full-text review. To qualify for inclusion, studies had to (i) be carried out in Ethiopia, Tanzania, or Uganda; (ii) focus on sheep or goats; (iii) present original quantitative or qualitative findings on production limitations; and (iv) be written in English.

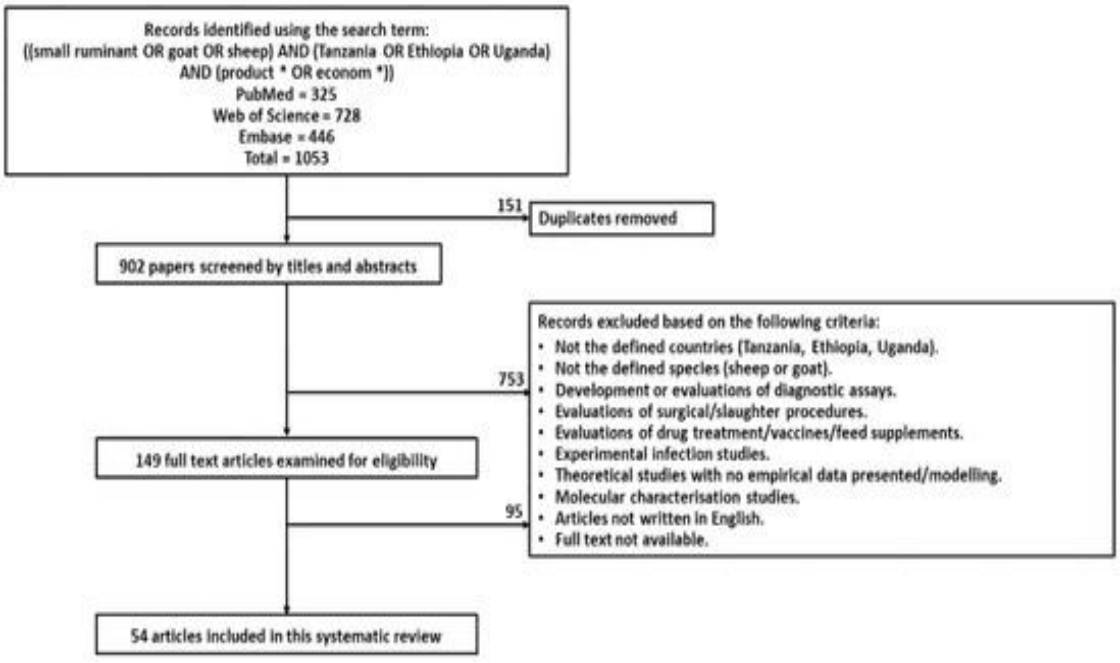


Figure 1. Flow diagram depicting the systematic review process used to determine eligible studies addressing constraints in small ruminant production.

Information obtained from the qualifying publications was organized using Microsoft Excel and contained the following parameters: (i) study classification (for instance, original investigation); (ii) participant number; (iii) data origin (such as farmer questionnaires); (iv) noted limitations or influencing factors; and (v) improvement measures proposed.

For the ranking procedure, only studies that reported farmer perceptions of major barriers to small ruminant production were considered. These data were gathered through household interviews, participatory rural appraisals (PRA), or group discussions. From every included paper, the three constraints considered most critical were extracted, and their corresponding indices were computed following the formula outlined in earlier research [26-28]:

$$I_j = \sum_{i=1}^{3} r_j X_{ij} \Big/ \left(\sum_{j=1}^{n} \sum_{i=1}^{3} r_j X_{ij} \right) \quad (1)$$

A weighted score (r_i) of 3, 2, and 1 was allocated to the first, second, and third most significant constraints, respectively, corresponding to ranks (i) 1, 2, and 3. The term Xij refers to the number of instances reported in the literature for rank i (i = 1, 2, or 3) associated with constraint j, where j includes: disease, feed insufficiency, drought, poor marketing infrastructure, limited water supply, restricted grazing access, unavailability of breeding stock, inadequate veterinary support, livestock theft, small flock numbers, lack of record systems, insufficient knowledge or education, and predation. The constraint with the largest index value was regarded as the most critical. To assess consistency between each country's constraint rankings and the overall ranking, Spearman's rank correlation was calculated in R version 3.6.0 [29] using RStudio [30].

Results and Discussion

Following the screening of 1053 records for duplicates and relevance according to inclusion and exclusion standards **(Figure 1)**, 54 studies were retained for detailed review. Most excluded publications either did not target the selected countries or species, or were limited to seroprevalence or experimental trials on diagnostic tools and nutritional supplements.

The reviewed studies were published between 1993 and 2019 **(Figure 2)**. Research conducted in Ethiopia accounted for the majority (n = 44; 84.5%), with only 6 papers from Tanzania and 4 from Uganda. Geographic representation of these studies by region or district is displayed in **Figure 3**. Among them, 21 of 54 (38.9%) focused exclusively on goats, 6 of 54 (11.1%) on sheep, and 27 of 54 (50%) on both species collectively. Nearly all publications (94.4%) reported primary field research within the respective countries, complemented by two review papers [11, 31] and one modelling analysis based on household data [32]. Of these original works, 82.4% utilized farmer surveys, participatory rural appraisals (PRA), or focus group sessions to identify production challenges and limitations.

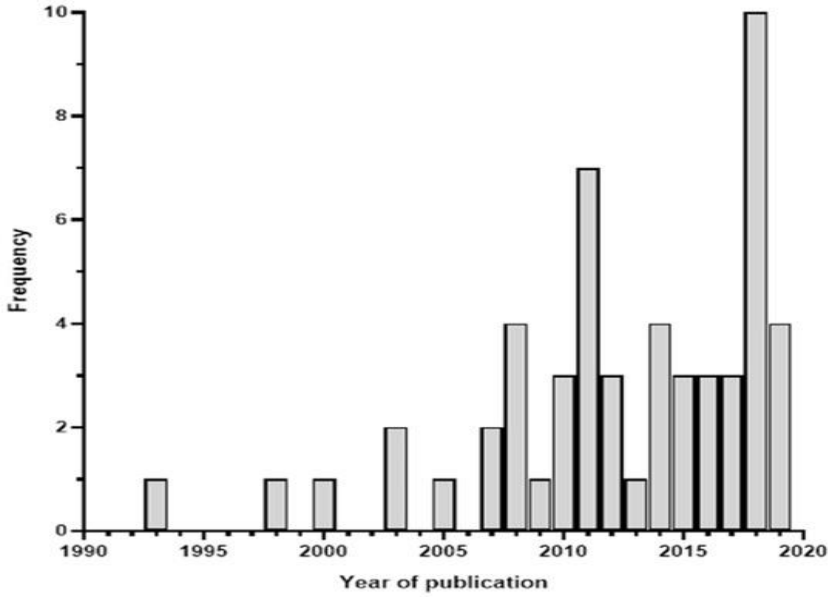
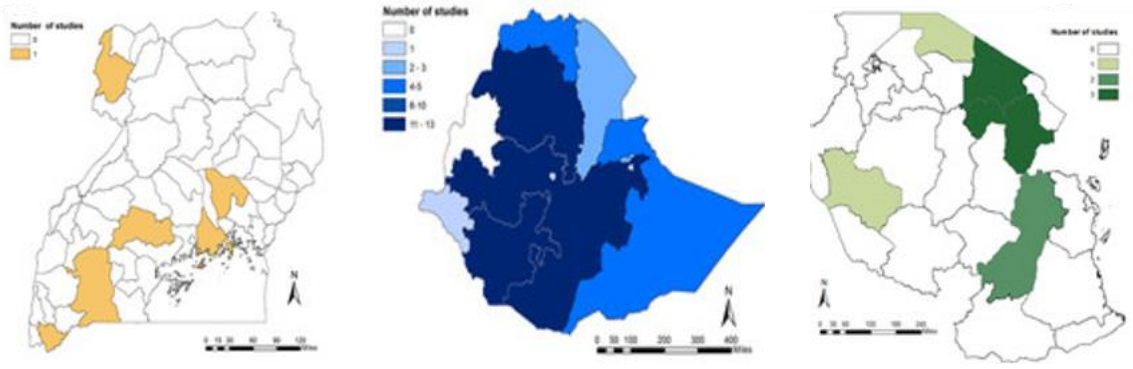


Figure 2. Number of published studies per year.



a) b) c)

Figure 3. Spatial representation of reviewed studies. Map (a) corresponds to Ugandan administrative districts, while Maps (b) and (c) illustrate the Ethiopian and Tanzanian administrative regions, respectively. Several studies encompassed more than one locality.

Barriers to small ruminant production

Figure 4 summarizes the key challenges reported across all eligible studies. Diseases and parasitic infestations emerged as the predominant issue, cited by more than half of all studies (61.1%) and by 51.9% of those from Ethiopia. Other frequently noted problems across the three countries included limited farmer training, shortage of high-quality breeding stock, insufficient livestock records, inadequate veterinary access, and underdeveloped marketing channels. Drought, feed shortages, restricted pasture areas, and predator threats were also recorded in Ethiopia and Uganda, but not in Tanzanian studies.

In detail, Ethiopia's most recurrent issues were disease (n = 28) and feed shortage (n = 13); in Tanzania, disease (n = 3) and low farmer awareness (n = 3); and in Uganda, limited veterinary services (n = 4).

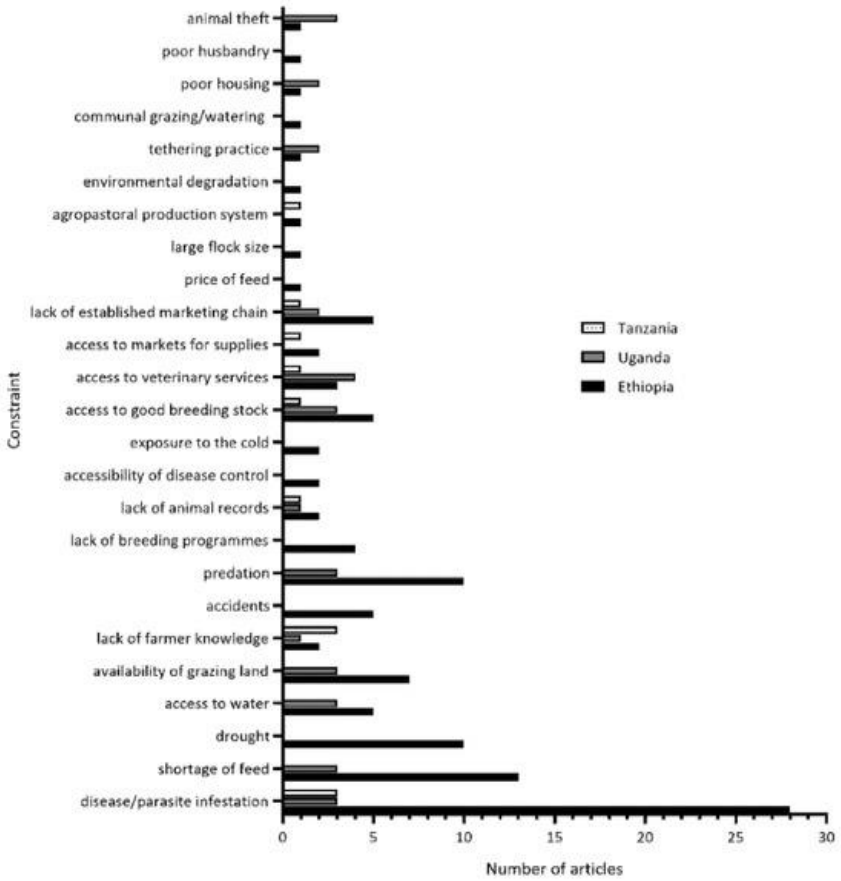


Figure 4. Identified constraints to small ruminant production across Ethiopia, Tanzania, and Uganda.

Farmer-prioritized ranking of constraints

Sixteen out of the 54 studies (11 from Ethiopia [9, 10, 15, 21, 33–39], one from Tanzania [40], and four from Uganda [19, 28, 41, 42]) presented farmer rankings of production barriers and were therefore included in the index analysis. Six of these papers covered multiple sites or production systems and were thus treated as separate datasets (n = 25) [9, 10, 28, 33, 37, 39]. The rankings obtained for each country are summarized in **Table 1**.

The highest-ranked constraints varied by country. In Ethiopia and Uganda—which together accounted for 24 of the 25 datasets—disease was rated as the leading concern (I = 0.292 and 0.441, respectively). In contrast, the sole Tanzanian study identified small flock size (I = 0.500) as the top issue, attributed to reduced genetic diversity in breeding animals [40]. Statistical analysis indicated a significant difference between national and combined rankings (Spearman's rho = −0.632, p = 0.021).

The next most critical factors were feed shortage and drought in Ethiopia, inadequate record keeping and limited farmer education in Tanzania, and restricted grazing access plus veterinary service limitations in Uganda.

Table 1. Farmer-reported prioritization of production constraints in small ruminants.

Constraint	Ethiopia (a = 11, n = 18)				Tanzania (a = 1, n = 1)				Uganda (a = 4, n = 6)				Overall (a = 16, n = 25)			
	I1	**I2**	**I3**	**Index**	**I1**	**I2**	**I3**	**Index**	**I1**	**I2**	**I3**	**Index**	**I1**	**I2**	**I3**	**Index**
Disease	7	3	4	0.292	0	0	0	0.000	5	0	0	0.441	12	3	4	0.311
Feed shortage	6	4	3	0.274	0	0	0	0.000	0	0	0	0.000	6	4	3	0.196
Drought	1	5	3	0.151	0	0	0	0.000	0	0	0	0.000	1	5	3	0.108
Poor marketing	1	1	1	0.057	0	0	0	0.000	0	0	0	0.000	1	1	1	0.041
Access to water	1	3	3	0.113	0	0	0	0.000	0	0	1	0.029	1	3	4	0.088
Access to grazing land	2	0	0	0.057	0	0	0	0.000	1	4	0	0.324	3	4	0	0.115
Access to breeding stock	0	1	1	0.028	0	0	0	0.000	0	0	1	0.029	0	1	2	0.027
Access to veterinary services	0	0	0	0.000	0	0	0	0.000	0	1	2	0.118	0	1	2	0.027
Theft	0	0	0	0.000	0	0	0	0.000	0	0	2	0.059	0	0	2	0.014
Small flock size	0	0	0	0.000	1	0	0	0.500	0	0	0	0.000	1	0	0	0.020
Lack of record keeping	0	0	0	0.000	0	1	0	0.333	0	0	0	0.000	0	1	0	0.014
Lack of knowledge/education	0	0	0	0.000	0	0	1	0.167	0	0	0	0.000	0	0	1	0.007
Predators	0	1	1	0.028	0	0	0	0.000	0	1	0	0.059	0	2	1	0.034
Spearman's rho statistic	0.939 (p = < 0.001)				−0.632 (p = 0.021)				0.318 (p = 0.289)							

a = number of studies; *n* = number of ranking datasets (some studies provided multiple results); *I1–I3* = counts of studies identifying each constraint as first, second, or third priority, respectively. The underlined index values mark the three top-ranking constraints.

Disease

Table 2 lists the diseases and parasitic infestations identified as limiting factors in small ruminant productivity, along with the references where each was cited. In Ethiopia, external parasites—such as mites, fleas, ticks, and lice—were the most repeatedly highlighted cause of productivity decline. Intestinal parasites (*Haemonchus spp.*, *Trichostrongylus spp.*, *Cysticercus tenuicollis*) and sheep/goat pox followed as the second and third most frequently discussed conditions.

Among the four Ugandan investigations [19, 28], two described five major health problems—ectoparasites, gastrointestinal nematodes, orf, contagious caprine pleuropneumonia (CCPP), and heartwater—as key production barriers. In Tanzania, three of six studies [43-45] reported brucellosis, peste des petits ruminants (PPR), and foot-and-mouth disease (FMD) as the predominant obstacles to small ruminant production.

Table 2. Articles identifying each disease as a limitation to small ruminant production.

Disease	Ethiopia	Uganda	Tanzania	Total (% of 54 diseases reported)	References
Ectoparasites	12	1	0	13 (24.1%)	[10, 19, 21, 22, 33, 37, 46-52]
Gastrointestinal parasites	9	2	0	11 (20.4%)	[19, 28, 33, 34, 37, 38, 48, 53-56]
Orf	7	1	0	8 (14.8%)	[9, 19, 37, 48, 51, 56-58]
Sheep/goat pox	7	0	0	7 (13.0%)	[9, 10, 20, 21, 33, 46, 58]
Pasteurellosis	6	0	0	6 (11.1%)	[9, 10, 20, 33, 37, 48]
CCPP	5	1	0	6 (11.1%)	[9, 10, 19, 20, 33, 50]
Brucellosis	5	0	1	6 (11.1%)	[20, 43, 59-62]
PPR	4	0	1	5 (9.3%)	[9, 10, 20, 44, 58]
Coenurosis	4	0	0	4 (7.4%)	[37, 48, 56, 58]
Diarrhoeal syndrome	4	0	0	4 (7.4%)	[10, 34, 50, 56]
Anthrax	3	0	0	3 (5.6%)	[10, 37, 50]
Pneumonia	3	0	0	3 (5.6%)	[34, 37, 57]
Mastitis	3	0	0	3 (5.6%)	[10, 21, 63]
Heartwater	1	1	0	2 (3.7%)	[19, 57]
Mineral deficiency	2	0	0	2 (3.7%)	[10, 38]
Listeriosis/circling disease	1	0	0	1 (1.9%)	[10]
FMD	0	0	1	1 (1.9%)	[45]
Foot rot	1	0	0	1 (1.9%)	[21]
Nairobi sheep disease	1	0	0	1 (1.9%)	[20]
Pyogenic infection	1	0	0	1 (1.9%)	[57]
Toxoplasma gondii	1	0	0	1 (1.9%)	[64]
Trypanosomiasis	1	0	0	1 (1.9%)	[21]
Caseous lymphadenitis	1	0	0	1 (1.9%)	[57]

[1] n = 54. CCPP = contagious caprine pleuropneumonia; PPR = peste des petits ruminants; FMD = foot-and-mouth disease.

Reports indicated that ectoparasites and pox infections produce symptoms such as irritation, swelling, anaemia, and wasting. These effects reduce hide and skin value, often leading to rejection at tanneries and income loss for producers [22, 37, 46, 47, 49, 50, 52]. Vector-borne conditions like Nairobi sheep disease and heartwater were also recorded in Ethiopia and Uganda, producing fever, weight loss, lameness, and respiratory distress [57].
Gastrointestinal worm infestations were connected with diarrhoea, poor growth, and low body condition and were described as the chief cause of sheep mortality [38, 55, 56]. Toxoplasma gondii exposure showed a strong statistical link with abortion [64], while carcass or organ rejection in abattoirs was mainly due to hydatid cysts [54]. Viral conditions—such as PPR, orf, and sheep/goat pox—and bacterial diseases including brucellosis, pasteurellosis, and CCPP were implicated in reproductive losses (brucellosis) [61, 62], dermal lesions (pox, orf) [46, 51], and decreased milk yield (mastitis, FMD) [45, 63].

Potential solutions to the challenges identified

Out of the 54 qualifying publications, 40 also proposed remedies or evaluated ongoing interventions addressing the aforementioned challenges **(Table 3)**. Six evaluated livestock health or welfare projects—most notably the Dairy Goat Development Programme (DGDP) launched in Ethiopia in 1989 [65, 66] and a Heifer International initiative in Tanzania [31]—both designed to promote goat husbandry among smallholders. Reference [8] also

analysed the Twawose dairy goat cooperative in Tanzania to determine whether processing goat-milk yoghurt could strengthen local livelihoods.

Two Ethiopian community-based initiatives—the animal-health-worker (CAHW) network [67] and the community-based breeding program (CBBP) [11]—applied participatory frameworks, incorporating farmers' feedback to advance herd genetics and animal health practices.

Table 3. Proposed measures for improving small ruminant production across Ethiopia, Uganda, and Tanzania.

Constraint	Proposed Solution	References
Disease	Effective ectoparasite control via dipping or spraying	[19, 21, 33, 37, 46, 52]
	Sustainable gastrointestinal parasite management using medicinal plants and strategic anthelmintic application to delay resistance	[54, 56]
	Enhanced farmer and animal health worker training on disease transmission and biosecurity practices	[31, 43, 47, 54, 58, 61]
	Conduct regular epidemiological surveillance of transboundary diseases, prioritizing border regions with neighboring countries	[20]
	Invest in vaccine development and implement vaccination campaigns targeting brucellosis, FMD, sheep/goat pox, and heartwater	[21, 45, 51, 57, 60]
Access to veterinary services	Establish decentralized veterinary clinics to enhance routine and preventive care access	[10 ,32, 41, 44, 58]
	Expand training programs for veterinarians and paraveterinarians	[9]
	Strengthen veterinary drug supply chains and regulatory oversight	[9]
	Deploy trained community animal health workers (CAHWs) and participatory groups for vaccination and minor treatment services	[8, 9, 31, 65, 67]
Availability of quality feed	Farmer education on pasture management and conservation	[41]
	Expand grazing areas through environmental restoration and natural resource conservation	[15]
	Enhance forage quality via rotational grazing, reseeding, and introduction of high-yielding, adaptable grass and legume species	[33, 38, 41]
	Supplement diets with high-protein leguminous tree leaves or concentrates such as noug seed cake	[32, 34, 42]
Drought	Implement predictive early-warning systems for drought	[19]
	Facilitate strategic livestock migration during drought to reduce pressure on local resources	[35]
Breeding programmes	Rotate breeding males and mix flocks to minimize inbreeding	[58]
	Develop community-driven breeding programs using indigenous/hybrid breeds, incorporating farmer trait preferences and local knowledge	[10, 11, 37, 41, 58, 65-68]
	Provide affordable, accessible reproductive technologies including artificial insemination services	[11]
	Promote family-inclusive breeding performance record-keeping	[58]
	Offer training on financial and technical aspects of breeding, supported by national research institutes	[11]
Record keeping	Train farmers on animal identification and its benefits	[40]
	Ensure affordable supply of identification materials	[40]
	Develop user-friendly, mobile-compatible record-keeping systems	[11]
Availability of markets	Conduct value-chain analyses to identify barriers to smallholder market access and participation	[10, 22]
	Upgrade market infrastructure and information dissemination	[22]
	Incentivize smallholders to produce high-demand animal products	[65]

	Form farmer cooperatives and associations to strengthen formal market linkages and information access	[10, 11, 22]
Predation	Promote active shepherding among smallholders to deter wild predator attacks	[69]

Discussion

The purpose of this review was to identify the difficulties encountered by small-scale farmers raising small ruminants in the three East African nations included in the ALPHA program and to highlight approaches suitable for upcoming development efforts. Across all eligible sources, 25 distinct constraints were documented, with parasitic and infectious diseases, feed and grazing shortages, and limited water availability or drought being most recurrent.

Of the 54 studies analysed, 33 focused broadly on production constraints, while the other 21 centred on specific infections—14 being prevalence-based risk analyses, three examining ectoparasite incidence, and four discussing multiple pathogens. Disease consistently emerged as a principal restriction; however, this could reflect publication tendencies rather than true prevalence, since the original search strategy did not explicitly include disease-related keywords. Consequently, these disease-focused works may have skewed emphasis toward parasitism.

Variation in assessment criteria—ranging from expert assessments to farmer perspectives—could also influence how the impact of disease was ranked [24]. Among studies that included prioritisation exercises, methods for data gathering and interpretation differed considerably. Therefore, the ranking outcomes summarized here likely represent the perceived importance of constraints among farmers surveyed, and extending these findings to broader populations should be approached cautiously.

Presence and Control of Parasitic Infections

Numerous studies reported frequent detection of external and gastrointestinal parasites in small ruminants. Findings from this review indicate that control and prevention measures—including chemical treatments such as dips, sprays, and anthelmintics—must be cost-effective, sustainable, and adapted to seasonal fluctuations in parasite populations [20]. Additionally, growing concerns about drug resistance resulting from improper or excessive use were emphasized [56].

A considerable number of reviewed studies incorporated participatory disease-monitoring methods, which provided insights not only into infection rates but also into how diseases affect livelihoods and community well-being when designing intervention programs [70, 71]. While these participatory tools are valuable when paired with molecular or serological analyses, limitations exist regarding farmers' ability to accurately recognize diseases based solely on visible symptoms. Therefore, additional epidemiological research on major livestock diseases across all three nations is strongly recommended. Moreover, improved disease surveillance, especially in border regions, is essential to quickly contain cross-border outbreaks. The isolation and genetic characterization of pathogens to trace their transmission pathways remain crucial, and predictive epidemiological models may assist in developing control strategies, including ensuring vaccinations correspond to locally circulating strains [20, 45].

Veterinary Services and Infrastructure

The review highlights a significant gap in veterinary support systems, as each of the three countries had at least one study identifying limited access to veterinary services as a production bottleneck. In the absence of sufficient professional care, farmers frequently resort to self-treatment, traditional healers, or illicit medication sources to manage herd health [21]. Many papers recommended expanding diagnostic facilities, medicine availability, and trained personnel. Furthermore, educational campaigns promoting good animal management, biosecurity, and preventive practices could help reduce the spread of infectious diseases at the farm level [54].

Multidisciplinary and Integrated Approaches

This review underscores the importance of multifaceted strategies to enhance small ruminant productivity. Past research in Africa has demonstrated that addressing single constraints in isolation is ineffective [72, 73], a view supported by this review's findings. For instance, Mayberry *et al*. [32] found that while improved animal health care raised goat productivity, the most notable gains occurred when nutritional status also improved. Similarly, the Dairy Goat Development Programme (DGDP) in Tanzania revealed that while the initiative achieved better genetic performance and reduced inbreeding through enhanced record-keeping [58, 65], these genetic benefits were only realized when goats received adequate nutrition and basic medical attention.

Community-Based Development and Farmer Participation

Several community-driven interventions were identified as effective for enhancing farmer awareness and animal productivity. One successful example was the community-based animal health worker (CAHW) system in Ethiopia [67], where locally chosen individuals received training in disease recognition, vaccination, and basic treatment. These workers were widely viewed as reliable, approachable, and affordable, benefiting from existing traditional knowledge of diseases and cultural practices, allowing for efficient information dissemination. Such systems are particularly useful for mobile pastoralist communities, which often remain underrepresented in formal research and development efforts [74].

The creation of farmer cooperatives and associations also emerged as an effective participatory tool for improving market access, milk processing, land management, credit availability, and breeding record rotation, while simultaneously offering training opportunities [11, 31]. The advantages of dairy cooperatives have already been validated in East Africa and India [75–78]. Moreover, community-based initiatives related to land rehabilitation and resource management were identified as potential solutions to promote environmental sustainability, feed availability, and nutritional improvement for livestock [15, 79].

Finally, adopting a coordinated value-chain approach could ensure that all actors—from sheep and goat producers to agribusiness stakeholders—benefit collectively from improvements across production, processing, and marketing sectors [80].

Regional distribution of studies and knowledge gaps

A large proportion (84.5%) of the studies included in this review were conducted in Ethiopia, covering almost all administrative regions. In contrast, limited research has been carried out in Tanzania and Uganda, where only a few districts or regions have been studied. This uneven distribution may have introduced a regional bias, as findings could reflect local rather than national conditions. Therefore, additional research focusing on specific underrepresented areas is recommended. Another limitation arises from the inclusion of English-language publications only, which may have led to the exclusion of relevant studies written in other languages.

Most of the papers assessed presented primary research involving small ruminant keepers through household surveys, participatory assessments, or evaluations of development initiatives. Thus, the proposed interventions are either those that have been tested at a small scale or directly suggested by farmers as effective ways to improve their livelihoods. Findings from all three countries under review suggest that similar production barriers are shared across the region, implying that the identified strategies may be applicable throughout East Africa. Supporting this, research among pastoralists in Northern Kenya also revealed comparable issues, such as disease outbreaks, droughts, predation, and limited veterinary access [81]. Nevertheless, implementing solutions requires context-specific adaptation, considering variations in farming systems, cultural norms, and local practices. For example, although Nigeria forms part of the ALPHA initiative, it was excluded from this review because its geographical distance and distinct environmental and cultural conditions could influence production systems differently.

Conclusion

In summary, this review identified key constraints affecting small ruminant farming within the East African nations included in the ALPHA program, emphasizing notable research gaps—particularly in Tanzania and Uganda—that warrant further investigation. The findings underscore the necessity of implementing sustainable, farmer-informed interventions developed through participatory methodologies. Some of these approaches have already shown potential and could be replicated or scaled up in the target regions.

However, when designing development projects, it is crucial that issues are not addressed in isolation, given the interdependence of factors influencing productivity. For instance, genetic improvement alone will have minimal effect if animal health care, disease management, and nutrition are inadequate. Hence, future initiatives should adopt a comprehensive, integrated framework that simultaneously tackles multiple constraints to achieve tangible improvements in farmer livelihoods.

Furthermore, new methods for impact assessment should be considered, recognizing that many livestock owners are subsistence-oriented rather than focused on generating cash income. Developing indicators that reflect livelihood well-being and household resilience, rather than economic profit alone, would provide a more accurate measure of progress in small ruminant development programs.

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